THE EFFECTS OF WORK-RELATED VALUES ON COMMUNICATION BETWEEN R&D GROUPS

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Chapter 5

MEASURES OF THE VARIABLES

5.1 - APPROACH

This chapter presents the methods by which the scales and indicators, described in the previous chapter, are combined to provide measures of the variables used in the propositions. These variables are "constructs" employed in our attempt to describe the relationships among various phenomena occurring in R&D organizations. The character of these constructs as revealed by the characteristics of the measures as derived from response patterns is presented. The reliability and validity of the measures are considered in this chapter and in Chapter 6.

5.1.1 - Approach to Scale Construction

The approach used in the development of the measures of the variables—scale construction—for this study was similar to that used in many other studies in the field of organization theory (e.g., Kahn, et al., 1964; Lawrence and Lorsch, 1967). Likert-type scales (Likert, 1932; Guilford, 1954) were used for most of the measures. Rank order tasks were also used for the comparison of work-related value items. Differential weighting of items based on response characteristics was not employed. Some items that entered into a scale composed of a number of items were rescaled because of differing numbers of response categories—e.g., a choice of 7 responses for some, as contrasted to a choice of 5 in the remainder of the items comprising the scale.

Little of the data was in the form of nominal scales.* Those items that were, comprised such information as the type of organization and various other categorizations provided in the respondent's background questionnaire, Q01. They will be discussed in Chapter 6. The rank order data provides ordinal scales.* The remainder of the data may be treated as either ordinal or interval scales,* subject to the assumptions that one is willing to make.

There is considerable diversity of opinion in the social sciences as to the proper application of various commonly used statistical procedures to data of this nature (cf: Peak, 1953; Siegel, 1956). McNemar (1962, p. 375) takes the following position on the treatment of data as ordinal or nominal measures:

The crucial question, however, is whether or not the $F$, $t$, and $Z$ tests can, in view of their dependence on means and variances be safely used when the scale of measurement is, as is the rule in psychology, somewhere between the ordinal and interval scales. The question boils down to this: Will the $F$s, $t$s, and $Z$s follow their respective theoretical sampling distributions when the underlying scores are not on an interval scale? The answer to this is a firm yes provided the score distributions do not markedly depart from the normal form. Nowhere in the derivations purporting to show that the ratios will have sampling distributions which follow either the $F$ or the $t$ or the normal distribution does one find any reference to a requirement of equal units. (Equal units are, of course, required for an interval scale.) This view is supported by some empirical and pragmatic tests as discussed by Diamond (1959, p. 233):

It is reassuring to observe at the outset [of his discussion of non-parametric statistics] that the consequences of mathematical delinquency, while they are not to be disregarded, are less serious than they are often made to appear in the statements of statistical puritans. Published sampling experiments tend uniformly to support the view that the $t$ test and the $F$ test are rather satisfactory guides under the conditions which usually arise in practical work. The most extensive study of this kind was performed by D. W. Norton, and is reported at length by Lindquist. The general conclusions stated by Lindquist are: (1) that "the $F$-distribution seems so insensitive to the form of the [parent] distribution ... that it hardly seems worthwhile to apply any statistical test to the data to detect non-normality," and (2) that "unless the heterogeneity of form of variance is so extreme as to be readily apparent upon inspection of the data, the effect upon the $F$-distribution will probably be negligible." ... Tending to the same conclusion is the fact that in numerous experimental reports, in which the treatment of the data is by unimpeachable distribution-free methods, one finds a footnote or parenthetic comment to the effect that the data were also treated by parametric methods, with essentially the same results.

We have assumed additivity and treated the item responses as nominal measurements in forming measurement scales for the variables and also in the analysis of the scales themselves. In utilizing these measures for the variables in proposition testing, either an ordinal or interval scale was assumed as required and the results treated with appropriate caution.
5.1.2 - Reliability and Validity Considerations

Reliability. There is always some degree of uncertainty in any measurement. In order to adequately interpret the results obtained from a series of measurements an estimate of this uncertainty is needed. The reliability coefficient for an instrument provides this measure. It indicates the stability, consistency, or predictability of an instrument or method of measurement. This consistency may involve the responses from one item to the next within a given instrument (inter-item reliability), from one occasion to another (test-retest reliability), or from one measurement form to another (equivalence).

Cronbach (1951) observes that: "No validity coefficient and no factor analysis can be interpreted without some appropriate estimate of the magnitude of error of measurement. The preferred way to find out how accurate one's measures are is to make two independent measurements and compare them. In practice, (social scientists) have often not had the opportunity to recapture their subjects for a second test." Note the implicit assumption that when the two independent measurements are made that all other conditions are essentially the same. The difficulties involved in recapturing the subjects and in changing conditions are avoided by determining the consistency of responses within an instrument when multiple items are used in one measure. In effect, two forms of the same scale, or multiple forms--depending upon the particular reliability measure used--are created and the consistency of response determined by comparing one set with another. This provides a coefficient of inter-item reliability. The correlation between the scores of a test given at one time and the same test given after an interval indicates how stable the scores are, and so provides a coefficient of (time) stability. Reliability measured on the basis of one administration indicates inter-item stability. Both inter-item and stability measures provide an indication of the error of measurement.

Reliability is expressed as a correlation coefficient. A variety of approaches have been developed to meet various needs. Underlying them all is a comparison of error variance ($V_e$) in the measure to the total variance ($V_t$):

$$r_{tt} = 1 - \frac{V_e}{V_t}$$

where $r_{tt}$ is the reliability coefficient.
This approach, first operationalized by Hoyt (1941) for dichotomously scored items, as an alternative to the well-known Kuder-Richardson Formula No. 20 (1937), was generalized by Cronbach (1951) in his coefficient alpha. It allows any scoring pattern, such as the Likert scales used here, to be used without the loss of information involved when such scales are arbitrarily dichotomized—as would be required if the Kuder-Richardson formula were used.

To interpret reliability coefficients, Selltiz, et al (1959, p. 181) make the following points:

1) The reliability of a measurement procedure is always contingent on the degree of uniformity of the given characteristics within the population being measured. . . . Thus, a test with a low reliability in a very homogeneous population may have a high reliability in a very heterogeneous population.

2) High reliability is more important if we wish to make fine discriminations among individuals than if we wish to identify people who are at extremes.

3) Estimates of reliability apply to the average reliability scores of individuals in a group. . . Frequently, the reliability of a score at one point on a continuum is different from that at another point; for example, individuals who have more intense attitudes may be more consistent than individuals who are less intense. . . (I)nstruments of relatively low reliability (can be compensated for) by increasing the size of the sample. However, if we are interested in making statements or predictions about particular individuals on the basis of their scores, reliabilities below .90 are risky.

In this study we are not making predictions about individuals. We are dealing with a set of individuals, N = 230 or more, and the groups to which they belong (N = 66) often treated as pairs (N = 33). While it is desirable to have reliability coefficients as high as possible, they do not have to attain the 0.90 level to be useful for aggregated data.

Validity. "It is possible to study reliability without inquiring into the meaning of the variables whose reliable measurement is studied. It is not possible to study validity, however, without sooner or later inquiring into the nature and meaning of one's variables," (Kerlinger, 1965, p. 444). Validity, in general, raises the question: Are we measuring what we think we are measuring? While this is a central issue, there are a number of types of validity that are recognized. We shall briefly consider face validity, content validity, predictive validity, concurrent validity, and construct validity.
Face validity implies that the relevance of the measuring instrument to what one is trying to measure is apparent "on the face of it." The issue can only be resolved as a matter of judgement. In making this judgement, two major questions must be answered: "(1) Whether the instrument is really measuring the kind of behavior that the investigator assumes it is, and (2) whether it provides an adequate sample of that kind of behavior," (Selltiz, et al, 1965). The assumption that the behavior or property being measured in a test is actually that behavior, is most likely to be met in proficiency and achievement measures such as those of mechanical skills. When other types of constructs are involved, Peak (1953, p. 285) notes that "More often than not, additional meanings are smuggled in and the assumption is made that the observations are, in fact, interpretable as a sample of a known universe. . . ." 

Content validity is determined in terms of the question: Is the content of this scale or test representative of the universe of the content of the property being measured? Such universes of content items exist only theoretically, so content validation consists essentially in judgement (Kerlinger, 1965). Content validity and face validity are essentially the same, raising the same questions and utilizing the same methods of judgemental processes.

Predictive and concurrent validity are similar in that both refer to predicting to an external criteria. They differ only in the time dimension, with predictive validity referring to a future (or past) criterion, and concurrent validity to a contemporaneous one. These types of validation are generally employed without regard to the theoretical content of the instrument. There may be no obvious relation between the content of the test and the criterion. For this reason, Selltiz, et al, (1965) characterize both forms as "pragmatic validity." The primary question involved is: Does this test work--will it allow me to make the necessary decisions of categorization or choice? In this approach it is necessary that there be a reasonably valid and reliable criterion available to the investigator with which the scores on the instrument can be compared.

Construct validity is of central concern to the development of theory. Cronbach and Meehl (1955) first made the concept of construct validity explicit, although it has been implicit in the history of science. As long as the concept of phlogiston was assumed to be a necessary constituent of all combustible bodies, progress in the fields we now know as chemistry and thermodynamics was limited. The introduction of new, more stable constructs integrated into a theoretical
structure that allows a variety of new, substantiable predictions to be formed, is a major goal of scientific activity. The definitions of such constructs imply sets of propositions about their relations to other variables. "Thus, in examining construct validity, it is appropriate to ask such questions as: What predictions would one make, on the basis of these sets of propositions, about the relationships to other variables of scores based on a measure of this construct? Are the measurements obtained by using this instrument consistent with these predictions?" (Selltiz, et al, 1965, p. 159). Consequently, construct validation involves not only the measuring instrument, but the underlying theory. This being the case, the operations involved become involved and extremely time consuming. It becomes difficult to disentangle the validation of a construct, the instrumentation of its measures, and the theory of which it is a part.

These difficulties were mitigated and the notion of construct validation made more operational within the life span of a researcher by Campbell and Fiske (1959). They have provided a specific technique, the multitrait-multimethod matrix, that provides a quantitative focus on the adequacy of the measures of the construct in question, before hypotheses involving other variables are considered. This approach partially disentangles the validation of constructs from the total research process involved in attempts to validate a theory.

Campbell and Fiske propose two major requirements to be met in validating a construct: 1) To demonstrate that the different independent measurement methods for the same construct are convergent; and 2) To demonstrate that the measures of a construct ("trait") discriminate it from other constructs ("traits") from which it is intended to differ. Instruments can be invalidated by too high correlations with scales for other variables. The first shows convergent validity of multiple methods; the second shows discriminant validity among various constructs and methods. More than one construct and more than one method have to be employed in this validation process. The relation among the constructs can be shown in what Campbell and Fiske call a "multitrait-multimethod matrix," presenting all the intercorrelations for each of several traits measured by each of several methods. Several criteria are provided to guide estimation of the construct validity. These criteria and a multitrait-multimethod matrix are given in a later section where the technique is applied to data in this study.
Campbell and Fiske observe that

... reliability and validity can be seen as regions on a continuum. Reliability is the agreement between two efforts to measure the same trait through maximally similar methods. Validity is represented in the agreement between two attempts to measure the same trait through maximally different methods. A split-half reliability is a little more like a validity coefficient than is an immediate test-retest reliability, for the items are not quite identical. A correlation between dissimilar subtests is probably a reliability measure, but is still closer to the region called validity.

Some evaluation of validity can take place even if the two methods are not entirely independent. (1959, p. 83)

Such is the case in the example of the use of the multitrait-multimethod matrix provided in Section 5.4.5. In our example, the "multitraits" involved are the four task interdependence factors, and the "multimethods" are responses to two separate instruments. The questionnaires have some items in common so they were not completely independent. Nevertheless, their use illustrates the application of the technique and provides some indication of convergent and discriminant validation of the constructs involved.

Factor analysis may also be used in construct validation. It provides an indication of which scales are measuring the same thing and to what extent they are measuring it, (Kerlinger and Kaya, 1959a, b). The common factor variance, or communality, of a scale is the variance of a measure that is shared with other measures--the variance that two or more scales have in common. Convergent validity is indicated by high common factor variance and discriminant validity by low common factor variance.

5.1.3 - Numerical Basis

The various scales and factors were developed using the largest number of responses applicable. The work-related values factors were based on 260 responses to the Q08.3 instrument. Sixty-seven respondents completed the Q08.1&2 version. Proposition testing was based on 33 pairs of groups with a total of 284 people. Six pairs containing a total of 21 people were not included because a) responses were obtained from only one person in one of the groups in three cases, or b) they were part of the three "cross-organizational" pairs with a total of 10 people from whom some data was collected. Each group of these pairs was in a different organization. It was later decided to drop the responses from these 10 because of the small N and different nature of their problems. The characteristics of the scores are reported for the N on which they were developed or the N used in proposition testing, as appropriate, in the following sections.
5.2 - STRUCTURING THE VALUE CLUSTERS

The work-related values of engineers and scientists were measured to determine the effects of similarities and differences upon perceived communication problems. Eighty items were used to determine these values. The following sections describe a) the method by which the underlying values were determined, b) the several determinations made of the reliability of the measures, and c) the method used for determining the similarity and differences in values. Additional insights into the nature of work-related values and related items of importance to the respondents were gained during interviews with them, but the measurement of the values was based on the responses to the items considered here.

5.2.1 - Item Clustering

In order to be able to compare various pairs of groups on the basis of the similarity and differences in their work-related values, the 80 items were reduced to a smaller number of clusters of items. Cronbach (1958) discusses the problems involved with using a single, global index number to measure the "distance" between two entities. He advises against such a measure, which in this case might take the form:

\[ D = (d_1^2 + d_2^2 + \ldots + d_{80}^2)^{\frac{1}{2}} \]

where the \( d_i \) are the difference scores between the two groups on the 80 items. He recommends one to: "Reduce the data to reliable scores on independent, interpretable factors by one of the conventional factor-analytic methods (ordinarily with rotation to orthogonal simple structure)," (1958, p. 369).

Work-related values were determined from the eighty Q08.3 questionnaire items. Using all Q08.3 questionnaires\* a principal components factor analysis with rotation was performed. Program FACTOR of the Vogelback Computing Center was used with a squared multiple correlation estimate of communality, and minimum eigenvector values of 0.8 for principal factor and 0.1 for rotated factor extraction. The results of this factor analysis for 244 respondents are shown in Appendix 5A.

* As of 5 August, 1969. An additional 16 were received in September and October.
The 12 factors that emerged account for 80% of the common factor variance, with the first 10 factors accounting for 73% of the variance.

In factor analysis, if the majority of signs in a column are positive or negative, this does not necessarily have an intrinsic meaning. The signs in a given column can all be reversed by a different implementation of the routine. Changes of signs within a column are meaningful (Harman, 1960). A bi-polar factor would be indicated by items with loadings of roughly equal magnitude and opposite sign.

The loadings, given in Appendix 5A, were used to select the item clusters to be used in determining the work-related value profiles of individuals and groups. An item with a factor loading of less than 0.30 was not included in a cluster. As shown in Appendix 5A, some items loaded on more than one factor. (Further development of the instrument would be required to enhance the purity of the factors.) In such cases the item was assigned to the factor for which it had the highest loading. If two loadings were essentially the same (± 0.03), the assignment was made on the basis of the content of the item.*

The factors are given in Table 5.2-1. The first 10 are clearly interpretable and were given the names indicated.# The eleventh factor comprises only two items and does not have a clear interpretation. One item deals with aesthetics of design and the other with congeniality. This factor was not used in testing the propositions. The twelfth factor is bi-polar and is composed of five items with loadings greater than 0.30. By extending the loadings down to 0.22, ten items were included—five with positive and five with negative loadings. All of the items except #36 appear in other factors. The interesting aspect of this factor is that it is bi-polar and the content of the items carries a suggestion of a "local-cosmopolitan" dimension (Gouldner, 1957). However, the items are not fully consistent along this dimension. Note especially #58 and #51. This factor is not as strong as the others as indicated by its weak loadings arising in the context of the other items. Because of the duplication of items and their weak loadings, Factor XII was not used in testing the propositions. The ten factors utilized are composed of 77 of the 80 items in the questionnaire.

* Item 15 loaded 0.27 on Factor II and 0.31 on Factor V, but was assigned to Factor II on the basis of its content.
# I appreciate the suggestions of R. T. Barth and D. T. Kegan in naming the factors.
Table 5.2-1

Work Values

**Factor I  Personal Interaction or Relationship Values.**

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>66 .72</td>
<td>To have tolerance.</td>
</tr>
<tr>
<td>67 .69</td>
<td>To have understanding or sensitivity.</td>
</tr>
<tr>
<td>55 .62</td>
<td>To help others.</td>
</tr>
<tr>
<td>60 .58</td>
<td>To be unselfish.</td>
</tr>
<tr>
<td>4 .47</td>
<td>To be sociable.</td>
</tr>
<tr>
<td>29 .42</td>
<td>To have a sense of humor.</td>
</tr>
<tr>
<td>54 .45</td>
<td>To be loyal to one's work group.</td>
</tr>
<tr>
<td>65 .46</td>
<td>To have self-discipline.</td>
</tr>
<tr>
<td>1 .38</td>
<td>To have emotional neutrality - keep one's emotions in check.</td>
</tr>
<tr>
<td>57 .38</td>
<td>To anticipate the wishes of one's group before acting.</td>
</tr>
<tr>
<td>72 .38</td>
<td>To promote the welfare of one's work group.</td>
</tr>
</tbody>
</table>

**Factor II  Engineering and Technology Performance Values.**

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 .79</td>
<td>To have reliability of design.</td>
</tr>
<tr>
<td>11 .71</td>
<td>To design for quality control.</td>
</tr>
<tr>
<td>45 .69</td>
<td>To provide for manufacturability of design or &quot;implementability&quot; of approach.</td>
</tr>
<tr>
<td>8 .68</td>
<td>To provide functional utility of design.</td>
</tr>
<tr>
<td>27 .66</td>
<td>To refine a design; to make it the best possible.</td>
</tr>
<tr>
<td>69 .62</td>
<td>To provide for maintainability of design.</td>
</tr>
<tr>
<td>32 .58</td>
<td>To do rigorous testing.</td>
</tr>
<tr>
<td>24 .58</td>
<td>To provide for safety of design.</td>
</tr>
<tr>
<td>5 .55</td>
<td>To attain stated specifications.</td>
</tr>
<tr>
<td>10 .46</td>
<td>To meet delivery schedules.</td>
</tr>
<tr>
<td>76 .44</td>
<td>To have simplicity of design or approach.</td>
</tr>
<tr>
<td>61 .41</td>
<td>To use proven techniques or items.</td>
</tr>
<tr>
<td>6 .40</td>
<td>To fully develop ideas theoretically before trying them in practice.</td>
</tr>
<tr>
<td>15 .27</td>
<td>To exceed technical specifications.</td>
</tr>
</tbody>
</table>

**Factor III  Scientific or Technological Work Fulfillment Values**

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>78 .61</td>
<td>To have freedom to choose how one will carry out his work.</td>
</tr>
<tr>
<td>77 .57</td>
<td>To have innovative designs or approaches.</td>
</tr>
<tr>
<td>80 .57</td>
<td>To bring order and simplicity into chaotic or complex material.</td>
</tr>
<tr>
<td>16 .43</td>
<td>To be creative, innovative, imaginative.</td>
</tr>
<tr>
<td>19 .39</td>
<td>To work on difficult and challenging problems.</td>
</tr>
<tr>
<td>68 .33</td>
<td>To have sophistication of design or approach.</td>
</tr>
</tbody>
</table>
Table 5.2-1 (cont'd)

Factor IV Career Values.

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>.75 To advance oneself economically.</td>
</tr>
<tr>
<td>70</td>
<td>.69 To advance and move ahead in organizational position.</td>
</tr>
<tr>
<td>64</td>
<td>.59 To have social status and prestige.</td>
</tr>
<tr>
<td>35</td>
<td>.55 To build one's professional reputation.</td>
</tr>
<tr>
<td>56</td>
<td>.52 To have a stable, secure future.</td>
</tr>
</tbody>
</table>

Factor V Science Values.

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>.68 To contribute to broad technical knowledge in one's field.</td>
</tr>
<tr>
<td>71</td>
<td>.67 To probe deeply and thoroughly into scientific/technical phenomena.</td>
</tr>
<tr>
<td>26</td>
<td>.63 To make technical or scientific knowledge openly available.</td>
</tr>
<tr>
<td>13</td>
<td>.51 To make full use of one's present knowledge and skills.</td>
</tr>
<tr>
<td>63</td>
<td>.48 To have a sense of mission for science or technology.</td>
</tr>
<tr>
<td>9</td>
<td>.44 To develop technical competence in others.</td>
</tr>
<tr>
<td>74</td>
<td>.43 To be a member of one's professional community outside the organization.</td>
</tr>
<tr>
<td>48</td>
<td>.42 To have an academic orientation - theoretical, analytical.</td>
</tr>
<tr>
<td>51</td>
<td>.41 To work on problems of great value to the nation and society.</td>
</tr>
<tr>
<td>52</td>
<td>.37 To objectively judge technical or scientific work.</td>
</tr>
<tr>
<td>30</td>
<td>.34 To discover general principles that apply to many situations.</td>
</tr>
</tbody>
</table>

Factor VI Project Direction or Guidance Values.

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>.54 To know how others are progressing in their work.</td>
</tr>
<tr>
<td>3</td>
<td>.47 To be able to lead and control.</td>
</tr>
<tr>
<td>59</td>
<td>.45 To be flexible in the approaches one considers.</td>
</tr>
<tr>
<td>79</td>
<td>.44 To consider trade-off possibilities.</td>
</tr>
<tr>
<td>58</td>
<td>.33 To get acceptable results, adequate to do the job.</td>
</tr>
<tr>
<td>33</td>
<td>-.40 To work with things moreso than people.</td>
</tr>
</tbody>
</table>

Factor VII "Quick Fix" or Immediate Payoff Values.

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>.59 To compromise, rather than do exhaustive research, analysis, or development.</td>
</tr>
<tr>
<td>75</td>
<td>.59 To get quick solutions.</td>
</tr>
<tr>
<td>14</td>
<td>.48 To work by cut and try methods.</td>
</tr>
<tr>
<td>42</td>
<td>.43 To work on problems for which there are ready-made solutions.</td>
</tr>
<tr>
<td>31</td>
<td>.42 To have an application orientation - pragmatic, empirical.</td>
</tr>
<tr>
<td>61</td>
<td>.38 To use proven techniques or items.</td>
</tr>
</tbody>
</table>

Factor VIII Collegial Growth Values.

<table>
<thead>
<tr>
<th>Item Loading</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>.47 To work with colleagues of high technical competence.</td>
</tr>
<tr>
<td>21</td>
<td>.46 To subject ideas to practical trial as soon as possible.</td>
</tr>
<tr>
<td>25</td>
<td>.45 To learn and develop through interactions with colleagues.</td>
</tr>
<tr>
<td>28</td>
<td>.44 To fully report the sources of one's ideas.</td>
</tr>
<tr>
<td>49</td>
<td>.42 To have freedom to carry out one's ideas within project objectives.</td>
</tr>
<tr>
<td>50</td>
<td>.33 To present and discuss ideas with colleagues.</td>
</tr>
<tr>
<td>40</td>
<td>.32 To know why things are being done the way they are.</td>
</tr>
</tbody>
</table>
Table 5.2-1 (cont'd)

Factor IX  Organizational Performance Values.
(Organizational "credo")

Item Loading

 43  .54  To be efficient in one's work.
 44  .50  To be loyal to one's organization.
 39  .41  To reduce total project costs.
 23  -.44  To have freedom to choose _what_ one will work on.

Factor X  Professional and Personal Integrity Values.

 18  .66  To be persistent in one's work.
 17  .64  To be sincere.
  7  .56  To be dedicated (rather than ambitious).
 34  .55  To have a sense of mission for one's projects.
 38  .52  To be conscientious.
 20  .44  To act as one believes, regardless of contrary opinion.
 41  .49  To operate ethically.
 44  .42  To be loyal to one's organization.

Factor XI

 37  .49  To have congenial co-workers or colleagues.
 62  .53  To have aesthetic appeal of design.

Factor XII

 48  .36  To have an academic orientation - theoretical, analytical.
  6  .33  To fully develop ideas theoretically before trying them in practice.
 58  .29  To get acceptable results adequate to do the job.
 35  .26  To build one's professional reputation.
 36  .23  To have similar "outside" interests to one's group.
 44  -.22  To be loyal to one's organization.
 51  -.26  To work on problems of great value to the nation and society.
 53  -.31  To have enthusiasm.
 54  -.34  To be loyal to one's group.
 72  -.39  To promote the welfare of one's work group.
Items 23 and 33 were reverse-scored because of their negative loadings. Work-related value scores were derived for each respondent by calculating his mean score for the items comprising each factor, weighting all items equally. The mean scores and other statistics for individuals are given in Table 5.2-2. The abbreviated titles for the factors are used in this and following tables and figures. Work-related value scores for a group were derived by taking the mean score on each factor for the individuals in the group. Statistics for the group scores are also given in Table 5.2-2. The difference in mean scores for individuals and groups is 1% or less. The standard deviation for group scores is smaller, as would be expected.

Integrity and Collegial Growth values ranked first and second across all the engineers and scientists in the study. Career and Quick Payoff values ranked in the last two places. In eight of the value factors there were individuals who scored at either extreme. One attained the maximum score for Personal Relationship and Quick Payoff. The value scores are discussed further in Chapter 8.

5.2.2 - Value Similarity/Difference Measures

Propositions Pl.2 and Pl.3 include the variable "similarity of work-related values." The actual measure utilized was the difference in importance for each work-related value taken between one group of a pair and the other group, or between an individual in one group and the other group (his "Referenced Group"). The difference score for the \( i \)th individual was formed by taking the absolute value of the difference between his score on a given value factor \( V_i \) from that of the mean score of his Referenced Group \( k \):

\[
\text{Value Difference } i_j = |V_{ij} - \overline{V_{ik}}|
\]

The difference score for the \( n \)th pair was formed by taking the absolute value of the difference between the mean score of all the individuals in one group of a pair from the mean score for all the individuals in the second group of the pair for each value factor \( k \):

\[
\text{Value Difference } nk = |\overline{V_{kn1}} - \overline{V_{kn2}}|
\]
Table 5.2-2
Work Value Statistics of Engineers and Scientists

<table>
<thead>
<tr>
<th>Rank</th>
<th>Name*</th>
<th>Mean#</th>
<th>Stand. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTEGRITY</td>
<td>2.975</td>
<td>.574</td>
<td>0.50</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.994)</td>
<td>(.322)</td>
<td>(1.69)</td>
<td>(3.71)</td>
</tr>
<tr>
<td>2</td>
<td>COLLEGIAL GROWTH</td>
<td>2.894</td>
<td>.532</td>
<td>1.28</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.902)</td>
<td>(.265)</td>
<td>(2.09)</td>
<td>(3.50)</td>
</tr>
<tr>
<td>3</td>
<td>PROJECT DIRECTION</td>
<td>2.823</td>
<td>.545</td>
<td>0.56</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.826)</td>
<td>(.314)</td>
<td>(1.67)</td>
<td>(3.67)</td>
</tr>
<tr>
<td>4</td>
<td>WORK FULFILLMENT</td>
<td>2.710</td>
<td>.584</td>
<td>0.67</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.673)</td>
<td>(.336)</td>
<td>(1.42)</td>
<td>(3.33)</td>
</tr>
<tr>
<td>5</td>
<td>ENGINEERING</td>
<td>2.547</td>
<td>.685</td>
<td>0.04</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.571)</td>
<td>(.487)</td>
<td>(.83)</td>
<td>(3.47)</td>
</tr>
<tr>
<td>6</td>
<td>PERSONAL RELATIONSHIP</td>
<td>2.501</td>
<td>.601</td>
<td>0.09</td>
<td>3.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.521)</td>
<td>(.374)</td>
<td>(1.09)</td>
<td>(3.27)</td>
</tr>
<tr>
<td>7</td>
<td>ORGANIZATIONAL</td>
<td>2.432</td>
<td>.642</td>
<td>0.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.440)</td>
<td>(.380)</td>
<td>(1.25)</td>
<td>(3.42)</td>
</tr>
<tr>
<td>8</td>
<td>SCIENCE</td>
<td>2.384</td>
<td>.640</td>
<td>0.04</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.406)</td>
<td>(.387)</td>
<td>(1.48)</td>
<td>(3.23)</td>
</tr>
<tr>
<td>9</td>
<td>CAREER</td>
<td>2.002</td>
<td>.778</td>
<td>0.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.010)</td>
<td>(.503)</td>
<td>(.40)</td>
<td>(3.60)</td>
</tr>
<tr>
<td>10</td>
<td>QUICK PAYOFF</td>
<td>1.755</td>
<td>.588</td>
<td>0.17</td>
<td>3.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.762)</td>
<td>(.363)</td>
<td>(1.00)</td>
<td>(2.63)</td>
</tr>
</tbody>
</table>

* Full factor titles are given in Table 5.2-1.

# Parenthetical figures are for group scores (N = 66), other figures are for individual's scores (N = 260).
The distribution of value difference scores for group pairs, accumulated over the ten factors, is shown in Figure 5.2-1. The mean value difference for all factors is 0.39 and the mode is 0.25. The distribution is skewed with a tail extending to a maximum difference of 1.95.
5.2.3 - Reliability of Work-Related Values Scales

The reliability of the work-related value measurement scales was determined by
two different methods with data from three sets of respondents. The methods
employed were test-retest and inter-item reliability measurement. Test-retest
reliability measurements were made with three groups. Two of these groups were
engineers who had returned to Vanderbilt University from industry for a
Master's degree in Engineering Management.* One group of 16 had just begun the
program when the Q08.3 questionnaires were given in October, 1969. The other
Vanderbilt group of 11 was beginning their second year of the program and were
working in industry at that time. (Students in the program spend one semester
at Vanderbilt, one year in industry, and then one more semester at Vanderbilt.)
The questionnaires were mailed to the second group by the author with a cover
letter from Dr. Williamson. The third group was composed of 23 night school
students in the author's class at DePaul University. None of these students
were engineers or scientists, but all held full time jobs. Four weeks after
each of these groups completed the questionnaire for the first time, they filled
it out a second time.

The test-retest reliability for all 50 university students was determined by
correlating the scores on each value scale from the first to the second adminis­
tration. The results are presented in Table 5.2-3. The test-retest reliability for all items in the questionnaire is 0.83. Six of the correlations
for the individual scales are 0.74 or higher and the lowest is 0.58.

The inter-item reliability was determined for the 260 respondents of the field
study and the 50 university students. The Cronbach alpha coefficient (1951)
for inter-item reliability was calculated using program TESTAT (Veldman, 1967)
for each value scale and for all scales combined. The inter-item reliability
for all items in the questionnaire is 0.92 in the field study, 0.93 for the
first administration to the university students and 0.96 for the second admini-
stration. Six of the value scales have inter-item reliabilities of 0.70 or
higher.

* I wish to thank Dr. Merritt Williamson for his cooperation in making his
students available and administering the questionnaire.
# Performed with library program SPSS at the Vogelback Computing Center,
Northwestern University.
Table 5.2-3
Value Scales Reliability

<table>
<thead>
<tr>
<th>No. of Items</th>
<th>Integrity</th>
<th>Collegial Growth</th>
<th>Project Direction</th>
<th>Work Fulfillment</th>
<th>Engineering</th>
<th>Personal Relationship</th>
<th>Organizational</th>
<th>Science</th>
<th>Career</th>
<th>Quick Payoff</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Study</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>14</td>
<td>11</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>6</td>
<td>80</td>
</tr>
<tr>
<td>(N = 260)</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Univ.&quot; Test</td>
<td>75</td>
<td>61*</td>
<td>61*</td>
<td>60</td>
<td>83</td>
<td>85</td>
<td>24</td>
<td>82</td>
<td>66</td>
<td>26</td>
<td>93</td>
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<tr>
<td>(N = 50)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Univ. Test</td>
<td>84</td>
<td>77*</td>
<td>77*</td>
<td>68</td>
<td>88</td>
<td>87</td>
<td>28</td>
<td>88</td>
<td>79</td>
<td>64</td>
<td>96</td>
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<tr>
<td>Retest (N = 50)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test-Retest</td>
<td>88</td>
<td>80</td>
<td>68</td>
<td>58</td>
<td>88</td>
<td>74</td>
<td>63</td>
<td>88</td>
<td>78</td>
<td>65</td>
<td>83</td>
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<td>(N = 50)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Cronbach "alpha" inter-item reliability coefficients.

* Items erroneously combined into one scale of 13 items.
The value scales consistently having the highest reliability coefficients are Science, Engineering, Personal Relationship, Integrity, and Career.

5.2.4 - Use of Q08.1/Q08.2 Data

The first version of the Work Values instrument, as described in Section 4.5.3, had a different response format from the final version. Twenty items were presented on each of four pages in a part identified as Q08.1. This was repeated with the items arranged in a different random order in a second part identified as Q08.2 in the same instrument package. On each page the respondent was asked to check the five items he considered most important to him and his group. The Q08.1 & 2 forms were completed by 67 respondents from six pairs of groups in two organizations. It was considered worthwhile to attempt to utilize this data, provided the results were consistent with the data obtained from the Q08.3 version.

Scores were developed for each value scale by first assigning a value of 2 to each item checked. Since all items appear twice in the instrument, the possible scores for any given item were 0, 2, or 4. The score for each value scale was then calculated by taking the mean score for the items in the ten scales for each individual. The next step was to find the mean and standard deviation of each scale for these 67 respondents. The scores were then standardized to the same mean and standard deviation of the same work-related value scale of the Q08.3 instrument. For a given value scale:

$$V'_1 = (V_1 - \bar{V}_1)(S_3 / S_1) + \bar{V}_3$$

where $V'_1$ = rescaled Q08.1/2 score, $V_1$ = original score, $\bar{V}_1$ = mean original Q08.1&2 score, $\bar{V}_3$ = mean Q08.3 score, $S_1$ = standard deviation of Q08.1&2 scores, and $S_3$ = standard deviation of Q08.3 scores.

This method of rescaling makes the two types of scores comparable. The means and standard deviations are necessarily the same. Only characteristics of the distribution of the scores can be different, and such differences may, in part, be due to differences in the respondents' values as well as to the instrument.
The intercorrelations of the value scales with and without the Q08.1&2 data are shown in Table 5.2-4. The net effect on the value scales is to decrease 37 of the 45 intercorrelations. The difference between only six of the 45 pairs is significant at the 0.05 level. The lack of effect on the value difference scores can be seen in Figures 7.2-1 through 7.2-10 of Chapter 7, where these scores are plotted against the perceived communication problems scores. The scores from Q08.1&2 are drawn as stars (*). No consistent pattern emerges from the ten scattergrams. The data from these 67 respondents was used in the tests of Propositions P1.2 and P1.3 reported in Chapter 7. A different measure of value similarity based on the Q09 rank order instrument was also used to test these same propositions. These tests provide indirect evidence of the comparability of the Q08.1&2 and Q08.3 scores in that both series of tests produce the same results. The method devised for scoring the Q08.1&2 data appears to be satisfactory.
# Table 5.2-4

Intercorrelations of Value Factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERSONAL RELATIONS</td>
<td>08</td>
<td>10</td>
<td>30</td>
<td>31</td>
<td>22</td>
<td>13</td>
<td>34</td>
<td>28</td>
<td>54</td>
</tr>
<tr>
<td>ENGINEERING</td>
<td>-</td>
<td>05</td>
<td>12</td>
<td>-02</td>
<td>21</td>
<td>36</td>
<td>25</td>
<td>30</td>
<td>12*</td>
</tr>
<tr>
<td></td>
<td>(11)</td>
<td>(14)</td>
<td>(18)</td>
<td>(25)</td>
<td>(41)</td>
<td>(35)</td>
<td>(33)</td>
<td>(35)</td>
<td></td>
</tr>
<tr>
<td>WORK FULFILLMENT</td>
<td>-</td>
<td>20*</td>
<td>34</td>
<td>20</td>
<td>02</td>
<td>30</td>
<td>-10</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(28)</td>
<td>(55)</td>
<td>(20)</td>
<td>(13)</td>
<td>(45)</td>
<td>(-09)</td>
<td>(43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAREER</td>
<td>-</td>
<td>24</td>
<td>17</td>
<td>11</td>
<td>17</td>
<td>15</td>
<td>18</td>
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<td>(15)</td>
<td>(28)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIENCE</td>
<td>-</td>
<td></td>
<td>-02</td>
<td>-07</td>
<td>34</td>
<td>02</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(14)</td>
<td>(07)</td>
<td>(57)</td>
<td>(05)</td>
<td>(43)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROJECT DIRECTION</td>
<td>-</td>
<td>21</td>
<td>18*</td>
<td>15</td>
<td>08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(09)</td>
<td>(38)</td>
<td>(04)</td>
<td>(21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QUICK PAYOFF</td>
<td>-</td>
<td>02</td>
<td>14</td>
<td>04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(12)</td>
<td>(-05)</td>
<td>(12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COLLEGIAL GROWTH</td>
<td>-</td>
<td></td>
<td>09</td>
<td>37*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(13)</td>
<td></td>
<td>(63)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORGANIZATIONAL</td>
<td>11</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>(12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTEGRITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Correlations for individuals used in proposition testing (N = 284). Parenthetical figures are correlations deleting Q08.1&2 data (N = 117). * Correlations significantly different from each other at .05 level.
5.3 - COMMUNICATION MEASURE

The characteristics of the quality of the information exchange process between two groups were measured by a number of items in the "Work Communication and Work Structure" questionnaire, CD Q02. The items were combined into a scale providing a measure of perceived communication problems (PCP scale). A low numeric score on this scale implies that few problems are perceived, and a high score implies many problems. The scale does not indicate the quality of message content in terms of the "brilliance" of the ideas expressed or other such aspects that extend beyond the absence of problems into the region of "highly effective" communication.

The following sections describe the structure of the scale, the two methods used to assess the reliability of the scale, and the application of the scale to the group and group pair levels of analysis.

5.3.1 - Perceived Communication Problems (PCP) Scale

The scale measure was fifteen items from questionnaire Q02: numbers 5, 6, 7, 9, 10, 11, 17, 18, 19, 36, 37, 62, 63, 64, and 66. Items 9, 10, 11, and 19 were reverse scored since their content and response categories run opposite to the other items. Items 62-64 had 7 point response categories. To maintain equal weighting, these items were re-scaled to a 5-point range by multiplying each response by 5/7. The first two items dealt with slightly different aspects of time delays (delays in general and delays in receiving information about changes) and correlated 0.71, so they were treated as one item in deriving the PCP score by summing them and dividing by 2.0.

Items 9, 10, and 11, which dealt with how adequately the respondent's group was informed of the Referenced Group's current work status, completion targets, and input expectations, were paralleled with items 14, 15, and 16, concerned with information needs on the same items. In the case of a group pair with low interdependence, the PCP score could artificially be made to look better by a respondent indicating that he was "completely" or "very adequately informed" for the underlying reason that he simply did not need the information. Accordingly, if, and only if, a need item was scored blank, 1 (Not at all), or 2 (To a very little extent), and the corresponding adequacy item was originally
scored 4 (Very adequately) or 5 (Completely adequately)*, then the adequacy item was assigned the nominal score of 3 (Moderately adequately) to keep the PCP score from appearing unduly "good."

Responses of "Does not apply," "Don't need to know," or "Not applicable" were treated as blanks. This, of course, would reduce the total score, so the total score for a respondent was corrected manually by replacing his blanks with the mean score on the item for his group. These "created blanks" and actual blanks were 3.2% of the total number of item responses. Of these, 1.3% were actual blank responses.

Three hundred twenty-three people completed 337 Q02 questionnaires. Fourteen people filled out two questionnaires each, responding with respect to two separate Referenced Groups. The complete set had the following characteristics:

- Mean = 34.4
- Standard deviation = 8.03
- Standard error of mean = 0.46
- Min. = 14
- Max. = 63

The distribution of scores used in tests of the propositions are shown in Figure 5.3-1.

5.3.2 - Group and Pair Scores

The PCP scores for groups were formed by taking the mean score of the individuals comprising each group. The distribution of PCP scores for groups, their mean, and their standard deviation are given in Figure 5.3-1. The PCP score for a pair of groups was formed by taking the mean score for the two groups. Each group is given equal weight. The distribution of PCP scores for group pairs, their mean, and their standard deviation are also given in Figure 5.3-1.

Figure 5.3-2# shows the cumulative distribution of group PCP scores in rank order for 66 groups. The level of Task Interdependence (discussed in the next section) is also indicated by code numbers. The distribution of scores is reasonably uniform with two "tails" present, as would be expected if the scores came from an underlying normal distribution.

* Since items 9, 10, and 11 were reverse-scored, a value of 4 or 5 on these items in the questionnaire contributes 2.0 or 1.0 points to the PCP total score.

# This figure, and others in this dissertation, were drawn by the Vogelback Computing Center's CALCOMP plotter using a subroutine, PLTTR, prepared for the author by Miss Carol Wagner.
mean = 34.6  
s.d. = 8.1  

PCP for INDIVIDUALS  
N = 284

mean = 34.2  
s.d. = 5.9  

PCP for GROUPS  
N = 66

mean = 34.2  
s.d. = 4.8  

PCP for PAIRS  
N = 33

Fig. 5.3-1 - Distributions of PCP Scores for Individuals, Groups, and Pairs
Fig. 5.3-2 - Cumulative Distribution of Group PCP Scores

1 = Low TI
2 = Moderate TI
3 = High TI
The group PCP scores ranged from a minimum of 21.2 to a maximum of 49.2 or a range of 4.8 standard deviations. This spread of scores is one indication that the instrument was performing satisfactorily. The standard deviation of scores within groups ranged from a minimum of 0.55 to a maximum of 13.0 (both from groups of three people). The distribution of the standard deviations of PCP scores within groups is shown in Figure 5.3-3. There does not appear to be any significant association between the magnitude of the standard deviation and the mean PCP score for a group. Deleting one group with a PCP score of 21.2 and a standard deviation of 9.0 changes the correlation between PCP and the standard deviation of PCP from -0.32 to +0.22.
5.3.3 - Reliability

The inter-item reliability of the 15 items forming the PCP scale was determined using program TESTAT (Veldman, 1967) to calculate the Cronbach alpha coefficient. The value of alpha was 0.82.

The inter-item reliability of two other sets of items associated with the communication process was of interest. For the four frequency of contact items (questions 1 - 4) used in the multiple regression analyses of Chapter 7, alpha was 0.86. For the three "information needs" items (questions 14-16) used in the Task Interdependence score, alpha was 0.77.

The alpha inter-item reliability measure extracts the systematic variance within the set of responses by each person, and the systematic variance from one person to the next for each item (i.e., row variance and column variance). The residual variance is the random error reflected in the reliability measure. A highly reliable instrument could be constructed by asking a number of very similar questions about the same construct. The intercorrelations among such a set of items would be high. As the questions differentiate more, covering a larger number of aspects of the underlying construct, the intercorrelations of the items becomes smaller and the inter-item reliability tends to drop also. When the questions involve a variety of aspects of the same underlying construct, the pattern of intercorrelations reveals further aspects of the reliability of the responses. The greater the conceptual similarity of the items, the higher the intercorrelations should be. The greater the conceptual difference between the items, the lower the intercorrelations should be. Examination of the intercorrelations on this basis provides further evidence of the reliability of a scale.

Intercorrelations. The intercorrelations of the items comprising the PCP scale are shown in Table 5.3-1. The signs of all the correlations are consistent with the content of the items when wording effects are taken into account. The pattern of the correlations indicates that the respondents were making discriminations among the items. The correlations of adjacent items that are conceptually similar are reasonably high (on the order of 0.60), but adjacent items that are not so similar have lower correlations. For instance, while general accuracy and completeness of information (questions 62 and 63) are correlated 0.61, general usefulness of information (question 64) correlates 0.42 with the preceding question about completeness. Questions 36 and 37 involved completeness
Table 5.3-1

Correlations of PCP Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Number</th>
<th>Time Delay</th>
<th>Current Knowledge</th>
<th>Surprise &amp; Clarity</th>
<th>Change Messages</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reply delay</td>
<td>5</td>
<td>9 10 11</td>
<td></td>
<td>36 37 62 63 64 66</td>
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<td></td>
</tr>
<tr>
<td>Chg. reply</td>
<td>6</td>
<td>71</td>
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<tr>
<td>Chg. info</td>
<td>7</td>
<td>45 43</td>
<td></td>
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<td></td>
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<tr>
<td>Current status</td>
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<td>-40-42-54</td>
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<tr>
<td>Goals</td>
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<td>-31-38-42</td>
<td>66</td>
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<tr>
<td>Input reqmts</td>
<td>11</td>
<td>-25-28-49</td>
<td>54 61</td>
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<td></td>
<td></td>
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<tr>
<td>Unexp. requests</td>
<td>17</td>
<td>04 05 02</td>
<td>-03 02 03</td>
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<td></td>
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<tr>
<td>Unexp. changes</td>
<td>18</td>
<td>21 23 26</td>
<td>-07-04 00</td>
<td>56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarity</td>
<td>19</td>
<td>-30-29-35</td>
<td>32 37 34</td>
<td>-22-26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completeness (Chg)</td>
<td>36</td>
<td>34 26 35</td>
<td>-32-31-21</td>
<td>12 23-39</td>
<td></td>
<td></td>
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<tr>
<td>Accuracy (Chg)</td>
<td>37</td>
<td>33 27 29</td>
<td>-25-26-12</td>
<td>18 26-31</td>
<td>56</td>
<td></td>
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<tr>
<td>Accuracy</td>
<td>62</td>
<td>43 39 37</td>
<td>-30-29-34</td>
<td>12 21-45</td>
<td>45 36</td>
<td></td>
</tr>
<tr>
<td>Completeness</td>
<td>63</td>
<td>43 42 46</td>
<td>-34-34-41</td>
<td>05 19-46</td>
<td>48 39 61</td>
<td></td>
</tr>
<tr>
<td>Usefulness</td>
<td>64</td>
<td>25 24 30</td>
<td>-34-30-28</td>
<td>04 08-29</td>
<td>24 24 56 42</td>
<td></td>
</tr>
<tr>
<td>Over-all</td>
<td>66</td>
<td>38 39 47</td>
<td>-55-53-52</td>
<td>03 08-39</td>
<td>29 29 55 59 59</td>
<td></td>
</tr>
</tbody>
</table>
and accuracy of information about project changes. Questions 63 and 62 asked about completeness and accuracy of information in general. The two completeness questions correlate 0.48 and the two accuracy questions correlate 0.36. The two "surprise" questions--17, concerning unexpected requests for information requiring significant effort to respond to, and 18, concerning unexpected changes--are correlated 0.56. Adjacent question 19, concerning clarity of information, correlates -0.22 and -0.26 with them.

The over-all pattern of responses indicates that the respondents were using the scale as intended; that they were discriminating between the items where intended and providing similar responses where intended. This provides further evidence of the consistancy of the responses in addition to the alpha reliability coefficient.

5.3.4 - Distribution and Accuracy of Frequency of Contact Estimates

In addition to obtaining information on perceived communication problems, measures of four aspects of frequency of contact between the groups of a pair were obtained in the Q02 instrument. The eight response categories, ranging from (1) Several times a day, to (8) Never, were selected so as to obtain an approximately normal distribution. This was accomplished as shown by the response distributions in Figure 5.3-4.

Questionnaire responses to items involving frequency of contact and direction of initiation of contact are frequently subject to bias (Rubenstein, 1953). Validation of responses to such questions, or determination of the magnitude of the bias present, usually requires extended observation in a field site. The design of this study did not include such observation. However, an estimate of the validity of the responses to one such question can be obtained from the data collected.

Question #1 of Q02 asks how frequently the respondent thinks members of his group are in contact with the Referenced Group. Question #2 asks how frequently he is in contact with them. Those respondents seeing themselves as contacting the other group more often, or as often, as any other person in their own group, would normally assign the same score to both questions. The correlation between these two responses is 0.60, indicating, as expected, that a number of the
Fig. 5.3-4 - Response Distribution to Four Frequency of Contact Questions

1 = Several times a day  
8 = Never
respondents are in contact with the other group less often than another person in their own group.

In analyzing the data at the group level, the mean score for the group on each question was obtained. This pooling of responses by groups tends to stabilize the group estimates for Question #1 and create a mean response to Question #2 closer to the group mean. The correlation between the two questions at the group level, with the data pooled by groups, is 0.79.

The significance of the difference between these two $r$s may be obtained by converting them to z-scores and obtaining the standard error of the difference (McNemar, 1962, pp. 139-40). The probability that this difference of the correlations is due to chance is less than 0.0005. It appears that the respondents are estimating at least the group perception of frequency of contact, if not the actual frequency, relatively accurately.

5.4 - TASK INTERDEPENDENCE MEASURES

Four dimensions of task interdependence were described in Chapter 3: Work Initiation and Influence, Input/Output Dependence, Mutual Dependence, and an Advisory and Consulting relationship. This section describes the scales constructed to measure these dimensions and the overall level of task interdependence perceived by individuals and groups. The reliability, conceptual consistency of the dimensions, and validity as determined through the multitrait-multimethod matrix are presented.

These analyses made use of data from CD Q02 and RB Q09.2 (Appendix 4B). The instrument developed by Barth included a number of questions pertaining to the structure of the working relationship between groups. These were structured so that the scores for the same dimensions could be derived, but sixty percent of the items were different in specific content, tapping aspects of the relationship not included in CD Q02.

5.4.1 - Formation of the Scales and Their Characteristics

The items included in each scale for the four interdependence dimensions are listed below. All of the items had 5-point response scales. The score for each
scale was formed by calculating the mean of the responses to the items included in the scale.

**WORK INITIATION AND INFLUENCE (WI)**

Q02: 26, 31, 32, 34, 58, 59, 60  
Q09.2: 1, 4, 5C, -6A, -6B, 8, 10, 15, 17, 20

**INPUT/OUTPUT DEPENDENCE (DEP)**

Q02: 25, 30, 33, 35, 53, 54, 56, 57  
Q09.2: 2, 3, -5A, -5B, 6C, 7, 9, 16, 18, 21

**MUTUAL DEPENDENCE (MID)**

Q02: 14, 15, 16, 23, 24, 27, 55, 61  
Q09.2: 13A, 13B, 13C, 19

**ADVISORY AND CONSULTING INTERDEPENDENCE (ADV)**

Q02: 28, 29  
Q09.2: 11, 12

The items with a minus sign were reverse scored. The Work Initiation and Influence scale is of the form, "We influence/initiate for them;" the Input/Output Dependence scale is of the form, "We are dependent on them;" the Mutual Dependence scale, "We are interdependent upon each other;" and the Advisory and Consulting Interdependence scale, "We advise or consult with each other."

A total of 340 people responded to one or both questionnaires. Of these 250 (74%) responded to both. This count includes fourteen persons who responded with respect to two groups; they filled out two Q02 questionnaires separately. None of these completed two Q09.2 questionnaires. The mean, standard error of the mean, standard deviation of the responses, minimum, and maximum are shown in Table 5.4-1.

Group scores for the four scales were formed by taking the mean response to each scale of all the individuals in the group. The statistics for the four interdependence scales are shown in Table 5.4-2, and their intercorrelations in Table 5.4-3.
Table 5.4-1
Characteristics of Task Interdependence Scales by Individuals

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.E.</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WI - Work Initiation and Influence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q02 (N = 340)</td>
<td>2.72</td>
<td>.043</td>
<td>.793</td>
<td>1.00</td>
<td>4.57</td>
</tr>
<tr>
<td>Q02 (N = 250)</td>
<td>2.79</td>
<td>.048</td>
<td>.760</td>
<td>1.00</td>
<td>4.57</td>
</tr>
<tr>
<td>Q09.2 (N = 250)</td>
<td>2.55</td>
<td>.040</td>
<td>.639</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td><strong>DEP - Input/Output Dependence</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q02 (N = 340)</td>
<td>2.80</td>
<td>.039</td>
<td>.724</td>
<td>1.00</td>
<td>4.87</td>
</tr>
<tr>
<td>Q02 (N = 250)</td>
<td>2.85</td>
<td>.045</td>
<td>.715</td>
<td>1.00</td>
<td>4.87</td>
</tr>
<tr>
<td>Q09.2 (N = 250)</td>
<td>2.65</td>
<td>.050</td>
<td>.786</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td><strong>MTD - Mutual Dependence</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q02 (N = 340)</td>
<td>3.45</td>
<td>.038</td>
<td>.703</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Q02 (N = 250)</td>
<td>3.48</td>
<td>.042</td>
<td>.662</td>
<td>1.37</td>
<td>5.00</td>
</tr>
<tr>
<td>Q09.2 (N = 250)</td>
<td>3.08</td>
<td>.055</td>
<td>.876</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td><strong>ADV - Advisory/Consulting Interdependence</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q02 (N = 340)</td>
<td>2.38</td>
<td>.047</td>
<td>.873</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Q02 (N = 250)</td>
<td>2.35</td>
<td>.056</td>
<td>.885</td>
<td>1.00</td>
<td>5.00</td>
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<tr>
<td>Q09.2 (N = 250)</td>
<td>2.59</td>
<td>.048</td>
<td>.755</td>
<td>1.00</td>
<td>4.50</td>
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</table>
Table 5.4-2

Characteristics of Task Interdependence Scales by Groups

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Initiation (WI)</td>
<td>2.625</td>
<td>0.604</td>
<td>1.292</td>
<td>3.739</td>
</tr>
<tr>
<td>Input/Output Dependence (DEP)</td>
<td>2.713</td>
<td>0.621</td>
<td>1.347</td>
<td>3.984</td>
</tr>
<tr>
<td>Mutual Dependence (MTD)</td>
<td>3.272</td>
<td>0.552</td>
<td>1.688</td>
<td>4.063</td>
</tr>
<tr>
<td>Advisory and Consulting (ADV)</td>
<td>2.478</td>
<td>0.445</td>
<td>1.750</td>
<td>3.417</td>
</tr>
</tbody>
</table>

N = 66

Table 5.4-3

Correlations of Task Interdependence Scales by Groups

<table>
<thead>
<tr>
<th></th>
<th>ADV</th>
<th>MTD</th>
<th>ADV</th>
</tr>
</thead>
<tbody>
<tr>
<td>WI</td>
<td>34</td>
<td>61</td>
<td>-16</td>
</tr>
<tr>
<td>DEP</td>
<td>-</td>
<td>70</td>
<td>-13</td>
</tr>
<tr>
<td>MTD</td>
<td>-</td>
<td>-21</td>
<td></td>
</tr>
</tbody>
</table>

N = 66
5.4.2 - Task Interdependence Scale

A single measure for Task Interdependence (TI) was desired. The group advisory and consulting score was excluded from the overall task interdependence scale because it was conceptualized as discriminating the activity of the coupling process among groups with low task interdependence. Potentially it also provides information about groups with moderate and high levels of interdependence, but in these cases, responses to it are more likely to be confounded by task-related discussions on mutual projects. The concept of Work Initiation and Influence is conceptually related to, but distinct from, that of "dependence." Including it in the overall measure of TI reduced the spread of the scale and hence the ability to discriminate the perceived levels of task interdependence.

The overall TI measure was formed by summing the Input/Output Dependence (DEP) and Mutual Dependence (MTD) scales for individuals, groups, or pairs of groups. Figure 5.4-1 shows the cumulative distribution of group TI scores in rank order for the 66 groups used in proposition testing.

5.4.3 - Reliability

Inter-item reliability of the four scales was determined using Cronbach's alpha coefficient (Cronbach, 1951) as implemented in a computer program by Veldman (1967). The alpha coefficient of inter-item reliability for all items treated as one scale is 0.90. The alpha coefficients for the four scales in the two forms both completed by 250 respondents are:

<table>
<thead>
<tr>
<th></th>
<th>WI</th>
<th>DEP</th>
<th>MTD</th>
<th>ADV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q02</td>
<td>0.75 (7)</td>
<td>0.73 (8)</td>
<td>0.80 (8)</td>
<td>0.75 (2)</td>
</tr>
<tr>
<td>Q09.2</td>
<td>0.79 (10)</td>
<td>0.85 (10)</td>
<td>0.68 (4)</td>
<td>0.49 (2)</td>
</tr>
</tbody>
</table>

Parenthetical figures are the number of items in each scale. The relatively low Q09.2 advisory scale alpha value will be discussed below.

Ten questions are identically worded in both questionnaires. Since most of the questionnaires were administered with a time separation of from two to ten weeks between Barth's and Douds' field site activities, a test-retest reliability...
Fig. 5.4-1 - Cumulative Distribution of Group TI Scores
correlation coefficient can be obtained on each of the ten individual items. One hundred twenty-one were administered from five to ten weeks apart, 68 from two to five weeks apart, and 61 at the same time. Test-retest correlations for individual items can be expected to be generally lower than similar tests of multiple-item scales. The correlations are shown in Table 5.4-4.

The only unsatisfactory correlations are those associated with the two Advisory and Consulting scale items which comprise the total scale in both instruments. Examination of the alpha coefficients indicates that the error variance is arising in the Q09.2 instrument. Since the two items are identically worded, appear in the same order, and their test-retest correlations are appreciably different from the other items, there is no ready explanation for the discrepancy.

Table 5.4-4  
Task Interdependence Item Test-Retest Correlations

<table>
<thead>
<tr>
<th>Q02 item #</th>
<th>Q09.2 item #</th>
<th>Scale</th>
<th>Pearson-r</th>
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</thead>
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<tr>
<td>25</td>
<td>3</td>
<td>DEP</td>
<td>.62</td>
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<td>26</td>
<td>4</td>
<td>WI</td>
<td>.65</td>
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<tr>
<td>27</td>
<td>19</td>
<td>MTD</td>
<td>.51</td>
</tr>
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<td>28</td>
<td>11</td>
<td>ADV</td>
<td>.44</td>
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<td>29</td>
<td>12</td>
<td>ADV</td>
<td>.34</td>
</tr>
<tr>
<td>30</td>
<td>7</td>
<td>DEP</td>
<td>.58</td>
</tr>
<tr>
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</tr>
<tr>
<td>34</td>
<td>20</td>
<td>WI</td>
<td>.63</td>
</tr>
<tr>
<td>35</td>
<td>21</td>
<td>DEP</td>
<td>.69</td>
</tr>
</tbody>
</table>
5.4.4 - Scale Structure Consistency

A factor analysis was performed on the combined interdependence items of the two instruments to determine the structure of the scales as revealed by the response patterns. Since 51 items were included in the factor analysis, the number of factors extracted could be expected to be greater than the four conceptualized.

A principal axis analysis with rotation was performed using Program FACTOR of the Vogelback Computing Center with a squared multiple correlation estimate of communality and minimum eigenvector values of 0.8 and 1.0 for principal factor and rotated factor extraction. The results of the factor analysis for 250 respondents are shown in Table 5.4-5. Factor loadings of from 0.30 to -0.30 have been deleted since these items make a relatively small contribution to the explanation of the underlying dimension when several higher loadings are present. It should be recalled that when the majority of signs in a column are positive or negative, this does not necessarily have an intrinsic meaning—the signs in a given column can all be reversed by a different implementation of the routine. Changes of sign within a column are meaningful. Signs have been reversed in columns headed with (-1). The rows and columns have been re-arranged for visual interpretation. The conceptual scales to which the items were assigned are indicated in the left margin.

Factors 1 and 2 comprise the Work Initiation and Influence (WI) scale; factors 3 and 4, the Input/Output Dependence (DEP) scale; factors 5, 6, and 7, the Mutual Dependence (MID) scale; and factor 8 very clearly is the Advisory and Consultation scale (ADV). Two other factors emerge, but first the exceptions in factors 1 - 8 bearing on the four scales will be discussed.

Because of the minus signs on items 5A, 5B, 6A, and 6B, they were reverse scored in constructing the scales. This is consistent with the sense of the items. Items #20 and #21 in Q09.2 and #34 and #35 in Q02 are identical pairs. #20 and #34, "They work on long term activities originating from us," appear positively in the WI scale and negatively in the DEP scale. The converse is true of #21 and #35, "We work on . . . from them." In each of these cases, the appearance of the item in the "wrong" factor is consistent with that factor because of the
Table 5.4-5 - Task Interdependence Item Factor Loadings

<table>
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204
negative sign. Item #26 of Q02 is another such case. In essence it says that another group does not have to complete its work in order to go to them for advice. Since items #7 and #20 in Q09.2 are the same as #30 and #34 in Q02--all of which appear in factor 7--these four inconsistencies amount to only two. Their sense indicates that working for another group creates interdependence with them either from the viewpoint of the "superior" or "subordinate" group. This is consistent with the discussion in Sections 3.2.4 and 3.2.5. Items #25 and #60 are also in a similar situation. Item #1, "Work or project changes initiated by us influence their work activities," loads appreciably on factors in both the Work Influence and Dependence scales. Retrospectively, it is not difficult to see this makes good sense for either case and so does not discriminate between them.

The two "new" factors that emerge are #9 and #10. The content of items #5A, 5B, 6A, and 6B scored positively in factor #10 clearly indicates independence of one group from another. In factor #9, eight of the nine items include the phrase "to adequately perform our work" and one "both of us must work concurrently." Two of the first eight include the phrase, "work in parallel." This factor appears to tap a dimension of general interdependence when two groups are working at the same time on a project. By reverse scoring the items in factor 10, these two factors could be combined to provide a bipolar scale of interdependence-independence in a combined instrument.

An independent analysis was made of the content of the factor structure. The judge had experience doing R&D work in industrial and government organizations, but was not familiar with the details of this project, and had not read any of the theoretical discussion of task interdependence.*

He characterized the two factors included in "Work Initiation and Influence" as:

1) Technical supervision
2) Task supervision or non-technical supervision

The factors included in "Input/Output Dependence" were characterized as:

3) Task subordination
4) (Their) mandatory consulting or review

* We appreciate Robert Large performing this interpretation of the factors.
The three factors included in "Mutual Dependence" were characterized as:

5) Mandatory parallel work involving shared specifications or goals.  
   (Product development)
6) Consulting on goals.
7) Goal or activity awareness.

The "Advisory and Consulting" factor was characterized as:

8) Mutual non-task information transfer.

The two remaining factors were characterized as:

9) Parallel work involving transfer of technical output and critical review (System development).
10) Project objective or deadline independence.

These characterizations of the separate factors comprising each scale are generally supportive of the original scale designations and provide further insight into the nature of task interdependence between R&D groups. The factor analysis of the combined CD Q02 and RB Q09.2 interdependence items resulted in more dimensions than the four conceptualized. This reveals features of the coupling of one group with another as perceived by the respondents, but also supports the four-dimensional conceptualization in that there are no basic contradictions. The conceptualized dimensions are composed of one or more factor analysis dimensions.
5.4.5 - Validity Considerations

The scales provided by questionnaires Q02 and Q09.2 provide measures of the level and nature of task interdependence of one group upon another as perceived by individuals within the groups. In Section 3.2.4 and 3.2.5 four "dimensions" of task interdependence were conceptualized. The validity of such concepts and their measures can be examined in terms of face validity, content validity, predictive validity, concurrent validity, and construct validity (Section 5.1.2).

Here we shall focus primarily on the construct validity of the four concepts in the measures of task interdependence. Face validity involves the reader's judgment as to whether or not the items tap the concept involved. Content validity involves the adequacy of the sampling of the items from the hypothetical universe of all possible items relating to the concept involved. The items have been presented in Chapter 4 for the reader's judgment. Concurrent and predictive validity, differing only in the time dimension, are characterized by prediction to an outside criterion. Concurrent validity is relevant here in that the correlation of individuals' scores based on perceptions to the level of task interdependence provided by an outside observer is of interest. However, this study focuses on groups rather than individuals. No data was collected from external sources about the interdependence of individuals.

At this stage, the primary issue in question involves the adequacy of the concepts involved in "task interdependence." The issue, at this point, is that of construct validity. The approach of Campbell and Fiske (1959), utilizing convergent and discriminate validation to determine construct validity, is addressed to this issue. To make use of this method, multiple traits (variables) and multiple methods (data sources or instruments) are required. Here the "traits" involved are the four components of task interdependence: Work Initiation and Influence, Input/Output Dependence, Mutual Dependence, and Advisory and Consulting "Interdependence." The two sources of data available in this study are questionnaires Q02 and Q09.2 which were administered at different times in most organizations.*

The primary question addressed is: Do these four concepts measure something

*Ten of a total of 51 items appear in both instruments, so the two sets of scales are not completely independent.
different and do the two methods measure the same thing for each concept? If we find that the concepts as presently conceived, measured, and tested are viable with the data now available, in the next stage of development it would be appropriate to determine how distinct from, or similar to, these concepts are to other potentially closely related or confounding concepts, such as some measure of authority or job satisfaction, and to determine the convergence of the measures with ratings from other sources—managers and peers not a part of the working groups—and by other methods—structured interview or inspection of memoranda, for instance. From such work, a set of instruments for use in R&D organizations could result that would be available for other studies. Measures of other "traits" are available in the joint study, but none are fully replicated in both studies in such a manner as to allow them to be tested by the Campbell and Fiske method for convergent and discriminant validation.

The method requires a multitemp-multimethod correlation matrix to be constructed such as in Table 5.4-6. The various regions of the matrix have been labeled following Campbell and Fiske. The reliability diagonals, A, one for each method, are the inter-item reliabilities discussed before. They could also be designated as the monotrait-monomethod values. Adjacent to each reliability diagonal is a hetero-trait-monomethod triangle indicated by a solid line. The lower left quadrant is a heteromethod block composed of two heterotrait-heteromethod triangles indicated by broken lines and a validity diagonal composed of monotrait-heteromethod values.

Four criteria bear on the question of validity. The criteria, paraphrased from Campbell and Fiske (1959), and the observations here are as follows.

1. The entries in the validity diagonal should be significantly different from zero and sufficiently large to encourage further examination of validity.
   - This criteria is met in all four cases.

2. A validity diagonal value should be higher than the values lying in its column and row in the heterotrait-heteromethod triangles.
   - This criteria is easily met in all eight cases.

3. A third desideratum is that a variable correlate higher with an independent effort to measure the same trait than with measures designed to get at different traits which happen to employ the same method. For a given variable, this involves comparing its values in the validity
Table 5.4-6

Multitrait-Multimethod Matrix of Task Interdependence Scores

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<tr>
<th>Source</th>
<th>Q09.2</th>
<th>Q02</th>
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<td>ADV</td>
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<td>04</td>
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"Mean" r, monotrait:
70 68 52 41

Mean |r|, heterotrait:
16 17 27 03
22 27 32 05

A - Reliability diagonals
B - Heterotrait - monomethod triangles
C - Validity diagonal
D - Heterotrait - heteromethod triangles
N = 250
diagonals with its values in the heterotrait-monomethod triangles. - Three of the four variables meet this criteria.

4. A fourth desideratum is that the same pattern of trait interrelationships be shown in all of the heterotrait triangles of both the monomethod and heteromethod blocks.

- This is met with respect to both the direction and approximate magnitude of change in all triangles.

The second criterion can also be expressed by comparing the average intercorrelation among tests aimed at the same trait and the average absolute correlation with tests aimed at different traits (Scott, 1969). These figures are shown below the matrix.

In all cases the scale reliabilities exceed their heterotrait correlations, and in all cases they exceed their monotrait correlations on the validity diagonal, indicating the distinctiveness of the scales. Similarly, the different measures for the same traits intercorrelate more strongly with each other than they do with measures for other traits, as shown beneath the matrix, indicating discriminant validation. The smallest discrimination is obtained with the MTD scale from Q02. This scale is also involved in the exception to criterion #3. "If two instruments (scales) aimed at different traits intercorrelate almost as highly as their respective reliabilities, this may be attributed to the inclusion in one of the concepts that belong in the other," (Scott, 1969, p. 262). The closest approach to this occurs at one point in the scale where the MTD scale of Q02, with an inter-item reliability of .80, correlates 0.63 with the DEP scale of Q02 which has a reliability of .73. As noted in Section 3.2.5, Mutual Dependence (MTD) conceptually is closely related to Input/Output Dependence (DEP) and so the elevation of this correlation and three other DEP-MTD combinations in the matrix lends support to the construct. The elevated correlation of MTD with WI probably arises from the inclusion of items dealing with information needs. This is also evident in the factor analysis. The low correlation of the two scales for ADV (which are in fact identical representing only different time points of data collection) has been discussed previously.

As indicated in the discussion immediately above, the multitrait-multimethod matrix is also useful for detailed analysis of the instruments as well as for validation.

The primary purpose of the multitrait-multimethod matrix is to determine two
critical aspects of construct validity--discriminant and convergent validity. The analysis here indicates that the four dimensions of task interdependence converge with the two methods of measurement and each factor is discriminable from the other--the concepts are distinct. Although this analysis is limited by the similarity of the instruments, there appears to be some validity to the constructs conceptualized, at least to the extent that they correspond to the perceptions of the people in the groups. A new approach is not needed. It would be worthwhile to extend the methods used and the data sources to obtain better estimates of convergent validity and concurrent validity in terms of externally, as well as internally, perceived interdependence; and to extend the traits included to show discrimination against plausible rival constructs.
Chapter 6

FIELD OBSERVATIONS

6.1 - OVERVIEW

This chapter brings together the qualitative data obtained from interviews with managers and participants and some of the data obtained from the questionnaires. Section 6.2 describes characteristics of the organizations and government agencies that participated in the pilot study and the field study. The remainder of the chapter considers field study participants only.

Section 6.3 presents a number of details about the background and current characteristics of the respondents—distribution of age, seniority, educational background, current technical field, job type, role, and group tenure. The "typical" respondent is also characterized.

Section 6.4 compares the values of the respondents in the various agencies. The values of the respondents in four organizations of one agency are analyzed in detail and related to their work activities.

Section 6.5 presents detailed descriptions of several of the group pairs participating in the study. Information obtained from observations and interviews is coupled with that obtained from measures of the variables described in the preceding chapter.

The discussion in Sections 6.4 and 6.5 provides a basis for evaluating the validity and utility of the scales for PCP (perceived communication problems), TI (task interdependence), and the 10 work-related values.

6.2 - THE PARTICIPATING ORGANIZATIONS

The geographical locations of the fifteen organizations cooperating in the two studies encompassed most of the country. Six were located on the East Coast, six in the Midwest, and three in the South and West. Three organizations were industrial R&D laboratories. Twelve were geographically decentralized units of federal agencies. The organizational affiliations were:
The general activities of these organizations included: consumer product packaging, electronics instrumentation, solid-state electronics and communications technology for both military and industrial applications, nuclear power systems, weapon systems development and manufacture, investigation of the inner and outer space environment, and aircraft and missile development and testing.

The size of the organizational segment from which groups were selected for the study varied widely, although most were large. Ten had between 1,000 and 10,000 personnel, two between 100 and 1,000, and three under 100.

Most of the organizations arranged for six to eight working groups of from two to ten engineers and scientists to be included in the study. Across organizations, a total of 66 groups participated. In most cases these groups were formal organizational units or the part of a formal unit that, due to the nature of its work, dealt with the other group with which it was paired for the study. In some cases, an entire organizational unit was included in the study, based on managerial decision, even though not everyone dealt with the counterpart group. Our "instruments" provided for this possibility by allowing data from those who did not work with the counterpart group to be segregated from those who did.

At the completion of the field work 340 participants had completed questionnaires, and interviews had been held with 104 respondents as well as with 54 managers. Typical job titles of the latter were: Branch Chief, Section Head, Laboratory Director, etc. In each organization, managers, via a short questionnaire, also provided independent summary evaluations of the quality of the relations between the paired groups, and the innovativeness, effectiveness, etc., of the individual groups.

Three of the organizations were asked to participate only in the pilot phase of the study while the interviews and questionnaires were being developed and refined. Data from three "cross-organizational" pairs was not used in proposition testing (see Section 5.1.3). All the data available is used in the discussions of the values of engineers and scientists to follow.
6.3 - CHARACTERISTICS OF THE RESPONDENTS

In this section we describe the characteristics of the respondents involved in the study as revealed in the "Background Information" questionnaire, Q05.* It was completed by 337 respondents.

Barth or Douds met with the respondents in personal interviews or group sessions. Both met with all respondents except for two organizations where Barth took both sets of questionnaires. It was noted during these sessions that there were eight women in the study—four of them computer programmers and four scientists—and six black engineers.

The distribution of respondent's ages was:

- 18% 20 - 29 years old
- 30% 30 - 39 years old
- 36% 40 - 49 years old
- 15% over 50 years old

with a mean and median of 35, and standard deviation of 10 years.

The distribution of years of employment with the present organization was:

- 5% less than one year
- 11% 1 - 2 years
- 23% 3 - 5 years
- 23% 6 - 10 years
- 37% over 10 years

The educational background of the respondents was determined by the highest degree awarded and the year of award:

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* The tabulations used in this section were prepared with library program SPSS at the Vogelback Computing Center.
The respondents were asked to describe the major field of their highest degree (column A below) and their current technical field (column B).

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<td>0.3%</td>
<td>0.0%</td>
<td>Electrical Power</td>
</tr>
<tr>
<td>32.2%</td>
<td>34.1%</td>
<td>Electronics</td>
</tr>
<tr>
<td>0.0%</td>
<td>0.3%</td>
<td>Materials Science</td>
</tr>
<tr>
<td>6.8%</td>
<td>1.2%</td>
<td>Mathematics</td>
</tr>
<tr>
<td>10.3%</td>
<td>10.7%</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>21.0%</td>
<td>14.5%</td>
<td>Physics</td>
</tr>
<tr>
<td>0.9%</td>
<td>5.9%</td>
<td>Computer Programming</td>
</tr>
<tr>
<td>0.6%</td>
<td>8.3%</td>
<td>Systems Engineering</td>
</tr>
<tr>
<td>1.6%</td>
<td>1.5%</td>
<td>Biology or Life Sciences</td>
</tr>
<tr>
<td>2.6%</td>
<td>1.5%</td>
<td>Medicine</td>
</tr>
<tr>
<td>1.3%</td>
<td>0.3%</td>
<td>Ind. Eng. or Eng. Mgmt.</td>
</tr>
<tr>
<td>3.5%</td>
<td>1.8%</td>
<td>Meteorology</td>
</tr>
<tr>
<td>11.3%</td>
<td>11.6%</td>
<td>Other</td>
</tr>
</tbody>
</table>

The highest degree and current technical field were the same for 56% of the respondents. Ten respondents checked a second current technical field—eight added Systems Engineering, one added Electronics, and one added Mechanical Engineering.

The respondents were asked to describe to what extent they considered themselves to be a specialist relative to their colleagues in their own department or division. The distribution over the seven response categories was:

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Somewhat</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4%</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td>4%</td>
<td>22%</td>
<td>26%</td>
</tr>
<tr>
<td>21%</td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

Four categories were provided to indicate the respondent's job type. The distribution of responses was:

47% Individual contributor or team member
45% Project head, group leader, supervisor, or other management of technical direction position
4% Technical or scientific advisor or fellow
4% Other
The respondents were also asked "Would you describe yourself *primarily* as a:"

- 22% Scientist
- 46% Engineer
- 20% Supervisor or Manager
- 12% Other

The respondent was asked how long he had been with his present group and how long it had been composed of more or less the same people. The mean response to the first question was 4.5 years and to the second, 3.8 years.

Thus we might characterize the typical respondent in the following manner. He was in his early 40's and had been working in his present organization for more than eleven years. He had a bachelor's degree in electronics. While many of his associates were now working in a field different from that in which they had gotten their degrees, he was still working in the same field and considered himself to be an engineer, one who was more than "somewhat" of a specialist. He worked as a technical team member with a group that he had belonged to for the last five years. The group had been composed of more or less the same people for the last four years.
6.4 - COMPARISON OF VALUES ACROSS ORGANIZATIONS

Are the work-related values of engineers and scientists in one organization or agency different from those in another? If it was known that they were different, and how they were different, the knowledge would be helpful in the choice of management policy and organizational design. Each government agency must adapt to changing budget levels and Congressional policy. New policies, structures, and actions must be implemented. Knowledge of the bases affecting how their personnel characteristically evaluate such decisions would help managers making such decisions.

It is of interest to tentatively explore the similarities and differences among the organizations. It can only be tentative because the responses are not a random sample.

6.4.1 - Inter-Agency Value Comparisons

The mean scores on each value factor are shown in Table 6.5-1 for the three government agencies and the industrial organization that participated in the field study. The mean score for all individuals in each agency was compared to the mean of all others combined. Nine of 40 entries are significantly different from those of all others combined at the .01 level or better. Two in Engineering and one in Science are significantly different at the .001 level.

The personnel from Agency I value the clusters of Professional and Personal Integrity, Collegial Growth, Project Direction, Work Fulfillment, and Science equally with the other engineers and scientists as a group.

Values pertaining to their personal Career appear to be somewhat more important to the Agency I respondents and they appear to be somewhat more oriented towards obtaining Quick Payoff in their work. They place more importance on values pertaining to Personal Interaction or Relationships and the classic values of a good organizational performer than the others. The largest difference is in their Engineering values. The Agency I respondents hold Engineering values to be very significantly more important than do their counterparts.

The sample of Agency II respondents are not significantly different from the others in any of the values.
Table 6.4-1
Work-Related Value Scores of Agencies

<table>
<thead>
<tr>
<th>Rank</th>
<th>Value Factor</th>
<th>Agency I N = 143</th>
<th>Agency II N = 48</th>
<th>Agency III N = 80</th>
<th>Industrial N = 42</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTEGRITY</td>
<td>3.02</td>
<td>2.93</td>
<td>3.02</td>
<td>2.73***</td>
</tr>
<tr>
<td>2</td>
<td>COLLEGIALL GROWTH</td>
<td>2.92</td>
<td>2.82</td>
<td>2.79</td>
<td>2.94</td>
</tr>
<tr>
<td>3</td>
<td>PROJECT DIRECTION</td>
<td>2.85</td>
<td>2.81</td>
<td>2.75</td>
<td>2.82</td>
</tr>
<tr>
<td>4</td>
<td>WORK FULFILLMENT</td>
<td>2.68</td>
<td>2.76</td>
<td>2.78</td>
<td>2.78</td>
</tr>
<tr>
<td>5</td>
<td>ENGINEERING</td>
<td>2.72***</td>
<td>2.41</td>
<td>2.26***</td>
<td>2.66</td>
</tr>
<tr>
<td>6</td>
<td>PERSONAL RELATIONSHIP</td>
<td>2.61**</td>
<td>2.45</td>
<td>2.45</td>
<td>2.25**</td>
</tr>
<tr>
<td>7</td>
<td>ORGANIZATIONAL</td>
<td>2.56**</td>
<td>2.31</td>
<td>2.29*</td>
<td>2.30</td>
</tr>
<tr>
<td>8</td>
<td>SCIENCE</td>
<td>2.42</td>
<td>2.39</td>
<td>2.52*</td>
<td>1.94***</td>
</tr>
<tr>
<td>9</td>
<td>CAREER</td>
<td>2.11*</td>
<td>1.80</td>
<td>1.76**</td>
<td>2.02</td>
</tr>
<tr>
<td>10</td>
<td>QUICK PAYOFF</td>
<td>1.89**</td>
<td>1.64</td>
<td>1.65</td>
<td>1.60</td>
</tr>
</tbody>
</table>

* Significantly different from all others combined at the .05 level.
** Significantly different from all others combined at the .01 level.
*** Significantly different from all others combined at the .001 level.
While Agency III, and most of the respondents from that agency in the field study, is engineering oriented, the mean score of the respondents on Engineering is very significantly lower than for all other respondents. Their score on Science is higher, but significant at only the .05 level. They also value Career appreciably less so than the others.

The industrial organization is significantly different from the government agencies on three of the values. They place significantly less importance on the values of Science, Integrity, and Personal Relationship. They are not significantly different from the government agency respondents in all the other values.

Again, it must be emphasized that undue importance cannot be attached to these findings. Elsewhere, in testing our propositions, we are concerned with the effects of differences in values between specific pairs of groups that communicate with each other. Here we are comparing differences among the scores of several sets of aggregates. In the former case the unit of analysis is the group pair. Here we have aggregated all respondents into 4 sets--three government agencies and an industrial organization. While the characteristics of the group pairs may potentially be not too different from those of a random sample, the comparisons made here are much more strongly subject to selection bias.

6.4.2 - Comparison of Values in the Organizations of One Agency

The value profiles of the sets of respondents from the organizations in Agency I were compared.

The data was obtained from 143 respondents from two sets of groups primarily concerned with technological material (28 and 41 respondents), one set of groups primarily concerned with electronics (54 respondents) and one set of Ph.D. level life sciences researchers (16 respondents). The first three groups were heavily involved with contractors, but the last group was not.

In Figure 6.4-1, A and B show the responses from members of two organizations that are in closely related lines of work. In theory, one would expect the engineering staff of one to be almost interchangeable with the other. They are practically indistinguishable from each other in the importance they place on the values of Collegial Growth, Personal Relationship, Organizational
Performance, Career, and Quick Payoff. Set A attaches more importance to the values of Project Direction than B, but less importance to Work Fulfillment, Engineering, Science, and Professional and Personal Integrity. In no case does either depart so far from the mean of the study sample as to be a cause for active concern—but the differences are sufficient to indicate the sets of groups are by no means alike. There have been processes actively at work in these two sets that have differentiated them.

The same actions taken in either organization that would affect the interpersonal ties or careers of individuals might have similar effects, but it appears that to take the same actions in both organizations affecting the structure, content, and performance of work itself would cause different reactions in A and B. And indeed, interviews with managers in each organization revealed similar attitudes towards their respective personnel, but different philosophies in their approaches to project performance.

The remaining set of groups, D, is composed of the 16 people doing basic and applied research in the life sciences. The management of the organization to which they belong has an expressed policy of structuring the organization on a mission-oriented basis. The resulting project-oriented operation is quite foreign to the background and training of the young Ph.D's who enter this organization and who comprise roughly one third of the scientific staff. (The organization has deliberately chosen to act as a post-doctoral training ground to a certain extent.) They appear to function well in this environment—which at times succeeds in pressuring basic research to produce results relevant to particular missions. They are also reported to frequently have difficulty adjusting to the traditionally structured research organizations they typically join when they leave.

In Figure 6.4-1 we find the respondents in D at an extreme, either the highest or lowest, in every value cluster but Career. Here all four sets of groups are so close together as to be indistinguishable. The pattern of their responses is particularly interesting when contrasted to the other, engineering-dominated groups. Considering their background, it is not at all surprising that they attach high importance to the values of Science, and are the lowest group on Engineering values. It is perhaps surprising that they scored as high as they did on Engineering, but an inspection of the items reveals the reason. This group is continually involved with experimental designs for their scientific
research, and so many of the "design" items are meaningful to them. Perhaps more important is the mission-oriented philosophy of the organization which makes schedules and implementation highly relevant to their work.

But we can infer they will not be rushed at the sacrifice of the quality of their work. They strongly reject values leading to "quick payoff" decisions; place an unusually high value on professional and personal integrity; and they consider fulfillment through the work they do to be quite important to themselves.

It is particularly interesting to note that they value Collegial Growth--learning and developing through discussions with one's colleagues--and Personal Relationship items--helpfulness, sense of humor, sensitivity, etc.--quite highly and moreso than their counterparts. It was noted during interviews that while they are part of mission-oriented activities which bring them into fairly frequent contact with each other and into jointly sharing longer term work-output goals, in most cases, each man had his own laboratory for his day-to-day work. It requires tact and some degree of sensitivity for them to successfully deal with each other--each man values his own ideas highly--but they readily exchange ideas about what they are working on, what they have learned, techniques, and so on, with each other. The project structure of their work is not so tight as frequently found in engineering, and they do attach less importance to Project Direction or Guidance values.
6.5 - DESCRIPTION OF SELECTED GROUP PAIRS

Frequently development programs require the establishment of a testing facility. In this study a group pair in each of three organizations had this functional relation. In all cases the test facility was located at a considerable distance from the development group. In two cases the distance was on the order of a one-hour drive. In the third case the distance was much greater, but the group affiliated with the test operations operated out of the same facility as the development group. They functioned, in part, in a liaison capacity.*

It has been observed before in analogous situations that relations between test groups and design or development groups may be more difficult to maintain satisfactorily than among the various project groups engaged in the design and development of the product (e.g., Shepard, 1954). Undoubtedly, physical distance exacerbates whatever other difficulties may be involved. Of particular interest here, are the similarities and differences in outlooks and approaches to their work problems of the group pairs involved. Sections 6.5.1 and 6.5.2 describe the relationships between the groups of the first two pairs.

The second set of cases compares two pairs of groups in the same organization. One pair has an effective working relationship when work needs to be done by one for the other. The other pair of groups in the same laboratory experiences more difficulties.

6.5.1 - "The Evaluators"

The design and development group in this case was often responsible for the fabrication of prototype units, many of which frequently had the potential for large-scale use in the field. These units would have to operate in a wide range of environments, often severe, and frequently with little maintenance. The units themselves are not necessarily of high complexity. They are frequently "state of the art" in their field of application, but not necessarily in the field of technology from which the physical manifestation of their design concept is drawn.

* In the first two cases the study included respondents from the test facility. In the third case, it did not.
The test site had been in operation for many years staffed with a few technicians. Prior to a major reorganization of the agency involved, the test station had been primarily engaged in acceptance testing of unsophisticated commercial equipment. At the time of reorganization, when the development group and a "systems" group had been established, the field site was also upgraded to deal with more sophisticated items. This included the addition of staff with engineering degrees as well as added equipment and facilities.

Since the reorganization, the mode of operation had been for the design group to turn over their devices to the test group when they were "completed." Drawings and manuals invariably followed weeks or months later. There was little contact between the groups.

Up to the time of the study, top management and the systems group had discouraged contact between the groups. They had established a theoretical rationale that the test group was to act as an independent evaluation group, and therefore there should not be much contact between the groups. Further, the test reports were to be sent to the systems group, not to the development group.

The development group saw themselves as strongly initiating work for the test group (1.3 standard deviations above the mean for all groups in the study), but as not being at all dependent upon the test group (1.0 s.d. below the mean). They expressed many negative opinions about the field test group. They viewed the test group as a service unit of questionable technical competence who did not technically understand the equipment being tested, tested it inappropriately, and used the wrong criteria in evaluating it. In part, they saw the test group as insufficiently skilled, and in part as not having caught up with the times (with the changed technical orientation of the agency subsequent to the reorganization). They saw themselves as having considerable difficulties in information exchange with the test group (1.7 s.d. above the mean).

The test group also saw the problems in information exchange, although they did not acknowledge that the problems were as severe (0.9 s.d. above the mean). However, in interviews, they readily acknowledged the difficulties. The communication problem was corroborated by a top manager and members of the systems group.
Even though they were supposed to function as independent evaluators, in practice much of their work came from the development group. They were well aware of this; the justification for their existence depended largely upon the output of the development group. While the equipment was supposedly complete, it embodied new technical and operational concepts, had all the bugs of any prototype, and was often not supported by documentation. They saw themselves as being highly dependent upon the development group (0.9 s.d. above the mean), a dependency that was not reciprocated. (As noted, the development group scored 1.0 s.d. below the mean.) Both groups held the other in relatively low regard (1.1 and 0.8 s.d. below the mean of all groups' level of respect for their counterparts).

The value profiles for the two groups are shown in Figure 6.5-1. The shape of
the patterns is roughly comparable but there are three strong divergences. The field test group attached more importance to the Integrity and Career items than did the development group, whereas the latter attached an unusually high importance (for the study as a whole) to Engineering values. It is also interesting to note that the test group placed more importance on Science values than their counterparts. (Both are below the mean for the study as a whole.) It appears that the values of the field test group are well-suited for their job of acting as evaluators with their being above the mean on Integrity, high on Engineering values, close to the mean on Science values, and below the mean on Quick Payoff. Both groups are below the mean on Project Direction values, which might be contributing to some of the difficulties in handing work over at the interface. The large difference in Engineering values, arising from the unusually high importance placed on them by the development group, likely contributed directly to the difficulties they were experiencing. Other than this one point, the value differences between the groups do not appear sufficiently different of themselves that the two groups should not be able to work effectively together if some of the managerially imposed behavioral patterns were modified.

6.5.2 - "Project In-House"

This report centers around two groups involved in the development of a truly state-of-the-art device of high technological sophistication. While the device itself was not of unduly large size, its unique application (and those of related units anticipated in the future) required the construction of a massive, complex test cell that itself was a state-of-the-art installation. The cell was constructed at an on-going test facility about an hour away from the site of the parent operation.

For the first time in the history of the parent agency, a project-type organization had been established for the development of the device. While the major components of the device were designed and fabricated by contractors, the design of the unit itself and many of the sub-assemblies were done by the project staff. The extent of in-house work that this represented was also a major innovation for the parent organization. Many of the engineers had not done detailed design work for several years. Apparently, this requirement that they actually do the design work had initially met with considerable resistance, undoubtedly based upon uncertainty about their own competence.
It was a unique experience for this researcher to see so many drafting boards in government offices. The boards had proved to be a successful strategy brought on by necessity. The central drafting facility could not handle the load created by the project. Budget and manpower restrictions did not allow hiring additional draftsmen, so the boards were purchased and set up in the engineers offices. By the time of the study—when most of the drafting requirement was over—it was evident that unused, or perhaps unknown, skills had been regained and the engineers were taking considerable pride in their project. The ultimate test of their abilities was yet to come when the unit went into operation at the test facility.

The engineering group at the test facility was relatively new. The special test cell and associated buildings had only recently come into existance. Much of their early activity had gone into completing and testing the physical aspects of the test cell; then they turned to the design and installation of the sophisticated test measurement and control system.

The test site, which included a number of other test facilities, had traditionally been regarded as a support organization to the operations of the parent site. It was apparent that Project In-House required a high level of engineering talent at the test facility. With some difficulty a suitable staff had been assembled at its remote, but not unattractive, location. A major inducement offered was the opportunity to do significant engineering and the promise to not be "just a support group." In addition to the development of the complex instrumentation and control system, the assembly of the project item was taking place there.

While testing of major components and sub-assemblies was done at the main facility, by the groups who had designed them, the assembly into a complete system—where design oversights and mistakes became obvious—was being done at the test site.

The management of the organization had encouraged communication between the groups. There is no evidence that restrictions were imposed as in the case of "The Evaluators." But considerable difficulties in the relations between the groups were experienced almost from the start. This manifested itself in a variety of forms—complaints about the unavailability of drawings, differences about the required level of "clean room" treatment, continual redesign and
modification of sensor installations, wrangling about design changes initiated by either group, continuing disagreement about the testing plans, etc. Both the project manager and test site manager were characterized by the respondents as strong personalities and both were well respected by their men. They had agreed in principle that the test site engineers would be equally responsible for the unit being developed to permit them to utilize their design skills as promised.

While the project manager gave no evidence of regarding the test facility as a support unit, several of the respondents in the design group did express this attitude. Comments were also made about overlapping of responsibilities and many of the difficulties they were experiencing were attributed to this.

Several months prior to this study, the managers had taken steps to alleviate the difficulties in the working relations between the sites. A major one was obtaining a man from elsewhere in the parent organization to act as liaison agent between the sites. He was instrumental in straightening out a number of straightforward difficulties such as the availability of needed drawings. He was directly attached to the project manager's office. At the time of the interviews, the respondents from both groups indicated their respect for him, and confidence in his discretion. They attributed improvement in the working relations in part to him.

However, many difficulties were still being experienced. Both groups reported in questionnaire responses essentially the same level of problems in information exchange* (1.2 and 1.4 standard deviations above the means of all groups in the study). Both groups had a fairly clear understanding of how their counterparts viewed the coupling and communication relationships (1.0 and 0.4 s.d. more accurate than the mean for the whole study). The design group saw themselves as strongly initiating or influencing the work of the test site group (1.5 s.d. above the mean), and the latter saw themselves as dependent upon the design group to nearly the same extent (1.1 s.d. above the mean). The development group realized to some extent that they were also dependent upon the test group (0.5 s.d. above the mean).

*Information exchange as used here includes requests for data or assistance and the communication of problems as well as communication of data or solutions.
Neither group held the other in very high regard. One indicated their level of respect for the other to be 1.6 standard deviations below the mean of all groups in the study, and the other an extreme 2.5 s.d. below the mean.

The value profiles of the two groups are shown in Figure 6.5-2. There is limited similarity between the two. They are in close agreement on Career and Organizational values (slightly above the mean) and on Science values (below the mean). They are both oriented towards Project Direction values, the older group moreso. They also value Quick Payoff more and Integrity less than the test group who are at the mean of the study. With large differences between the groups, the development group is seen to place high importance on Engineering and Work Fulfillment values, and below average importance on Collegial Growth and Personal
Relationship values. Their counterparts in the test group are opposite to them in each of these categories.

While the values of the two groups are at least moderately similar in six of the ten clusters, major differences occur in four clusters very much a central part of their daily work experience and considerable difficulty is being experienced in their information exchange process. The appointment of a liaison man that each group (and others not reported here) learned they could trust, moved an extremely difficult situation to a point where it was more tolerable. The physical distance between the groups compounds the difficulty in further improving the situation. It would appear that a sophisticated or very concerted management effort will be required to improve the situation. The unique characteristics of the project hardware itself could provide one basis for such action.

6.5.3 - "The Components Cooperators"*

A major part of one organization was involved with the development of electronics systems and components. One pair of groups in the study were involved in this process. Group A was primarily a research group studying basic properties of certain types of physical phenomena. Group B was concerned with applications— they were "engineering and hardware oriented," as several of the respondents put it. Most members of both groups had received their training and had experience in physics, but B's members were mostly engaged in electronics type of work.

The two groups were located on the same floor in the same building, and five members who were interviewed agreed that, for small groups of 15 or fewer individuals, the informal method of maintaining awareness of each others' work and requirements was best. Several members of one group had previously been members of the other group. Work for Group A was usually initiated by Group B on occasion, after a formal authorization had been received. Members of B identified specific problem areas, evaluated specifications, etc., and determined how requirements were affected by the state of the art by drawing on the technical expertise of A's members. B's members also made use of the other

* This section and the following were adapted from an original draft prepared by Richard Barth.
group's test facilities. Tests were usually performed by personnel from both groups. Both groups saw their task interdependence as being less than that typical of the other pairs in the study (0.9 standard deviations below the mean). They both reported that they had relatively few problems in communication (0.6 and 1.0 standard deviations below the mean).

Members of B, who had in prior years been part of A, provided effective and receptive channels of communication between the two groups. Along with this, they were also effective information sources on the technical capability of A, the test equipment available and its limitations, and were aware of the extent to which A could respond quickly to requests. Having good knowledge of the particular areas in which A's members were expert made it easy for former members of this group to tailor and present B's requests for advice and guidance from A in sufficient detail and specificity without getting involved in peripheral problems. In preparing written requests for support from A, members of the other group had been highly successful in pointing out the specific areas in which they did not possess the required capability. Members of A agreed that written, as well as informal requests, from B were clearly expressed and confined to problems, including those connected with hardware, which B could not solve by itself.

Much of the work-related interactions of members of these two groups occurred on an informal basis. This type of interaction had brought about the kinds of cooperation and integrative relationship required for effective functioning. In addition, it had allowed these groups to accommodate to, as well as tailor, the constraining aspects imposed by the organization (rules, regulations, etc.) to a point where they did not prove a great hindrance to the groups working together productively.

6.5.4 - "The Contractors"

Another pair of groups in this same laboratory had a somewhat less satisfactory relationship. Group C was engaged in component development of electronic devices which were intended for use by D in its system development and integration work. Members of C felt that the other group simply did not realize, or would not admit, that the quality of the various systems developed could not be better than that dictated by the state of the art in component development. Even though C had gone to D to let them know of their "availability," and had
attempted to keep them informed of changes in the state of the art (SOA) in component development, D preferred to let an outside (industrial) systems contractor also do the component work.

Of the dollar resources available to D, only a small amount, if any, was allocated to support component development by C. The rationale of D seemed to be that, with an outside contractor, a fixed price and delivery date were assured along with component development. However, any advantages gained by this arrangement were often offset by setbacks due to the following: 1) in order to meet delivery dates and not to exceed the set fixed price, the industrial contractor usually used off-the-shelf components which, after the system had been integrated for testing, degraded the system such that not all predetermined performance parameters were met or exceeded; 2) the use of off-the-shelf component items implied that the resulting system did not always reflect the most current SOA in component development technology; and 3) D got "hooked-in" with one manufacturer.

As of the time of the study, it appeared that the consequences of (1) and (2) had, over time, actually provided the impetus for D to solicit the support of C. But, as a member of C put it, "...then it's usually kind of late in the game. They (D) always run to us when the contractor did sloppy work and the system meets only 6 out of 10 parameters. Both the contractor and they (D) don't realize all the potential problems when a large number of off-the-shelf items are thrown together. They're so systems-oriented they don't even realize that components in themselves are small systems that become subsystems of the system they're supposed to generate."

Interviews with other members of C revealed that the only formal opportunity for informing D of the SOA in component development was provided by an annual division-level meeting which usually generated a directive for more interaction at the working level. Unfortunately, members of D seemed to desire interaction only after problems had been identified, rather than drawing on the expertise of C when evaluating the competence of the contractor in terms of components to be used, performance parameters to be set, and the extent to which proposed off-the-shelf items would meet specified requirements.

In terms of work initiation and control aspects, the overall structure of the relationship between these two groups was quite similar to that of A and B.
Group C could provide excellent technical support and advice to Group D. However, D controlled the work initiation aspects of the relationship in that C had no formal or informal control over D's actions and was limited to working with or for them only when called upon to do so. Except for occasions when D had component/system performance problems and officially requested C's support, C was limited to influencing the activities of the other group through expert advice on a purely informal basis.

This difference in the nature of the work relationship between the groups was reflected in their Task Interdependence scores. They were 1.4 standard deviations apart from each other. Group D, with the money and the outside contractor, was 0.7 s.d. below the mean; Group C, with the skills and knowledge that were used too little and too late, saw themselves as being more closely related to the work at 0.7 s.d. above the mean.

When Group D did come to Group C, the joint work by these two groups was well organized and led to good solutions to systems problems. Group D saw the communication between them as being better than Group C did, but both recognized the presence of communication problems. D scored 0.4 s.d. below the mean and C scored 0.4 above the mean. Unfortunately, however, fruitful joint effort of this type was not initiated by D in the earlier stages of the system development cycle when the application of C's knowledge of components would have eliminated many of the problems that occurred later.
Chapter 7

TESTS OF THE PROPOSITIONS

7.1 - INTRODUCTION

Several of the propositions developed in Chapter 3 were tested by various statistical, and non-statistical, methods. This chapter presents the results of those tests. Chapter 5 described characteristics of a number of the items and variables that were used in testing the propositions. Table 7.1-1 lists the names of the variables used in this chapter and the six-digit mnemonic abbreviations used in computer routines and tabulations. Chapter 6 presented the background characteristics of the sites, groups, and individuals involved in the study. The characteristics of the variables were probed by relating interview data to the "quantitative" results derived from responses to questionnaires.

The analytical approach has been to utilize various sources of information and various methods of analysis applicable to the same phenomena insofar as possible within the ever-present constraints of the original design of the research study, the instrumentation available prior to the study, the instrumentation developed for the study, and the skills, time, and energy of the researcher. The application of this approach was illustrated in several ways in Chapters 5 and 6. This was perhaps best exemplified in its quantitative form in the discussion of the factors associated with task interdependence where a multi-trait, multi-method matrix was developed and analyzed.

This approach was continued in testing the propositions. The propositions were tested by as many as four different methods; some were tested at three different levels of analysis (i.e., as they applied to individuals, to groups, and to pairs of groups); and some were tested using two different types of data that measured the same underlying variable. Eight of the explicit propositions from Chapter 3 were tested in this manner. The propositions were tested using the questionnaire data. In carrying out these tests, use of the multiple regression technique, to control the effects of other variables on the dependent variable of the propositions, led to tests of some additional propositions. These are considered further in Chapter 8. In other cases, the a priori proposition was sufficiently complex that there was a simpler, rival proposition evident. Where this was the case, the simpler proposition was tested first.
The data of this study does not represent a random sample of a defined population. It does represent a sample that appears to have a useful range of values for several of the variables, but it cannot be claimed that the underlying premise for statistical tests of a random sample is met. Nevertheless, statistical tests were used for several practical, if not theoretically correct, reasons. The most obvious, and least satisfying, reason is the precedent existing in the field. More important is the question of how one interprets the numbers he obtains. Tests of significance help provide this interpretation. If a proposition is clearly disconfirmed, it is unlikely that it would be supported given a random sample. If it is very strongly supported, it is likely to be supported given a random sample. For outcomes that lie between these extremes, the test of significance provides a "benchmark" indicating those cases meriting further attention and perhaps replication in another study. We have used the tests of significance in this latter sense, of providing a benchmark. Additionally, we have sought to confirm or disconfirm the propositions by using multiple methods and multiple data sources.

The findings of this chapter will be summarized in Chapter 8.

Table 7.1-1

List of Variables and Mnemonics

<table>
<thead>
<tr>
<th>Communication and Work Flow</th>
<th>Work-Related Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP - Perceived Communication Problems</td>
<td>PERSEL - Personal Relationships</td>
</tr>
<tr>
<td>WI - Work Initiation and Influence</td>
<td>ENG - Engineering</td>
</tr>
<tr>
<td>DEP - Work Dependence</td>
<td>FULFIL - Work Fulfillment</td>
</tr>
<tr>
<td>MTD - Mutual Dependence</td>
<td>CAREER - Career</td>
</tr>
<tr>
<td>ADV - Advice and Consultation</td>
<td>SCI - Science</td>
</tr>
<tr>
<td>TI - Task Interdependence</td>
<td>PRJDIR - Project Direction</td>
</tr>
<tr>
<td>DIR - Direction of Dependence</td>
<td>QKFIX - Quick Payoff</td>
</tr>
<tr>
<td></td>
<td>CLGROW - Collegial Growth</td>
</tr>
<tr>
<td></td>
<td>ORGZL - Organizational</td>
</tr>
<tr>
<td></td>
<td>INTGRT - Integrity</td>
</tr>
<tr>
<td>Frequency of Contact</td>
<td>(Work-Related) Value Differences</td>
</tr>
<tr>
<td>FRQ GP - Perceived Group Frequency of Contact</td>
<td>Values above plus the letter D</td>
</tr>
<tr>
<td>FRQ2 - Individual's Frequency of Contact</td>
<td>Value Comparisons</td>
</tr>
<tr>
<td>FRQ3 - Frequency of Seeking Change Info (Q02 #3)</td>
<td>PRCSIM - Perceived Similarity</td>
</tr>
<tr>
<td>FRQ4 - Frequency of Receiving Change Info (Q02 #4)</td>
<td>ACLSIM - Actual Similarity</td>
</tr>
<tr>
<td>RESPECT - Respect for Other Group</td>
<td>PRLACC - Perceptual Accuracy</td>
</tr>
<tr>
<td>R(LO)</td>
<td>See Section 7.4.1</td>
</tr>
</tbody>
</table>
Propositions P1.2 and P1.3 both deal with the effects of dissimilarity of work-related values between an individual and another group, or between two groups, upon their perceived communication problems.

**Proposition P1.2:** For a given level of task interdependence perceived by an individual between his working group and another group, the less the similarity of his work-related values to those of the other group, the greater the communication problems he will perceive as existing between the two groups.

**Proposition P1.3:** For a given level of task interdependence perceived to exist between two working groups by the members of those groups, the less the similarity of the work-related values of the two groups, the greater the communication problems each will perceive as existing between the two groups.

In both propositions, perceived task interdependence is incorporated as a major parameter. We may first examine the propositions ignoring the parameter. If the effect of dissimilarity of work-related values is strong, or if the effect of the level of task interdependence upon perceived communication problems (PCP) is weak or complicated by other factors, the main effect postulated may become evident. If the effect of dissimilarity of values is dominant and there is a linear relation between the extent of value differences and PCP, large differences in values would be accompanied by large PCP scores and small differences in values would tend to be accompanied by small PCP scores. The correlation between all or most of the value factors and PCP would be significantly positive. However, other factors, such as those incorporated by Barth in his parallel study of inter-group climate, can also be expected to give rise to communication problems. These would tend to appear as large PCP scores even with small differences in work-related values. According to the proposition as stated, one would not expect to find low PCP scores tending to accompany high value differences, although large PCP scores might accompany small value differences.

### 7.2.1 - Correlational Tests of P1.2 and P1.3

The difference score for the jth individual was formed by taking the absolute value of the difference between his score on a given value factor (V_i) from that of the mean score of his Referenced Group (k):

\[
\text{Value Difference } i_j = | Value_{ij} - \overline{Value}_{ik} |
\]
The difference score for the \( n \)th pair was formed by taking the absolute value of the difference between the mean score of all the individuals in one group of a pair from the mean score for all the individuals in the second group of the pair for each value factor (\( k \)):

\[
\text{Value Difference}_{nk} = \left| \frac{\text{Value}_{kn_1}}{\text{Value}_{kn_2}} \right|
\]

At the "individuals" level of analysis appropriate to Pl.2, the PCP score was that of the given individual. Group scores were the mean score of the individuals in the group. At the "group pairs" level of analysis appropriate to Pl.3, each group was given a weight of 1.0 to derive a mean PCP score for the pair from the two group scores.

The correlations of differences in work-related values with PCP scores at the individual, group, and pairs levels of treatment are given in the left-hand set of columns of Table 7.2-1. The correlations were generally quite small. The only statistically significant* correlation involved difference in science values, and the minus sign made it contrary to the hypothesis.

The effect of the perceived level of task interdependence (TI) was removed by taking the partial correlation of PCP with value difference:

\[
r_{12,3} = \frac{r_{12} - r_{13}r_{23}}{\sqrt{1 - r_{13}^2} \sqrt{1 - r_{23}^2}}
\]

where 1 = PCP score, 2 = value difference score, and 3 = TI score (McNemar, 1962, p. 166). At the "individuals" level of analysis for Pl.2 the TI score was that of the given individual. At the group level, it was the mean of the individuals in the group, and at the pairs level, it was the mean of the group scores.

The correlation of PCP with TI for individuals was 0.06 and at the pairs of groups level it was .02. The correlations of TI with the value difference scores are given in the right-hand columns of Table 7.2-1. The largest correlation

* This is providing that we assume the data came from a random sample.
Table 7.2-1

Correlations of Work-Related Value Differences

<table>
<thead>
<tr>
<th>Value Difference</th>
<th>with PCP</th>
<th></th>
<th></th>
<th>with TI</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Individ.</td>
<td>Group</td>
<td>Pair</td>
<td>Individ.</td>
<td>Group</td>
<td>Pair</td>
</tr>
<tr>
<td>Personal Relations</td>
<td>-.02</td>
<td>-.09</td>
<td>-.11</td>
<td>.00</td>
<td>-.19</td>
<td>-.21</td>
</tr>
<tr>
<td>Engineering</td>
<td>-.01</td>
<td>.03</td>
<td>.03</td>
<td>-.14*</td>
<td>.09</td>
<td>.10</td>
</tr>
<tr>
<td>Work Fulfillment</td>
<td>.01</td>
<td>.07</td>
<td>.09</td>
<td>.09</td>
<td>.08</td>
<td>.09</td>
</tr>
<tr>
<td>Career</td>
<td>.03</td>
<td>.23</td>
<td>.29</td>
<td>.14*</td>
<td>.15</td>
<td>.17</td>
</tr>
<tr>
<td>Science</td>
<td>-.04</td>
<td>-.29*</td>
<td>-.36*</td>
<td>.11</td>
<td>.13</td>
<td>.15</td>
</tr>
<tr>
<td>Project Direction</td>
<td>-.10</td>
<td>.06</td>
<td>.08</td>
<td>-.01</td>
<td>.02</td>
<td>.03</td>
</tr>
<tr>
<td>Quick Payoff</td>
<td>.05</td>
<td>-.04</td>
<td>-.05</td>
<td>-.06</td>
<td>-.18</td>
<td>-.20</td>
</tr>
<tr>
<td>Collegial Growth</td>
<td>.06</td>
<td>-.07</td>
<td>-.08</td>
<td>-.04</td>
<td>-.19</td>
<td>-.22</td>
</tr>
<tr>
<td>Organizational</td>
<td>-.06</td>
<td>-.08</td>
<td>-.10</td>
<td>-.00</td>
<td>-.07</td>
<td>-.07</td>
</tr>
<tr>
<td>Integrity</td>
<td>.01</td>
<td>.14</td>
<td>.17</td>
<td>.05</td>
<td>-.06</td>
<td>-.07</td>
</tr>
</tbody>
</table>

*sig. @ p ≤ .05
between TI and any of the value differences is -.22 and most are considerably smaller. By inspection it is apparent that the partial correlations would be little different from the original two variable correlations since the largest $r_{13}r_{23}$ term would be only 0.013.

Results. Propositions Pl.2 and Pl.3 have been tested first by taking the two-variable set of correlations between value difference scores and POP, and second, by partialing out the effect of task interdependence. (In the latter case the computations were not actually carried out because it was clearly evident that they would have a negligible effect.) The propositions have been disconfirmed by these tests.

Discussion. The reason for the low correlations of PCP with D-scores is evident when the scattergrams of Figures 7.2-1 through 7.2-10 are examined. Note that in each case the projection of PCP scores onto the Y-axis is the same since there are ten sets of value difference scores for each group. Almost all of the differences are under 1.0 (out of a 5 point scale). The largest differences between group pairs occur with respect to career where some are in the vicinity of 2.0 scale points. The distribution of value difference scores is highly skewed as was shown in Figure 5.2-1 where the D-scores for all ten factors are pooled. The distribution of PCP scores approximates that of a normal distribution.

If increasing differences in work-related values tend to cause increasing problems in communication, but smaller differences do not necessarily mean fewer problems (problems may still arise from other sources), then a scattergram similar to the sketch below would result. The lower right triangle would tend to be empty.

There is no test to determine the "sloping lower bound" that characterizes the ideal pattern given in the sketch and human judgment of such patterns can be quite variable. The reader at this point may inspect the scattergrams to see if in his judgment such a pattern exists in any of the figures. The visual test for the "lower bound" phenomenon may be made more severe by deleting 10% of the points—the two largest D-scores and the one group with the lowest PCP score.
Fig. 7.2-1 - Scattergram of PCP vs. PERSONAL RELATIONSHIP Value Difference N = 33

Note: Letter code indicates agency.
Numbers (1-33) indicate group pair.
Fig. 7.2-2 - Scattergram of PCP vs. ENGINEERING Value Difference
N = 33
Fig. 7.2-3 - Scattergram of PCP vs. WORK FULFILLMENT Value Difference

N = 33
Fig. 7.2-5 - Scattergram of PCP vs. SCIENCE Value Difference

N = 33
Fig. 7.2-6 - Scattergram of PCP vs. PROJECT DIRECTION Value Difference

N = 33
Fig. 7.2-7 - Scattergram of PCP vs. QUICK PAYOFF Value Difference
Fig. 7.2-8 - Scattergram of PCP vs. COLLEGIATE GROWTH Value Difference  
N = 33
Fig. 7.7-9 - Scattergram of PCP vs. ORGANIZATIONAL Value Difference  N = 33
Fig. 7.2-10 - Scattergram of PCP vs. INTEGRITY Value Difference

N = 33
The results of such visual judgments are equivocal. As they stand, the author—with his not insignificant biases—sees the requisite pattern in several of the scattergrams. Obscuring 10% of the extreme points, he finds the pattern in Personal Relationship and Project Direction and possibly in Work Fulfillment, Career, and Science Values, but certainly none are clear-cut.

Clearly, the three or four groups with the largest PCP scores do not have the largest value differences. If Proposition Pl.3 were true, some other factors would be a major source of difficulty in these cases. If the effects of other sources of communication problems can be removed, it may then be possible to more clearly determine the relation between PCP and differences in values. One technique for accomplishing this is multiple regression analysis.

7.3 - MULTIPLE REGRESSION ANALYSIS*

Multiple regression techniques provide a method of taking into account the composite effects of several variables, Xs, on a selected dependent variable Y. Among the principal uses of multiple regression pointed out by Snedecor and Cochran (1967) are:

1. Constructing an equation in the Xs that gives the best prediction of the values of Y.
2. When there are many Xs, finding the subset that gives the best linear (or non-linear, if required) prediction equation.
3. In some studies the objective is not prediction, but instead the discovery of which variables are related to Y, and, if possible, rating the variables in order of their importance.

This study is most nearly concerned with the third type of objective and, more particularly, with testing propositions that relate a set of Xs to a Y.

7.3.1 - Characteristics of Multiple Regression

In this section we shall briefly discuss some of the characteristics of multiple regression relevant to the analyses to follow. Additional details will be presented as they are needed later on in these analyses.

Simple correlation analysis involves determining the association between two variables, say X and Y. If one seeks an estimate of Y, given a value of X, the

*I thank Dr. M. Sorum for her comments on an earlier draft of this section.
variation in Y and X must be taken into account. This is done by finding the regression of Y on X; or alternatively, if one wishes to estimate values of X given a value of Y, the regression of X on Y. (In general, the variances of X and Y are not the same and so there are two regression lines and two regression coefficients: \( B_{y \cdot x} \neq B_{x \cdot y} \).)

Multiple regression is an extension of this concept to two or more "predictor" variables. Multiple regression, or multiple-correlation analysis* as it is sometimes called, provides an analysis of the relations among a single criterion variable, Y, and two or more predictor variables, the Xs. The end result is an equation in X yielding an estimated value of Y, designated \( \hat{y} \).

The utility of regression analysis for field studies is indicated by Williams (1959, p. 1), who evidently is primarily concerned with experimental applications:

Thus, on the one hand, the design of experiments is concerned with providing data from which the effects of various factors and the random errors affecting them can be most accurately and easily determined. On the other hand, regression analysis enables the effects of various factors to be evaluated from the experimental data even when the experiment does not follow a simple pattern, or when [as in field studies] the variables affecting the results cannot be controlled in such a manner as to make possible a designed experiment. . . .

Regression analysis can be adopted whether or not the data to be interpreted comes from a designed experiment. Where the experiment is designed to elucidate the effects of certain factors, the effects of other factors may be considered through a regression analysis, or by means of the technique of analysis of covariance, which enables the effects of the uncontrolled variables to be allowed for and the accuracy of the experiment to be consequently improved.

In true experimental designs, the effects of variables other than the focal ones, are usually removed by randomization and some type of experimental treatment is ordinarily involved. In field studies, random sampling of the subject population is similarly used to mitigate the effects of non-focal variables and to allow statistical tests to be made of a priori hypotheses. In organizational studies it is much more difficult to adequately define the population of interest and, in practice, very difficult to obtain the cooperation necessary at all

* Cooley and Lohnes (1964, p. 31) point out that "although there are important theoretical differences between regression and correlation analysis, in practice both correlation coefficients and regression equations are generally desired in the same problem, and either term is applied to the over-all analysis."
levels to obtain a random sample. More often the investigator can only strive to obtain a diversity of cases that cover an "adequate" range of the variables of interest. Such was the case in this study. Under these circumstances, multiple regression allows those non-focal variables that have been measured to be controlled for in testing the variables of primary interest.

This use of multiple regression analysis is not unlike that frequently encountered in engineering applications of the technique. In some specific applications, data is taken, perhaps on a number of variables, at selected values of an X-variable covering the range of interest. This use of selected values is roughly comparable to the limitation of using available data, or other data that may be obtained in field studies where the "sample" must be regarded as the total "population." Another difficulty that may be encountered in field studies, as well as engineering studies, is that the usual range of a variable may be small enough that no effect upon the response of the dependent variable is revealed, even when the variable does have an appreciable effect over larger ranges than those represented in the sample (Draper and Smith, 1966, p. 110).

A multiple regression equation may be linear in X, of the form:

\[ \hat{Y} = B_0 + B_1X_1 + B_2X_2 + \ldots + B_kX_k \]

where the \( B_i \) are the coefficients to be estimated and \( B_0 \) is a constant giving the Y-intercept of the regression plane. The equation may also be expressed in "normal" form:

\[ \hat{Y} - \bar{Y} = b_1(X_1 - \bar{X}_1) + b_2(X_2 - \bar{X}_2) + \ldots + b_k(X_k - \bar{X}_k) \]

where the \( X_i \) have been expressed as deviations from their means. The regression is then constrained to pass through the origin and so \( B_0 = 0 \) always. Data expressed in this form is said to be "centered." Draper and Smith (1966) provide examples of the use of this form in engineering applications. The X variables may also be expressed in standardized form: \( (X - \bar{X}) / S \), where \( S \) is the standard deviation of X. This eliminates all differences in scale. Where the magnitudes of the variables are of very different orders, this also has the practical benefit of reducing computational round-off errors during the matrix inversions involved in the calculations. Such differences in magnitude of the variables are usually not a problem in behavioral science applications, although
they might be in some organization theory studies if, for example, sales figures and attitudinal measures were combined in the same equation.

Multiple regression equations may also be non-linear. Higher integer powers of $X$ may be involved or the power term may be the coefficient to be estimated. The procedures developed for analyzing "residuals" provide very useful methods to determine when the mathematical model should be extended to a non-linear form.

For a given observation $(i)$, the residual $(e_i)$ is the difference between the observed and the predicted value of $Y$: $e_i = Y_i - \hat{Y}_i$. The set of residuals for all cases included in the determination of the regression equation coefficients may form certain characteristic patterns indicating changes needed in the mathematical model assumed, as well as other useful information. The use of residual analysis is illustrated and applied to the problem under investigation in a later section. When a linear equation is assumed, this assumption may be roughly checked by plotting the residuals against the $Y$ values. The scattergram resulting will show a curvature if the assumption is not adequate. This can be checked in greater detail by plotting the residuals against the $X$ variables.

Another important property of multiple regression is that it can utilize variables that are expressed in dichotomous form--scored as 0 or 1--as well as continuous variables. Both kinds may be included in the same equation (Veldman, 1967, p. 294). Dichotomous scores may be used to indicate group membership--e.g., American, Canadian, Mexican--by scoring each mutually exclusive category 1, if the observation comes from a member of the category, and 0 otherwise. Dichotomous variables in a multiple regression equation may also be used to represent a limited set of scores for a single variable of the study. For instance, questions with "agree, disagree," or "high, medium, low" response category forms should be represented in the equation by a set of dichotomous, or "dummy," variables. Note that if two mutually exclusive categories are involved, only one dummy variable is needed in the equation; if three categories, only two variables. Given the values of $N - 1$ dummy variables, the value of the $N$th is always known. In the analysis to follow, the respect variable is scored in this manner. In general we can deal with $r$ levels or categories by the introduction of $(r - 1)$ dichotomous dummy variables. Dummy variables also have other uses, such as in estimating characteristics associated with time trends where two separate regressions are known to exist (cf., Draper and Smith, 1966, p. 139ff). The use of dummy variables for behavioral data is discussed extensively in a text monograph by Bottenberg and Ward (1963) and by Suits (1957).
Werner (1969) observes that the term "dummy variable" is somewhat misleading.

As Suits (1957) points out:

There is nothing artificial about such variables; indeed in a fundamental sense they are more properly scales than conventionally measured variables. If we conceive the task of regression analysis to be that of providing an estimate of a dependent variable, given certain information, the use of linear regression yields biased estimates in the event of curvature. By partitioning the scale of a conventionally measured variable into intervals and defining a set of dummy variables on them, we obtain unbiased estimates since the regression coefficients of the dummy variables conform to any curvature that is present.

This procedure can be fruitfully applied to a variable like age, the influence of which is frequently U-shaped. Attempts to use chronological age as a linear variable may lead not only to the bias mentioned above, but to the failure of the variable to show significance in the regression. Although we sometimes resort to the use of a quadratic form in age to capture the curvature, there is little additional difficulty and in general better results in the application of a system of dummy variables defined by age classes. (p. 551)

7.3.2 - Interpretation of Equations

A given multiple regression equation, with its coefficients specified, is the result of assuming a mathematical model of a given form, e.g., in a linear case:

\[ Y = B_0 + B_1 X_1 + \ldots + B_k X_k + e \]

where the residuals \( e \) are distributed independently with zero mean and variance \( \sigma^2 \). Two assumptions are involved: one regarding the form of the equation, and the other regarding the distribution of the residuals. "The residuals contain all available information on the ways in which the fitted model fails to properly explain the observed variation in the dependent variable \( Y \)" (Draper and Smith, 1966, p. 26). They contain both random and systematic components. Provided that the systematic component is accounted for, the statistical significance of the estimates provided by the equation may be determined.

The assumption of normality of the \( e \)'s is required for such tests, but not for the other properties of the regression estimates. Significance is determined by making an F-test based on the ratio of the variance about the regression line (or hyperplane, when there are multiple independent variables) to the total variance. If the critical F-ratio is not exceeded, the predicted set of \( Y \) values is not significantly better than using the mean in all cases; i.e., \( \bar{Y}_i = B_0 = \bar{Y} \).
The multiple correlation coefficient, $R$, is the simple correlation between the $Y_i$ and $\hat{Y}_i$, but is usually expressed in terms of the independent variables. $R^2$ is the proportion of the sum of squares of deviations of $y$ from its mean that is attributable to the regression, while $(1 - R^2)$ is the proportion not associated with the regression. The test of the null hypothesis that $R = 0$ in the population from which the sample is drawn is identical to the F-test of the null hypothesis that all of the coefficients of the variables are zero: $B_1 = B_2 = \ldots = B_k = 0$. The test statistic is

$$F = \frac{R^2 / (N - 1)}{(1 - R^2) / (N-k-1)}$$

where $N$ is the number of cases and $k$ is the number of independent variables. $R^2$ is the proportion of variance "explained"--accounted for--by the regression equation as noted in all texts on multiple regression (cf., Draper and Smith, 1966, p. 24; Snedecor and Cochran, 1967, p. 402). Veldman (1967, p. 300) comments further:

The $R^2$ coefficient ... provides important information in addition to the probability value. Too often research workers report the statistical significance of the differences they obtain as if the associated probabilities were direct evidence of the practical significance of the results. If the sample is large enough, an Infinitesimal difference might well be statistically significant--and be of no practical importance at all. The $R^2$ coefficient provides a check on this aspect of the statistical analysis; it may be directly interpreted as the proportion of criterion variance which has been explained by predictor information. Another kind of caution is necessary here, however. The smaller the sample, the more inflated this $R^2$ value will be, and the more "shrinkage" may be expected upon cross-validation with a new sample using the same weights [coefficients]. This inflation reaches a maximum when the number of predictor variables is equal to (or greater than) the number of subjects in the sample. $R^2$ will always be 1.0 under this condition, but the probability value will also be 1.0. The two kinds of information provided by $R^2$ and the probability should be used together to evaluate the results of any statistical analysis in which they are both available.

An unbiased estimate, $R^I$, of the population value of $R$ is given by McNemar (1962, p. 184):

$$R^I = \left[1 - (1 - R^2) (N - 1/N - k)\right]^{1/2}$$

Different equations predicting to the same criterion variable, $Y$, may be compared. The gain in predictive capability afforded by the addition of one set
of variables to another may be determined in this manner. One variable or subset of variables may be deleted from an extended equation to determine their "importance" in determining the estimated value of the dependent variable. The technique is powerful, but the results must be interpreted with care because the "importance" only exists in the context of the other variables.

An F-test is used to determine if the predictions given by two equations are significantly different (cf., Draper and Smith, 1966; Veldman, 1967, p. 299):

\[
F = \frac{(R_1^2 - R_2^2) / (k_1 - k_2)}{(1 - R_1^2) / (N - k_1 - 1)}
\]

The critical F-value is taken with \(k_1 - k_2\) and \(N - k_1 - 1\) degrees of freedom at the chosen probability level. If the F-test for the difference between a full equation and a reduced equation with one or more variables deleted is not significant, the deleted variables have little effect in estimating the values of the dependent variable. This may be for one of several reasons to be discussed below.

One further observation on multiple-R and the multiple regression equation may be made that is particularly appropriate to field studies (or engineering data analysis--the context from which this is drawn). Draper and Smith (1966, p. 34) note that when the \(X_i\) and \(Y_i\) are all constants, in the sense of representing discrete values of a population, rather than sample values from some distribution, \(R\) can still be used as a measure of association. \(R\) is effectively a population rather than a sample value. The fact that a correlation \(R\) is nonzero implies only that there is an association between the values of \(Y\) and the \(X_i\), and does not by itself imply any sort of causal relationship whether the \(R\) is from a sample or population.

7.3.3 - Interpretation of the Coefficients

When raw data is used in a multiple regression analysis, the \(B\)-coefficients are scaled to the data for each variable. \(B_1\) measures the average or expected change in \(Y\) when \(X_1\) increases by 1 unit, all other variables remaining fixed.

Since the variables are not necessarily measured on the same scale, nothing can be said about the relative effects of the various \(X\) variables from their \(B\)-coefficients. If the raw data are rescaled by standardizing them to the same mean and variance, the coefficients, \(b\), reflect the relative contribution of each of
the variables. The one set of coefficients may be calculated from the other by the relation

$$b_i = \left( \frac{s_i}{s_y} \right) b_i$$

where $s_i$ is the standard deviation of $X_i$, and $s_y$ is the standard deviation of $Y$ (given in any text on multiple regression).

Associated with each estimated coefficient is an error of estimate. This value may be used to determine the confidence interval for the coefficient. A t-test is available to determine if the coefficient is significantly different from zero. However, if this test is applied to one variable at a time, the assumption is being implicitly made that the variables are completely independent. In general, this will not be the case and so the analysis of an equation should not be made on this basis. The t-test for coefficients provides a useful guide to selecting variables to be included in a reduced equation. The test of whether or not the deleted variables are "unimportant" should be made by comparing the two equations as described above.

Another check for the importance of a given set of regression coefficients is given by Snedecor and Cochran (1967, p. 388). The size of the regression coefficients in the full and reduced equations should be compared. In general, they will be different. In multiple regression, the size of any regression coefficient depends upon other variables included in the regression. Statements made about the size of a regression coefficient are not unique, being conditional on the other variables. With some variables deleted, if the change in the size of a remaining coefficient changes but little, this is evidence that it is stable.

In addition to comparing the $b$s, the partial correlations of the variable with $Y$ may be ranked, ignoring sign, to indicate the relative importance of the independent variables. This quantity is provided in many computer programs for performing multiple regression calculations.

In practice, correlations between the $X$s make it more difficult to tell which of them are most important in determining $\hat{Y}$. In many applications, two variables will be positively correlated with each other and with $Y$. Each variable's contribution to the $Y$ variance is much greater when used alone than when it follows the other variable in the multiple regression equation. The difference
in multiple-$R^2$s for two equations, one with and one without a given variable, may be interpreted as the proportion of variation in $Y$ explained by the independent contribution of the variable in the presence of the others.

In rare cases, the addition of a variable may increase the effect of a prior one. Veldman (1967, p. 301) notes that, "In some situations the addition of such a variable has a suppressor effect, cancelling out a component of the predictor's variation that interferes with its predictive efficiency. Suppressor variables usually have very low correlations with the criterion, but are substantially related to the predictor variable in question."

In addition to these sources of difficulty in determining the importance of a variable, another is the dynamic range observed for the variable. A variable may appear to be unimportant because it had little variation in the sample, not because it does not have an effect. In order to determine how a system works, you sometimes have to interfere with it—-a basic argument for field experiments.

Some general features of multiple regression, adapted from Snedecor and Cochran (1967, p. 407), are:

1. The regression coefficients change with each new grouping of the $X$—-with respect to either their number or their order of entry into the calculations.
2. The value of the "sum of squares due to regression," or multiple-$R$, which is determined by this quantity, never decreases with the addition of a new $X$; ordinarily it increases. The increase may be small and nonsignificant, but it estimates the contribution of the added $X$.
3. High correlations between two of the $X$ can upset calculations. If $r_{ij}$ is above 0.95, even double precision arithmetic in a computer program may not be adequate. One of the variables should be deleted.
4. If $R^2$ is small, most of the variation in $Y$ is unexplained. It may be random variation considered in the regression. If these other variables were found and brought in, the relations among the variables already included might change completely.
7.3.4 - Stepwise Regression

Multiple regression calculations are ideally suited for computers, if only because they are completely impractical to perform by hand when more than a very few variables are involved. A number of procedures have been devised for carrying them out, some of them, no doubt, devised to circumvent the difficulties involved in hand calculation. Of the several accepted techniques—six are briefly discussed with their advantages and limitations by Draper and Smith (1966, Chapter 6)—the stepwise procedure appears to be among the better feasible ones. It has been implemented in a variety of computer "canned" programs.

In stepwise regression one variable is added to the equation at a time. The first variable selected is the one that has the highest correlation with Y. The partial correlations of all the remaining variables with Y are then recalculated with the variance of the first variable removed. The variable having the highest partial correlation is the next to be selected for the equation. After the second variable is selected, the coefficients for the two variables are now recalculated and a new set of residuals determined. The process is then repeated until all variables are accounted for. Each variable added increases the value of $R^2$. In practice a criterion is built in so that the process stops when the change in $R^2$ falls below a given value. Hence, not all of the designated variables will necessarily be included in the final equation. The standardized coefficients of omitted variables would be quite small, smaller than any other variable present.

Actually, in the cycle described above, there are additional steps. After a new variable has been selected, a series of calculations are made which in effect changes the order of entry of the already chosen variables. If the contribution of a previously chosen variable to the sum of squares due to regression falls below a certain critical F-test level, the previous variable is dropped from the equation. This may occur when a redundant dummy variable is included, for instance, or when two variables have essentially the same partial correlation with the estimated value of Y, and that value is the largest of all unchosen variables, at that step of the calculations.

An extended, worked-out, example of the computational method for stepwise regression involving four predictor variables and 13 sets of data points is given in Draper and Smith (1966, pp. 178-195).
7.3.5 - Stepwise Regression Program B34T.

The computer program utilized here to perform stepwise regression is designated B34T and is available as a library program at the Vogelback Computer Center of Northwestern University. It is regarded as a highly sophisticated program in its structure and is very efficient and accurate in operation. It is based on the UCLA BiMed 134 Stepwise Regression Program, but was completely rewritten in double precision Fortran II by Hodson Thornber (1966).

In its normal stepwise mode of operation, which was utilized here, a variable is added to the regression equation when the F-value increases by 1%. A variable in the equation is deleted when the F-value decreases by 0.5%.

The program controls provide a great deal of flexibility, allowing a wide variety of approaches to regression analysis to be performed. It is possible to modify its operation so that, in effect, it performs other than stepwise regression. A number of subproblems may be performed in one run, and multiple main problems utilizing separate sets of data may also be performed in one run. A variety of data output options are provided. The program has proven to be very fast and more than adequately accurate for the type of data utilized here.
7.4 - FURTHER TESTS OF PROPOSITIONS P1.2 AND P1.3

7.4.1 - Analysis of Individual's Scores

The contribution of a number of variables to the level of communication problems perceived by individuals was examined by multiple regression analysis. It was apparent that differences in work-related values or perception of inter-group climate were most unlikely to entirely explain the extent of communication problems—other variables were involved. Indicators of several such variables were included in the questionnaires. Using multiple regression techniques, their effects were taken into account by including them with the independent variables concerned with work-related values.

It was desirable to limit the number of variables included in a multiple regression equation to a small fraction of the number of cases. There were 284 individuals, 66 groups, and 33 paired groups in this study. The number of variables that were taken into account at the "group" or "pairs of groups" level of analysis was limited by the relatively small number of cases. The number of individuals was sufficiently large to determine the relative importance of a number of variables.

Variables Included. The dependent variable predicted was the level of perceived communication problems (PCP). Subsidiary considerations in Chapter 3 state that PCP will be affected by the level and type of task interdependence, work flow, frequency of communication, and level of respect. The variables used in this stage of the analysis were:

- The dependent variable:
  
  PCP - Perceived communication problems

- Independent variables:

  WI - Work initiation and influence
  DEP - (Work) dependence
  MTD - Mutual dependence
  ADV - Advice and consultation (non-mutual project)
  TI - Task interdependence (DEP + MTD)
  DIR - Direction of dependence: = 1, if DEP > WI; = 0, otherwise.
  FRQ GP - Frequency of contact by group (Q02 #1)
  FRQ 2 - Frequency of contact by respondent (Q02 #2)
  FRQ 3 - Frequency with which information about changes is sought by respondent's group from Referenced Group (Q02 #3)
  FRQ 4 - Frequency with which information about changes is volunteered by Referenced Group (Q02 #4)
Nature of the Data. The PCP scores and task relationship measures (WI, DEP, MTD, and ADV) are continuous variables. The frequency of communication items (questions #1 to #4 of Q02) are 8-point scales. It has been shown previously that the time spans provided by the response categories were successfully selected so as to avoid the highly skewed frequency distributions usually associated with interaction frequency counts. Level of respect for the Referenced Group has been scored as a 3-point scale. Consequently, it is introduced into the equation by the use of "dummy" variables. These variables are defined as follows:

- **R(LO)** = 1, if respect score = 1 (low); = 0, otherwise.
- **R(MOD)** = 1, if respect score = 2 (moderate); = 0, otherwise.
- **R(HI)** = 1, if respect score = 3 (high); = 0, otherwise.

Note that only two of these three variables need be included in the regression equation, since if they are both 0, the third is implied.

Formation of the Equation. The regression equation was formed as a linear combination of the variables listed above. The form of the equation is:

\[
PCP = B_0 + B_1(WI) + B_2(DEP) + B_3(MTD) + B_4(ADV) + B_5(TI) + B_6(DIR) + B_7(FRQGP) + B_8(FRQ2) + B_9(FRQ3) + B_{10}(FRQ4) + B_{11}(R(LO)) + B_{12}(R(MOD)) + B_{13}(R(HI))
\]

Results. The step-wise regression program, B34T, was used to determine the values of the constants based on the scores of individuals (N = 284). At step 2, variable R(HI) was deleted. This occurred because it was redundant with R(LO) and R(MOD), confirming that the program takes into account this property as noted above.

At step 8, variable TI was deleted. TI is the sum of DEP and MTD. The latter variable had been entered in step 7, which effectively removed that same component of TI's contribution to the residual sum of squares at that point. The remaining effect of TI, since it is a simple sum of two variables, is necessarily the same as that of DEP. This may also be stated in another way. With the effect of MTD and six other variables removed, the partial correlation of TI and DEP with PCP becomes identical and so one of the two variables is removed. In
effect, the choice between the two is made on the basis of another criteria involving a tolerance that measures how close an inverted matrix is to becoming "singular"--the matrix equivalent to division by zero.

The resulting B-coefficients (for actual scores) and b-coefficients (for standard scores with mean = 0.0 and standard deviation = 1.0) and their characteristics are listed in Table 7.4-1. This set of coefficients forms an equation for the expected value of PCP with a multiple-R of 0.58 and $R^2 = 0.334$.

The null hypothesis that the multiple correlation is not significantly different from zero is identical to the F-test of the null hypothesis that all the coefficients are zero. This test is used to determine how adequately a given equation represents a set of data even when that data is not a "sample" from a population (Draper and Smith, 1966). The F-test is:

$$F = \frac{R^2 / k}{(1-R^2) / (N-k-1)}$$

where

- $N$ = number of respondents or cases, and
- $k$ = number of independent variables.

The obtained value of $F$ is compared to tabulated values of $F$ with $k$ and $N-k-1$ degrees of freedom at the chosen probability level (frequently $p < 0.05$). (Cf.; Snedecor and Cochran, 1967, p. 402; Bottenberg and Ward, 1963, pp. 108, 124-5.) In this case, there are 11 independent variables in the equation.

$$F = \frac{0.334 / 11}{(1-0.334) / 274} = 12.6$$

$$F(11, 274, .05) = 1.83$$

The obtained value of $F$ exceeds the requisite value for statistical significance, by a factor of six, indicating that it merits further consideration.* The $R^2$ value indicates the amount of variance "explained" by these variables (cf., references above and McNemar, 1962, pp. 165-6). In this case, 33% of the variance in PCP is accounted for.

* Tabulated values from Arkin and Colton (1963) have been used for $F_{critical}$ without interpolation.
Table 7.4-1

Regression Coefficients for Work Flow, Frequency, and Respect on PCP of Individuals

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP  =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0</td>
<td>24.72**</td>
<td>3.60</td>
<td>6.87</td>
<td></td>
</tr>
<tr>
<td>WI</td>
<td>0.121</td>
<td>1.39</td>
<td>0.97</td>
<td>1.44</td>
<td>0.11</td>
</tr>
<tr>
<td>DEP</td>
<td>0.148</td>
<td>1.71</td>
<td>0.92</td>
<td>1.85</td>
<td>0.13</td>
</tr>
<tr>
<td>MTD</td>
<td>-0.182</td>
<td>-2.04*</td>
<td>0.81</td>
<td>-2.52</td>
<td>-0.19</td>
</tr>
<tr>
<td>ADV</td>
<td>-0.059</td>
<td>-0.65</td>
<td>0.56</td>
<td>-1.16</td>
<td>-0.06</td>
</tr>
<tr>
<td>TI</td>
<td>(See note)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIR</td>
<td>0.019</td>
<td>0.31</td>
<td>1.35</td>
<td>0.23</td>
<td>0.004</td>
</tr>
<tr>
<td>FRQ GP</td>
<td>0.155</td>
<td>0.69*</td>
<td>0.32</td>
<td>2.19</td>
<td>0.06</td>
</tr>
<tr>
<td>FRQ2</td>
<td>0.055</td>
<td>0.25</td>
<td>0.29</td>
<td>0.84</td>
<td>0.03</td>
</tr>
<tr>
<td>FRQ3</td>
<td>-0.303</td>
<td>-1.36**</td>
<td>0.36</td>
<td>-3.74</td>
<td>-0.19</td>
</tr>
<tr>
<td>FRQ4</td>
<td>0.285</td>
<td>1.35**</td>
<td>0.36</td>
<td>3.77</td>
<td>0.20</td>
</tr>
<tr>
<td>R(LO)</td>
<td>0.592</td>
<td>9.91**</td>
<td>1.17</td>
<td>8.45</td>
<td>0.11</td>
</tr>
<tr>
<td>R(MOD)</td>
<td>0.304</td>
<td>4.99**</td>
<td>1.13</td>
<td>4.42</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Multiple R = 0.58
Std. error of PCP·X = 6.78
Multiple R² = 0.334

Note: TI deleted in step-wise regression with partial corr. same as DEP.
**Discussion of the Coefficients.** The B-coefficients allow the PCP score to be estimated in its "raw" form as scored on the questionnaires. These coefficients are useful in predicting PCP scores in future samples—which is not our objective here—but they cannot be directly compared because the scales for the variables are not the same. The b-coefficients, based on standardized data, are directly comparable in indicating the relative "importance" of the effect of the independent variables on the dependent variable (McNemar, 1962, p. 176). The two forms are related by:

\[ b_i = B_i \left(\frac{s_y}{s_i}\right) \]

where \( s_y \) and \( s_i \) are the standard deviations of the dependent and ith independent variable respectively.

The largest b-coefficient is 0.59 for R(LO), indicating that low respect is relatively strongly associated with the perception of problems in communication, as compared to the other variables considered. Moderate respect is also positively associated with the perception of communication problems with a coefficient of 0.30. Forcing R(HI), high respect, into the step-wise regression, R(MOD) drops out, and R(HI) appears with a coefficient of the same magnitude but opposite sign. This indicates that high respect is associated with decreased PCP to the same extent that moderate respect is associated with increased PCP when all other variables are held constant.

Frequency of contact with the Referenced Group by the respondent (FRQ2) is weakly (0.05) and not significantly associated with PCP. His perception of how frequently his group, as a whole, contacts the Referenced Group (FRQGP) is mildly (0.15) associated with PCP. Note that numerically larger values of frequency indicate less frequent contact, so a positive sign on the coefficient implies increasing problems with decreasing frequency.

Contrary to these two, non-content specific, questions about frequency of contact, the next two, more specific, frequency variables are significantly related to PCP. The coefficient for FRQ3 is -0.30 and FRQ4 is +0.28. The question for FRQ3 is:

*How often does your group attempt to learn from them about changes being made or proposed in their work which might affect you or your group?*
Perceived communication problems are greater the more often such information is sought. This might be indicating that communication problems make it necessary to contact the other group. On the other hand, PCP tends to be lower, if information about changes is provided by the other group as indicated by FRQ4:

How often does your group receive information from them about changes being proposed or made in project or technical work relevant to your group's responsibilities?

Again, the causal relationship could equally well be that providing such information tends to reduce or avoid problems in communication, and perhaps problems in carrying out the work as well. Ignoring the sign, the confidence limits for the two coefficients largely overlap. All other things being equal, the one factor is as helpful as the other is deleterious to communication.

Increasing the level of work initiation and influence (WI), or dependence (DEP), tends to increase PCP as indicated by $b_1 = 0.12$ and $b_2 = 0.15$. On the other hand, increasing perception of mutual dependence significantly tends to decrease PCP ($b_3 = -0.18$) as perceived by individuals. Increasing advice and consultation about projects in which the two groups do not have joint responsibility (ADV) has a weak, non-significant association with decreasing PCP ($b_4 = -0.06$). The smallest effect that still serves to explain some of the observed variance is contributed by the binary "direction of dependence" variable, DIR, which indicates whether the respondent scored higher on DEP or WI; i.e., whether he perceived his group as being more dependent upon the other group rather than initiating or influencing their work, or vice versa.

The "significance" of the coefficients above refers to the probability that they are different from zero. This does not necessarily mean that a non-significant coefficient does not improve the estimated value of PCP since the joint confidence region may still be restricted by it.

All of the coefficients for the variables discussed above "significantly" entered into the equation in one sense. In each step of the step-wise regression, a variable was entered only if in doing so it improved the estimated value of the dependent variable, PCP. The "significance" of the coefficients' values, at the last step, when all the variables had been entered into the equation, referred to the uncertainty in the value of the coefficient itself and the probability that it was significantly different from zero. Given the most likely values of the coefficients as calculated, all of them were "useful" in explaining the variance in the PCP scores.
Residuals. The multiple-$R^2$ value indicated that these ten variables accounted for 33% of the variance observed in the PCP scores. Substantiation for the hypotheses of the study would be provided if differences in work-related values and perception of inter-group climate (a prime focus of R. Barth's parallel study) also entered into an extended equation. However, at this point it was appropriate to determine the nature of the explanation provided by the equation developed so far. This was most readily done by examining the "residuals;" that is, the difference between the expected value, PCP, provided by the equation, and the actual value of PCP for each respondent.

While various statistics have been suggested to characterize the residuals of a regression equation, Draper and Smith (1966, p. 92) emphasize the use of visual plots: "... in practical regression situations a detailed examination of the corresponding residual plots is usually far more informative, and the plots will almost certainly reveal any violations of assumptions serious enough to require corrective action." Corrective action typically involves transformation of a variable to another form, or introducing non-linear terms such as higher powers of a variable or interaction terms involving the product of two variables. The purpose of residual analysis is clearly stated in the following passage.

The residuals are defined as the n differences $e_i = Y_i - \hat{Y}_i$, $i = 1, 2, ..., n$ where $Y_i$ is an observation and $\hat{Y}_i$ is the corresponding fitted value obtained by use of the fitted regression equation.

We can see from this definition that the residuals $e_i$ are the differences between what is actually observed, and what is predicted by the regression equation--that is, the amount which the regression equation has not been able to explain. Thus we can think of the $e_i$ as the observed errors if the model is correct. (There are, however, restrictions on the $e_i$--see Section 3.7) Now in performing the regression analysis we have made certain assumptions about the errors; the usual assumptions are that the errors are independent, have zero mean, a constant variance, $\sigma^2$, and follow a normal distribution. The last assumption is required for making $F$-tests. Thus if our fitted model is correct, the residuals should exhibit tendencies that tend to confirm the assumptions. This latter idea is the one that should be kept in mind when examining the residuals; we should ask, "Do the residuals make it appear that our assumptions are wrong?"

After we have examined the residuals we shall be able to conclude either

1. the assumptions appear to be violated (in a way that can be specified), or
2. the assumptions do not appear to be violated.

Note that (2) does not mean that we are concluding that the assumptions are correct; it means merely that on the basis
of the data we have seen, we have no reason to say that they are incorrect. The same spirit occurs in making tests of hypotheses when we either reject or do not reject (rather than accept). We now give ways of examining the residuals in order to check the model. These ways are all graphical, are easy to do, and are usually very revealing when the assumptions are violated. The principal ways of plotting the residuals $e_j$ are

1. Overall.
2. In time sequence, if the order is known.
3. Against the fitted values $\hat{Y}_i$.
4. Against the independent variables $X_{ji}$, for $j = 1, 2, \ldots, k$.

In addition to these basic plots, the residuals should also be plotted

5. In any way that is sensible for the particular problem under consideration.

Figure 7.4-1 shows the plot of residuals against the observed PCP scores. It is characterized by (a) a linear slope, (b) a band of approximately uniform width, and (c) a reasonably uniform density of points considering $N = 284$. This indicates that there is no evidence that the assumptions made are incorrect except that at least one more linear variable is required to remove the uniform slope. Indeed, if the slope were not present, there would be no reason to proceed any further into the investigation of the hypotheses of this study.

The standard error of $\hat{PCP}$, given $X_i$, the set of variables included so far, is 6.78. At a confidence level of .05, $\pm 1.96(\text{s.e.}) = \pm 13.1$ should include roughly 95% of the residual points—roughly, because any given plot is subject to chance variation. In this case, 12 points lie outside the limits; i.e., 95.8% lie within the limits. The boundary of the band of points is sufficiently defined to estimate that standard error in the width of the band is about 3.0 units on the scale by which PCP is measured. This provides a rough idea of the least inaccuracy of estimate that can be expected when other variables are introduced. The error of prediction is limited by the error of measurement of PCP.

Clearly, there is no evidence, i.e., no curvature in the band, to suggest that non-linear terms are required. This is not to say that there are no interaction, second-order, or higher order, variables present. There may be weak ones that would be revealed by statistical tests. But if they are present, they are not sufficiently strong to show up, given the uncertainties in the present measurements of the data examined.
Fig. 7.4-1 - PCP-Estimate Residuals
The analyses and discussion so far have indicated the nature of a portion of the data, providing some useful information of itself and a partial understanding of factors affecting the perception of communication problems. This is the first step in attempting to relate similarities and differences in work-related values to communication. The next step is to select a reduced equation that can be used in considering the "group" and "pairs of groups" levels of analysis.

**Selection of a Reduced Equation.** An equation with a smaller number of terms is desired. That is, we wish to delete some of the terms from the present, "full," equation prior to introducing the effects of work-related values. This cannot be done simply by omitting terms from the present equation. In effect, this would be setting selected coefficients to zero. In a regression equation, the value of a given coefficient depends upon all the data included in the equation. If a variable is deleted, the values of the other coefficients change, depending upon their partial correlation with the deleted one (and upon the order in which the variables have been put into the equation, which also affects the partial correlations at any given point in the analysis). The reduced equation must be calculated anew. The two equations may then be compared by an F-test to determine if there is a statistically significant difference between them.

Draper and Smith (1966) provide some prudent cautions and alternatives for this process, particularly applicable in situations where it may be possible to managerially control a variable, measure it more easily and cheaply, etc. In the case here, all of the data was at hand and the purpose of the reduction of the number of variables was to avoid loss of information in the later analysis; more descriptively, to avoid converting "error" into "information." That is, we wanted to avoid accounting for variance by loss of degrees of freedom, which leads to a better apparent fit as indicated by an increasing value of multiple-R.

In the stepwise regression for the full equation, variables were selected essentially on the basis of their contribution to multiple-R; that one which caused the greatest increase was selected. The order of entry of the variables into the full equation and the resultant multiple-R at each step was:

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>R</th>
</tr>
</thead>
</table>
| 1    | R(LO)    | .428
| 2    | R(MOD)   | .492
| 3    | FRQ4     | .515
| 4    | FRQ3     | .532
| 5    | FRQGP    | .550
| 6    | WI       | .557
| 7    | MTD      | .564
| 8    | DEP      | .573
| 9    | ADV      | .576
| 10   | FRQ2     | .578
| 11   | DIR      | .578 |
This information, and that in Table 7.4-1, initially indicated that it was not worthwhile retaining the last three variables (ADV, FRQ2, and DIR), and that the first four should be retained. The four remaining (FRQGP, WI, MTD, and DEP) need to be investigated.

Table 7.4-2 presents the results of this analysis. Seven reduced equations were considered. The $R^2$ of each was compared to the $R^2$ of the full equation using the F-test previously described. The F ratio for the equations and the critical F value at the 0.05 level are shown for each reduction. In reduction #3A, when five variables were deleted, the estimated values of PCP from this equation became significantly different. Reduced equation #2 was not significantly different from the full equation. It included the variables DEP, MTD, FRQGP, FRQ3, FRQ4, and RESPECT (in the form of two dummy variables). The multiple-R of the full equation, with ten independent variables, was 0.58 and the multiple-R of this reduced equation with seven independent variables was 0.56. The full equation explained 33.4% of the variance. The reduced equation explained 31.5% of the variance. Use of the reduced equation gains 3 degrees of freedom with a loss of 1.9% of the variance explained.

Both forms were statistically significant at more than the 0.01 confidence level. The F-ratio of this full equation was 13.68 and the critical F-ratio for 10 and 273 degrees of freedom at the 0.01 level was 2.41. The F-ratio of reduced equation #2 was 18.13, and the critical F-ratio for 7 and 276 degrees of freedom at the 0.01 level was 2.73.

7.4.2 - Values, Per Se, and Communication

It is appropriate to ask the question: Why investigate the more complicated proposition involving dissimilarity of work-related values, when the values themselves may adequately explain the communication problems perceived? This is a major point made by Cronbach (1958) in his discussion of similarity indices. Scores based on item or profile differences represent a more complex hypothesis than ones based on the simple variables. Prior to investigating a proposition involving difference scores, the simpler proposition should be investigated.

With 10 work-related values to consider, this may also readily be done by a multiple regression analysis. The simplest equation considering all of the value clusters is:
Table 7.4-2
Analysis of Reduced Equations

<table>
<thead>
<tr>
<th>Reduction</th>
<th>Variables</th>
<th>$R^2$</th>
<th>$k$</th>
<th>$d.f.$</th>
<th>$F$</th>
<th>$F_{crit}$</th>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>WI, DEP, MTD, FRQGP, FRQ3, FRQ4, R(LO), R(MOD)</td>
<td>0.329</td>
<td>8</td>
<td></td>
<td>0.68</td>
<td>1.98</td>
<td>n.s.</td>
</tr>
<tr>
<td>#2</td>
<td>DEP, MTD, FRQGP, FRQ3, FRQ4, R(LO), R(MOD)</td>
<td>0.315</td>
<td>7</td>
<td></td>
<td>1.94</td>
<td>2.05</td>
<td>n.s.</td>
</tr>
<tr>
<td>#3A</td>
<td>DEP, FRQGP, FRQ3, FRQ4, R(LO), R(MOD)</td>
<td>0.307</td>
<td>6</td>
<td></td>
<td>2.21</td>
<td>2.14</td>
<td>sig.</td>
</tr>
<tr>
<td>#3B</td>
<td>DEP, MTD, FRQ3, FRQ4, R(LO), R(MOD)</td>
<td>0.301</td>
<td>6</td>
<td></td>
<td>2.70</td>
<td>2.14</td>
<td>sig.</td>
</tr>
<tr>
<td>#4</td>
<td>FRQGP, FRQ3, FRQ4, R(LO), R(MOD)</td>
<td>0.303</td>
<td>5</td>
<td></td>
<td>2.11</td>
<td>2.26</td>
<td>sig.</td>
</tr>
<tr>
<td>#5</td>
<td>FRQ3, FRQ4, R(LO), R(MOD)</td>
<td>0.283</td>
<td>4</td>
<td></td>
<td>2.98</td>
<td>2.41</td>
<td>sig.</td>
</tr>
<tr>
<td>#6</td>
<td>FRQ4, R(LO), R(MOD)</td>
<td>0.265</td>
<td>3</td>
<td></td>
<td>3.52</td>
<td>2.65</td>
<td>sig.</td>
</tr>
</tbody>
</table>

* Significance, at .05 level, of difference in estimate provided by full equation and reduced equation.
\[
\hat{PCP} = B_0 + B_1 X_1 + \ldots + B_{10} X_{10}
\]

where \(B_i\) is the coefficient for the \(X_i\)th value cluster and \(B_0\) is the regression constant as usual. The results of this analysis are shown in Table 7.4-3.

**Results.** The coefficient for the Personal Relations variable did not attain a level sufficient to be included in the equation; i.e., its coefficient was quite small, less than the smallest one present. All other variables entered the equation. The \(R^2\) value was 0.080 with 9 variables present and 274 degrees of freedom. The F-ratio was 2.65 and the critical value was 1.91 at the 0.05 level, so the equation was significant. Examination of the coefficients showed that two of them, those for Science and Career values, were statistically non-zero. They accounted for 5.2% of the variance in a reduced, two-variable equation. In the full, ten variable equation, the coefficient for the Science variable in standardized form was -0.258 and for the Career variable was 0.119.

**Discussion.** There is some evidence that engineers and scientists scoring higher on the Science values cluster tended to perceive fewer problems in communication with their Referenced Group, whereas those scoring higher in Career values tended to see more problems. Whether or not this effect makes a significant difference in the regression model has to be tested by including these variables in an expanded equation. Other values, per se, had only a minor effect on the PCP score estimate.

**7.4.3 - Test of Proposition P1.2**

**Proposition P1.2:** For a given level of task interdependence perceived by an individual between his working group and another group, the less the similarity of his work-related values to those of the other group, the greater the communication problems he will perceive as existing between the two groups.

The preliminary analysis presented earlier indicated that a number of variables affect PCP. The immediately preceding discussion provides the basis for determining some of these factors and their relative importance. The relative contribution of values differences to PCP can now be determined, taking into account all of these other variables, including the task interdependence components referred to in the proposition.
Table 7.4-3

Regression Coefficients of Work-Related Values on PCP for Individuals

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0</td>
<td>38.75**</td>
<td>4.15</td>
<td>9.34</td>
<td></td>
</tr>
<tr>
<td>PERSRL</td>
<td>(F-value insufficient for inclusion)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENG</td>
<td>-.070</td>
<td>-.84</td>
<td>.80</td>
<td>-1.05</td>
<td>-.06</td>
</tr>
<tr>
<td>FULFIL</td>
<td>.013</td>
<td>.18</td>
<td>.91</td>
<td>.19</td>
<td>.01</td>
</tr>
<tr>
<td>CAREER</td>
<td>.138</td>
<td>1.52*</td>
<td>.64</td>
<td>2.37</td>
<td>.14</td>
</tr>
<tr>
<td>SCI</td>
<td>-.196</td>
<td>-2.50**</td>
<td>.87</td>
<td>-2.89</td>
<td>-.17</td>
</tr>
<tr>
<td>PRJDIR</td>
<td>.055</td>
<td>.87</td>
<td>.96</td>
<td>.91</td>
<td>.05</td>
</tr>
<tr>
<td>QKFIX</td>
<td>.114</td>
<td>1.49</td>
<td>.88</td>
<td>1.68</td>
<td>.10</td>
</tr>
<tr>
<td>CLGROW</td>
<td>-.010</td>
<td>-.15</td>
<td>1.04</td>
<td>-1.48</td>
<td>-.009</td>
</tr>
<tr>
<td>ORGZL</td>
<td>-.107</td>
<td>-1.32</td>
<td>.77</td>
<td>-1.71</td>
<td>-.10</td>
</tr>
<tr>
<td>INTGRT</td>
<td>-.024</td>
<td>-0.34</td>
<td>.91</td>
<td>-.37</td>
<td>-.02</td>
</tr>
</tbody>
</table>

Multiple R = 0.28
Std. error of PCP.X = 7.94
Multiple R^2 = 0.080
N = 284
The multiple regression form of the equation became:

\[
\hat{PCP} = B_0 + B_1 WI + \ldots + B_{12} R(MOD) + B_{13} (Career) + B_{14} (Science)
\]

\[
+ B_{15} (Value Diff 1) + \ldots + B_{24} (Value Diff 10)
\]

The two value factors, Career and Science, were included since they were significantly related of themselves to PCP. The coefficients \(B_{15}\) through \(B_{24}\) were associated with each of the ten value difference scores.

This equation represents proposition P1.2 with the addition of other parameters than just the task interdependence factors. The proposition was tested by comparing this equation to a reduced equation that omitted the independent variables of the proposition. The null hypothesis was that the full equation would not provide a significantly better estimate of PCP than the reduced equation. If the difference in estimates provided by the full equation were significantly better, the null hypothesis would be rejected and the proposition would have survived one attempt at disconfirmation.

**Input Data.** The characteristics of the input data for the first 14 variables have been discussed previously. The value differences were determined by taking the absolute value of the difference between an individual's score on each value factor and the mean score of his Referenced Group for the corresponding factor:

\[
Value Difference_{ij} = \left| \bar{V}_{ij} - \bar{V}_{ik} \right|
\]

where \(i = \text{value factor (V) number } 1 \leq i \leq 10\)

\(j = \text{respondent number}\)

\(k = \text{Referenced Group number for } i^{th} \text{ respondent.}\)

Each \(\bar{V}_i\) was used four times on the average, so the appropriate number of degrees of freedom may be questioned. This will be considered below.

**Results.** The results of the stepwise regression analysis for the full equation are shown in Table 7.4-4. The Advice and Consultation factor did not attain a sufficient level to enter into the equation. Its coefficient was much smaller than any present. The equation explained 38.0% of the variance in PCP scores with a multiple-R of 0.62.
Table 7.4-4

Regression Coefficients for a Full Equation with Individuals' Data

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0</td>
<td>25.03**</td>
<td>4.24</td>
<td>5.90</td>
<td></td>
</tr>
<tr>
<td>WI</td>
<td>.109</td>
<td>1.25</td>
<td>.98</td>
<td>1.28</td>
<td>.08</td>
</tr>
<tr>
<td>DEP</td>
<td>.154</td>
<td>1.78</td>
<td>.94</td>
<td>1.90</td>
<td>.12</td>
</tr>
<tr>
<td>MTD</td>
<td>-.178</td>
<td>-1.99*</td>
<td>.82</td>
<td>-2.44</td>
<td>-.15</td>
</tr>
<tr>
<td>ADV</td>
<td>(F-level insufficient for inclusion)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIR</td>
<td>.029</td>
<td>.48</td>
<td>1.35</td>
<td>.36</td>
<td>.02</td>
</tr>
<tr>
<td>FRQ GP</td>
<td>.173</td>
<td>.77*</td>
<td>.32</td>
<td>2.45</td>
<td>.15</td>
</tr>
<tr>
<td>FRQ2</td>
<td>.085</td>
<td>.39</td>
<td>.31</td>
<td>1.26</td>
<td>.08</td>
</tr>
<tr>
<td>FRQ3</td>
<td>-.316</td>
<td>-1.41**</td>
<td>.37</td>
<td>-3.82</td>
<td>-.23</td>
</tr>
<tr>
<td>FRQ4</td>
<td>.277</td>
<td>1.32**</td>
<td>.37</td>
<td>3.60</td>
<td>-.22</td>
</tr>
<tr>
<td>R(LO)</td>
<td>.570</td>
<td>9.45**</td>
<td>1.17</td>
<td>8.02</td>
<td>.44</td>
</tr>
<tr>
<td>R(MOD)</td>
<td>.278</td>
<td>4.57**</td>
<td>1.15</td>
<td>3.95</td>
<td>.24</td>
</tr>
<tr>
<td>CAREER</td>
<td>.111</td>
<td>1.23*</td>
<td>.54</td>
<td>2.27</td>
<td>.14</td>
</tr>
<tr>
<td>SCI</td>
<td>-.164</td>
<td>-2.09**</td>
<td>.67</td>
<td>-3.12</td>
<td>-.19</td>
</tr>
<tr>
<td>PERS D</td>
<td>-.106</td>
<td>-2.10</td>
<td>1.12</td>
<td>-1.87</td>
<td>-.11</td>
</tr>
<tr>
<td>ENG D</td>
<td>.082</td>
<td>1.65</td>
<td>1.08</td>
<td>1.52</td>
<td>.09</td>
</tr>
<tr>
<td>FULFL D</td>
<td>-.007</td>
<td>-.13</td>
<td>1.02</td>
<td>-.13</td>
<td>-.01</td>
</tr>
<tr>
<td>CARER D</td>
<td>.049</td>
<td>.71</td>
<td>.74</td>
<td>.96</td>
<td>.06</td>
</tr>
<tr>
<td>SCI D</td>
<td>-.013</td>
<td>-.26</td>
<td>1.03</td>
<td>-.25</td>
<td>-.02</td>
</tr>
<tr>
<td>PRJDR D</td>
<td>-.041</td>
<td>-.88</td>
<td>1.09</td>
<td>-.80</td>
<td>-.05</td>
</tr>
<tr>
<td>QKFIX D</td>
<td>.046</td>
<td>1.00</td>
<td>1.11</td>
<td>.90</td>
<td>.06</td>
</tr>
<tr>
<td>CLGRW D</td>
<td>.025</td>
<td>.58</td>
<td>1.22</td>
<td>.47</td>
<td>.03</td>
</tr>
<tr>
<td>ORGZL D</td>
<td>-.051</td>
<td>-1.00</td>
<td>1.01</td>
<td>-.98</td>
<td>-.06</td>
</tr>
<tr>
<td>INTG D</td>
<td>.056</td>
<td>1.12</td>
<td>1.13</td>
<td>-.99</td>
<td>.06</td>
</tr>
</tbody>
</table>

Multiple R = .616  
Std. error of PCP·X = 6.67  
Multiple R² = .38  
N = 284

*sig. @ p ≤ .05  
**sig. @ p ≤ .01
The F-value is

\[
F = \frac{R_1^2(n-k-1)}{(1-R_1^2)k} = \frac{0.383}{0.617} \frac{262}{22} = 7.40
\]

\[
F(22, 262, .05) = 1.62
\]

The equation is statistically significant.

The reduced equation, excluding the value difference variables, explained 34% of the variance with a multiple-R of 0.58. The F-test for the difference between the equations is:

\[
F = \frac{(R_1^2 - R_2^2)}{(1-R_1^2)} \frac{(n-k_1-1)}{(k_1-k_2)} = \frac{0.043}{0.617} \frac{262}{10} = 1.83
\]

\[
F(10, 262, .05) = 1.87
\]

The difference between the two equations was marginally insignificant. The presence of the value difference terms in the full equation provided a negligibly better estimate of an individual's PCP score than the reduced equation not containing these terms. None of the multiple regression coefficients were statistically significant individually. The largest single coefficient of the value difference terms was -.106 associated with PERS D. The negative sign indicated that it was contrary to the proposition. The small magnitude of the coefficients also implied that they would be sensitive to the other variables in the equation. (Recall the discussion in Section 7.3.3.)

To test the "strength" of the significance level, another equation was tested using a restricted set of variables. These variables were FRQ3, FRQ4, R(LO), R(MOD), CAREER, SCIENCE, and the 10 value difference terms for the full equation. The 10 value difference terms were omitted to form the reduced equation.

The results may be summarized as follows:

**Full equation:**

- \( R = 0.57 \)
- \( R^2 = 0.324 \)
- \( k = 16 \)
- d.f. = 268

**Reduced equation:**

- \( R = 0.53 \)
- \( R^2 = 0.283 \)
- \( k = 6 \)
In this case the difference in the equations was clearly not significant. The result obtained above is more firmly established.

**Consideration of Degrees of Freedom.** As noted, the proper number of degrees of freedom to be used may be questioned because of the use of repeated group means in forming the value differences. The correction would involve reducing the effective number of independent variables. This would increase the critical F-ratio. Since the differences between the equations is of marginal significance or not significant in the cases above, they would not be significant in either case with a more stringent requirement for the critical value of F.

7.4.4 - Multiple Regression Test of Proposition P1.3

**Proposition P1.3:** For a given level of task interdependence perceived to exist between two working groups by the members of those groups, the less the similarity of the work-related values of the two groups, the greater the communication problems each will perceive as existing between the two groups.

This proposition was tested by a multiple regression analysis in the same manner as Proposition P1.2. Task interdependence was incorporated by initially including the four task interdependence factors--WI, DEP, MTD, and ADV--as before. At this level of analysis, we were dealing with an N of 66 groups or 33 pairs of groups, so the multiple correlations could be expected to have much higher numerical values, but the reduction in the number of degrees of freedom increased the critical F-values as well.

**Nature of the Test.** The pattern of the analysis was similar to the previous one. The respect, frequency, task interdependence, and values variables were examined for their relative contribution to the estimated PCP score at the "group" level. A reduced set of variables was chosen to include with the value differences to form a full equation at the "pairs of groups" level of analysis. The test of the proposition was then to compare this full equation with a reduced equation from which the value difference terms were eliminated. The null hypothesis for P1.3 was that there was not a statistically significant difference between the two equations.
Nature of the Data. The group level data was formed by taking the mean value for each variable of the set of respondents in each group. The respect and four frequency variables were single items from questionnaire Q02. The four task interdependence and ten values variables were the group mean scores on each factor. The "direction of dependence" variable was formed in the following manner:

\[ \text{DIR} = 1 \text{ if } \bar{\text{DEP}} - \bar{\text{WI}} > 0.0, \]
\[ = 0 \text{ otherwise.} \]

The respect "dummy" variables were formed in the following manner:

\[ R(\text{LO}) = 1 \text{ if } \text{RESPECT} \leq 1.61; = 0 \text{ otherwise} \]
\[ R(\text{MOD}) = 1 \text{ if } 1.61 < \text{RESPECT} \leq 2.1; = 0 \text{ otherwise} \]
\[ R(\text{HI}) = 1 \text{ if } \text{RESPECT} > 2.1; = 0 \text{ otherwise.} \]

At the group level, the mean value of RESPECT was no longer an integer value and the variance was smaller. The cutting points established above maintain approximately the same distribution of dummy variable scores. This was indicated by the mean values of the dummy variables at the individual and group levels:

<table>
<thead>
<tr>
<th>Individual level</th>
<th>Group level</th>
</tr>
</thead>
<tbody>
<tr>
<td>R(LO)</td>
<td>.38</td>
</tr>
<tr>
<td>R(MOD)</td>
<td>.43</td>
</tr>
<tr>
<td>R(HI)</td>
<td>.19</td>
</tr>
</tbody>
</table>

Little further improvement in equivalence of means at the two levels was possible because of discontinuities in the distribution of scores.

For a given work-related value factor, the difference score was the absolute (numerical) value of the difference of the mean scores for a group and its Referenced Group:

\[ \text{Value Difference}_i = \left| V_{i1} - V_{i2} \right| \]

Formation of the Equations. The equations were composed of a linear combination of the individual variables as done before. The variables for each equation are
indicated in the text and listed in the tables. Because of the restricted number of observations at this level of analysis, it was not useful to form one equation with all 32 variables. The analysis was done in three parts: first, considering those variables not associated with values; second, considering values, per se; and third, considering value similarities and differences.

**Task Interdependence, Frequency and Respect.** A multiple regression equation for PCP with the four task interdependence factors, direction of dependence term, the four frequency of contact measures, and respect dummy variables was formed as indicated in Table 7.4-5. The equation explained 56% of the variance as indicated by a multiple-R of 0.75, and had an F-value of

\[
F = \frac{562}{.338} \frac{55}{11} = 8.32
\]

The critical value of F with 11 and 55 d.f. at the 0.01 level of confidence was 2.59; hence, the equation was statistically significant.

The results were similar to the same equation for individuals (Table 7.4-1). At the individual level the ratio \((F_{obtained})/(F_{critical}) = 7.4\), and at the group level it was 4.6. With the smaller N of 66, as compared to 284, and the same number of variables, the t-ratios for the coefficients were somewhat smaller--four coefficients and the constant, as compared to six and the constant, were significant at the 0.05 level or better. The following comparisons were noted. R(LO) remained significant at the 0.01 level, but R(MOD) no longer was. (It was significant at approximately the 0.049 level.) The b-score for FRQ4 had dropped appreciably and was no longer significant, but FRQ3--frequency of seeking out information about changes--remained a significant factor increasing PCP. FRQGP (perception of general frequency of group contact) remained significant.

Comparing FRQGP and FRQ2 coefficients in this group level analysis, it was noted that while FRQ2 (respondent's frequency of contact, the mean for the group) had a much smaller coefficient, this could easily be misinterpreted. The two variables were highly correlated \((r = 0.79)\). What the magnitude of the B-coefficients meant was that FRQ2 contributed a relatively small amount to the estimate of PCP after the contribution of FRQGP was accounted for. FRQGP entered the stepwise regression prior to FRQ2. If the latter were forced into the regression first, the coefficients for the two variables would be nearly, but not quite, reversed.
### Table 7.4-5
Regression Coefficients for Work Flow, Frequency, and Respect on PCP of Groups

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0</td>
<td>27.31*</td>
<td>7.68</td>
<td>3.55</td>
<td></td>
</tr>
<tr>
<td>WI</td>
<td>.158</td>
<td>1.52</td>
<td>1.77</td>
<td>.86</td>
<td>.12</td>
</tr>
<tr>
<td>DEP</td>
<td>.377</td>
<td>3.54*</td>
<td>1.59</td>
<td>2.23</td>
<td>.29</td>
</tr>
<tr>
<td>MTD</td>
<td>-.284</td>
<td>-3.05</td>
<td>1.74</td>
<td>-1.76</td>
<td>-.23</td>
</tr>
<tr>
<td>ADV</td>
<td>-.109</td>
<td>-1.46</td>
<td>1.40</td>
<td>-1.05</td>
<td>-.14</td>
</tr>
<tr>
<td>DIR</td>
<td>-.153</td>
<td>-1.83</td>
<td>1.99</td>
<td>-.92</td>
<td>-.12</td>
</tr>
<tr>
<td>FRQ GP</td>
<td>.365</td>
<td>1.74*</td>
<td>.85</td>
<td>2.03</td>
<td>.27</td>
</tr>
<tr>
<td>FRQ2</td>
<td>.198</td>
<td>.96</td>
<td>.81</td>
<td>1.19</td>
<td>.16</td>
</tr>
<tr>
<td>FRQ3</td>
<td>-.357</td>
<td>-1.82*</td>
<td>.73</td>
<td>-2.48</td>
<td>-.32</td>
</tr>
<tr>
<td>FRQ4</td>
<td>.141</td>
<td>.65</td>
<td>.68</td>
<td>.97</td>
<td>.13</td>
</tr>
<tr>
<td>R(LO)</td>
<td>.580</td>
<td>7.03**</td>
<td>1.60</td>
<td>4.40</td>
<td>.51</td>
</tr>
<tr>
<td>R(MOD)</td>
<td>.262</td>
<td>3.08</td>
<td>1.60</td>
<td>1.92</td>
<td>.25</td>
</tr>
</tbody>
</table>

Multiple R = .75
Std. error of PCP·X = 4.25
Multiple R² = .563  \( N = 66 \)
The magnitude and significance of the DEP and MTD coefficients have interchanged, with DEP now becoming more important. The signs of each have remained the same as before. Increasing work dependence tended to increase PCP and increased perception of mutual dependence on each other tended to decrease PCP.

**Values, Per Se, and Communication.** At the group level, the effect of work-related values, per se, on the perception of communication problems was determined by comparing a "full" regression equation containing these items with a reduced equation omitting them. The value scores were the mean scores for the individuals in each of the 66 groups.

The resulting multiple regression coefficients for the full equation are shown in Table 7.4-6. With a multiple-R of 0.84, the equation accounted for 70% of the variance in PCP, but note that there were 21 independent variables and only 66 observations. The reduced equation is given in Table 7.4-5. The improvement in prediction afforded by including all the work-related value factors is given by:

\[
F = \frac{0.700 - 0.563}{0.300} \frac{44}{21 - 10} = 1.83
\]

\[
F(10, 45, .05) = 2.05
\]

The difference in PCP values estimated by the two equations was not significant. At the group level of analysis, as at the individuals level, the inclusion of work-related value factors did not improve the estimate of PCP.

Two work-related value coefficients were significant at the group level of analysis. They were those for the SCIENCE and FULFIL (Work Fulfillment) variables. Both were significant at the .05 level and have b-coefficients of -.318 and .215, respectively. The coefficient for ENG was -.275, larger than that for FULFIL, but it was not significant at the .05 level by a small amount. The b-coefficients for CAREER (.216) and ORGZL (.204) were also worth noting.

For individuals, the coefficients for the SCIENCE and CAREER variables were significant, and those for QKFIX and ORGZL were also relatively large.
Table 7.4-6
Regression Coefficients for Work Flow, Frequency, Respect, and Work-Related Values on PCP for Groups

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0</td>
<td>8.78</td>
<td>14.17</td>
<td>.62</td>
<td></td>
</tr>
<tr>
<td>WI</td>
<td>.327</td>
<td>3.12</td>
<td>1.92</td>
<td>1.62</td>
<td>.24</td>
</tr>
<tr>
<td>DEP</td>
<td>.264</td>
<td>2.45</td>
<td>1.74</td>
<td>1.41</td>
<td>.21</td>
</tr>
<tr>
<td>MTD</td>
<td>-.268</td>
<td>-2.88</td>
<td>1.74</td>
<td>-1.65</td>
<td>-.24</td>
</tr>
<tr>
<td>ADV</td>
<td>.096</td>
<td>1.28</td>
<td>1.47</td>
<td>.87</td>
<td>.13</td>
</tr>
<tr>
<td>DIR</td>
<td>.037</td>
<td>.44</td>
<td>2.19</td>
<td>.20</td>
<td>.03</td>
</tr>
<tr>
<td>FRQ GP</td>
<td>.400</td>
<td>1.91*</td>
<td>.86</td>
<td>2.23</td>
<td>.32</td>
</tr>
<tr>
<td>FRQ2</td>
<td>.130</td>
<td>.63</td>
<td>.80</td>
<td>.79</td>
<td>.12</td>
</tr>
<tr>
<td>FRQ3</td>
<td>-.404</td>
<td>-1.99*</td>
<td>.82</td>
<td>-2.43</td>
<td>-.34</td>
</tr>
<tr>
<td>FRQ4</td>
<td>.203</td>
<td>.94</td>
<td>.86</td>
<td>1.10</td>
<td>.16</td>
</tr>
<tr>
<td>R(LO)</td>
<td>.816</td>
<td>9.91**</td>
<td>1.73</td>
<td>5.72</td>
<td>.65</td>
</tr>
<tr>
<td>R(MOD)</td>
<td>.374</td>
<td>4.40**</td>
<td>1.61</td>
<td>2.73</td>
<td>.38</td>
</tr>
<tr>
<td>PERSRL</td>
<td>.082</td>
<td>1.28</td>
<td>2.31</td>
<td>.55</td>
<td>.08</td>
</tr>
<tr>
<td>ENG</td>
<td>-.275</td>
<td>-3.33</td>
<td>1.65</td>
<td>-2.02</td>
<td>-.29</td>
</tr>
<tr>
<td>FULFIL</td>
<td>.215</td>
<td>3.76*</td>
<td>1.84</td>
<td>2.04</td>
<td>.29</td>
</tr>
<tr>
<td>CAREER</td>
<td>.206</td>
<td>2.40</td>
<td>1.34</td>
<td>1.80</td>
<td>.26</td>
</tr>
<tr>
<td>SCI</td>
<td>-.318</td>
<td>-4.83*</td>
<td>1.99</td>
<td>-2.42</td>
<td>-.34</td>
</tr>
<tr>
<td>PRJDIR</td>
<td>.024</td>
<td>.44</td>
<td>2.06</td>
<td>.21</td>
<td>.03</td>
</tr>
<tr>
<td>QKFIX</td>
<td>-.095</td>
<td>-1.54</td>
<td>2.00</td>
<td>-.77</td>
<td>-.12</td>
</tr>
<tr>
<td>CLGROW</td>
<td>-.015</td>
<td>-.34</td>
<td>2.85</td>
<td>-.12</td>
<td>-.02</td>
</tr>
<tr>
<td>ORGZL</td>
<td>.204</td>
<td>3.15</td>
<td>1.78</td>
<td>1.77</td>
<td>.26</td>
</tr>
<tr>
<td>INTGRT</td>
<td>.073</td>
<td>1.33</td>
<td>2.97</td>
<td>.45</td>
<td>.07</td>
</tr>
</tbody>
</table>

Multiple R = .837
Std. error of PCP\*X = 3.898

Multiple R² = .701
N = 66

*sig. @ p < .05
**sig. @ p < .01
Work-Related Value Differences. A multiple regression equation for PCP with the 10 work-related value differences, two work-related values, and three other variables (Respect, FRQ2, and FRQ3) was formed. Using data from the groups, the results were as indicated in Table 7.4-7. The equation explained 58% of the variance with a multiple-R of 0.58, and 50 degrees of freedom. None of the coefficients for work-related value differences attained a significant level.

This equation may be compared to a reduced equation consisting of R(LO), R(MOD), FRQ2, and FRQ3. This latter equation, with 62 degrees of freedom, had a multiple-R of 0.68 explaining 46% of the variance. Its F-value was 17.80. The critical value was $F(4, 62, .05) = 2.52$, so the value of multiple-R was significant. The F-value of the full equation in comparison to the reduced equation is

$$F = \frac{0.579 - 0.460}{0.421} = 1.29$$

$F(11, 51, .05) = 1.98$

The addition of the value difference terms did not significantly increase multiple-R. We could not reject the null hypothesis that there was no difference in the estimated values of PCP when these terms were included. The increase in multiple-R above was only apparent, caused largely by the restricted number of observations in comparison to the number of variables. The same test result was obtained at the individual level of analysis where the ratio of observations to independent variables was much larger.

Note that at the group level, it was necessary to use repeated values for the value differences. Each group of a pair necessarily had the same difference on a given factor as its counterpart. In effect, this reduced the number of degrees of freedom by roughly one half. A more appropriate value for the critical ratio would be approximately 2.18 rather than 1.98.

Test of P1.3 at the Pairs of Groups Level. The analysis above revealed several variables that significantly affect the PCP scores of individuals and groups. The extended analysis provided insights that would not have been obtained if Propositions P1.2 and P1.3 had been tested using only the factors contained in them. At both the individual and group level, the task interdependence factors had some effect on the PCP scores. The Science, Career, and Work Fulfillment values had a minor effect of marginal statistical significance.
Table 7.4-7

Regression Coefficients for Respect, Frequency of Contact, Career, and Science Values, and Value Differences on PCP for Groups

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0</td>
<td>24.11**</td>
<td>4.85</td>
<td>4.97</td>
<td></td>
</tr>
<tr>
<td>FRQ2</td>
<td>.474</td>
<td>2.30**</td>
<td>.71</td>
<td>3.23</td>
<td>.42</td>
</tr>
<tr>
<td>FRQ3</td>
<td>-.156</td>
<td>-.77</td>
<td>.69</td>
<td>-1.12</td>
<td>-.16</td>
</tr>
<tr>
<td>R(LO)</td>
<td>.683</td>
<td>8.79**</td>
<td>1.55</td>
<td>5.33</td>
<td>.60</td>
</tr>
<tr>
<td>R(MOD)</td>
<td>.404</td>
<td>4.75**</td>
<td>1.46</td>
<td>3.26</td>
<td>.42</td>
</tr>
<tr>
<td>CAREER</td>
<td>.214</td>
<td>2.50*</td>
<td>1.24</td>
<td>2.02</td>
<td>.27</td>
</tr>
<tr>
<td>SCI</td>
<td>-.159</td>
<td>-2.41</td>
<td>1.74</td>
<td>-1.38</td>
<td>-.19</td>
</tr>
<tr>
<td>PERS. D</td>
<td>.100</td>
<td>2.15</td>
<td>2.80</td>
<td>.77</td>
<td>.11</td>
</tr>
<tr>
<td>ENG D</td>
<td>.031</td>
<td>.69</td>
<td>2.68</td>
<td>.26</td>
<td>.04</td>
</tr>
<tr>
<td>FULFL D</td>
<td>.041</td>
<td>.51</td>
<td>1.39</td>
<td>.37</td>
<td>.05</td>
</tr>
<tr>
<td>CARER D</td>
<td>.064</td>
<td>1.56</td>
<td>2.79</td>
<td>.56</td>
<td>.08</td>
</tr>
<tr>
<td>SCI D</td>
<td>-.079</td>
<td>-1.80</td>
<td>2.49</td>
<td>-.72</td>
<td>-.10</td>
</tr>
<tr>
<td>QKFIX D</td>
<td>.066</td>
<td>2.14</td>
<td>3.52</td>
<td>.61</td>
<td>.09</td>
</tr>
<tr>
<td>CLGRW D</td>
<td>-.085</td>
<td>-1.92</td>
<td>2.46</td>
<td>-.78</td>
<td>-.10</td>
</tr>
<tr>
<td>ORGZL D</td>
<td>-.179</td>
<td>-4.08</td>
<td>2.92</td>
<td>-1.40</td>
<td>-.19</td>
</tr>
<tr>
<td>INTG D</td>
<td>.080</td>
<td>.96</td>
<td>1.43</td>
<td>.67</td>
<td>.09</td>
</tr>
</tbody>
</table>

Multiple R = .76
Std. Error of PCP·X = 4.34
Multiple R² = .579

* sig. @ p < .05
** sig. @ p < .01
N = 66
Value differences did not have an appreciable effect.

At the "pairs of groups" level, a multiple regression equation of PCP with the value differences alone was formed as shown in Table 7.4-8. The coefficients for differences in the Personal Relationship and Integrity factors did not attain a sufficient value to be included in the equation. None of the coefficients were statistically significant of themselves. The multiple-R of 0.42 explained 18% of the variance. The F-value was:

\[ F = \frac{0.424}{.576} \cdot \frac{24}{8} = 2.21 \]

\[ F(8, 24, .05) = 2.36 \]

The equation was not significant. The null hypothesis for P1.3 could not be rejected. At the pairs of groups level of analysis, differences in work-related values between groups did not explain the PCP scores measured.
Table 7.4-8

Regression Coefficients for Work-Related Value Differences on PCP for Group Pairs

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>34.92**</td>
<td>3.94</td>
<td>8.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PERS D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(F-value insufficient for inclusion)</td>
</tr>
<tr>
<td>ENG D</td>
<td>.200</td>
<td>3.13</td>
<td>3.61</td>
<td>0.86</td>
<td>.17</td>
</tr>
<tr>
<td>FULFL D</td>
<td>.080</td>
<td>1.40</td>
<td>3.79</td>
<td>0.37</td>
<td>.08</td>
</tr>
<tr>
<td>CARER D</td>
<td>.096</td>
<td>0.92</td>
<td>2.04</td>
<td>0.45</td>
<td>.09</td>
</tr>
<tr>
<td>SCI D</td>
<td>.092</td>
<td>1.78</td>
<td>4.50</td>
<td>0.39</td>
<td>.08</td>
</tr>
<tr>
<td>PRJDR D</td>
<td>-.352</td>
<td>-6.49</td>
<td>3.93</td>
<td>-1.65</td>
<td>-.32</td>
</tr>
<tr>
<td>QKFIX D</td>
<td>.204</td>
<td>3.03</td>
<td>3.91</td>
<td>0.77</td>
<td>.16</td>
</tr>
<tr>
<td>CLGRW D</td>
<td>-.300</td>
<td>-7.90</td>
<td>5.92</td>
<td>-1.33</td>
<td>-.26</td>
</tr>
<tr>
<td>ORGZL D</td>
<td>-.038</td>
<td>-0.63</td>
<td>4.44</td>
<td>-0.14</td>
<td>-.03</td>
</tr>
<tr>
<td>INTG D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(F-value insufficient for inclusion)</td>
</tr>
</tbody>
</table>

Multiple-R = 0.424
Std. error of PCP·X = 5.04
Multiple R² = 0.180
N = 33

*sig. @ p ≤ .05  
**sig. @ p ≤ .01
7.4.5 - Test of Propositions P1.2 and P1.3 with Rank-Order Data

Procedure. An alternative measure of similarity and dissimilarity in values is available from the rank-order questionnaire, Q09. In the second set of instructions, the respondent was asked to rank the set of 20 work-related value items in order of importance to himself. The mean rank order for each group was determined as described in Chapter 5. The rank order of an individual's values with respect to his Referenced Group ranking, or of one group with respect to its counterpart, provides a measure of the similarity between the two.

Since the numeric data were rank numbers, a non-parametric measure of association, such as Kendall's rank order correlation coefficient $\tau$ (Siegel, 1956) was used to provide a measure of the similarity between two sets of item rankings. The greater the coefficient, the more similar the two sets of ranks. The magnitudes of the Kendall-$\tau$ coefficients were used to rank order the pairs of groups on the degree of similarity of their values. Kendall-$\tau$ ranges from +1.0 to -1.0. For N pairs of groups, the pair with the coefficient closest to +1.00 was given rank #1, the pair with the coefficient closest to -1.00 was given rank #N, and all others were ranked in between. The individuals, or pairs, were also rank-ordered by their PCP scores and TI scores. The similarity of an individual's rank ordering of the 20 items with the mean ranking of the same items by his Referenced Group was established in the same manner.

With a rank order established for the independent and dependent variables, the propositions were tested with the Q09 data using the non-parametric correlation coefficient. Since task interdependence was stated as a parameter in the propositions, partial correlations must be taken. This was done with the Kendall-$\tau$ rank order correlation coefficient. Partial correlation cannot be taken with the Spearman-$\rho$ rank order correlation coefficient. The equation for the Kendall partial correlation is (Siegel, 1956, p. 226):

$$\tau_{xy'z} = \frac{\tau_{xy} - \tau_{zy} \tau_{xz}}{\sqrt{(1 - \tau_{zy}^2)(1 - \tau_{zx}^2)}}$$

The significance levels of Kendall-$\tau$ were determined by calculating their z-value as follows (Siegel, 1956, p. 221):
\[ z = \sqrt{\frac{2(2N + 5)}{9N(N - 1)}} \]

and determining the associated one-tailed probability from a normal curve table. This test is applicable when \( N \) is greater than 8. Since there were 20 items in the Q09 questionnaire and 230 or more respondents to the various questionnaires, it was applicable. There is no test for the significance of a Kendall partial rank correlation coefficient. As noted before, such tests are strictly applicable only when the data is obtained from a random sample of a population. We used tests of significance here to provide a benchmark for interpreting the correlation coefficients.

Rank order data was obtained from 60 groups (or 30 pairs). The input data for the analysis below came from 232 individuals in these groups who completed part B of questionnaire Q09.

**Results.** The correlation coefficients needed to test the propositions are listed in Table 7.4-9. Note that the sign of the correlations needs to be interpreted with care. Support for the proposition is indicated by a negative correlation between similarity of value rankings and PCP (high rank in similarity associated with low rank in PCP and vice versa).

The parameter, task interdependence (TI), is not associated with PCP. Note that this is not an independent confirmation of this same result noted in prior sections. It is merely a replication using a rank order statistic with exactly the same data. The parameter has no effect at either the individual level of analysis (Pl.2) or the group pair level (Pl.3).

At the individual level there is no association between similarity of values and PCP. At the group pair level there is an association, but in the opposite direction to that predicted. The value of 0.30 would be significant in a one-tailed test if the proposition stated that value similarity would lead to problems in communication. The test was repeated using only those pairs where
Table 7.4-9

Rank Order Correlations for Pl.2 and Pl.3

<table>
<thead>
<tr>
<th>Proposition:</th>
<th>Pl.2</th>
<th>Pl.2</th>
<th>Pl.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tau of ACLSIM, PCP</td>
<td>0.04</td>
<td>0.30*†</td>
<td>0.18</td>
</tr>
<tr>
<td>z-value</td>
<td>0.92</td>
<td>2.29</td>
<td>0.78</td>
</tr>
<tr>
<td>Tau of ACLSIM, TI</td>
<td>-0.02</td>
<td>-0.13</td>
<td>-0.13</td>
</tr>
<tr>
<td>z-value</td>
<td>-0.50</td>
<td>-0.98</td>
<td>-0.54</td>
</tr>
<tr>
<td>Tau of TI, PCP</td>
<td>-0.06</td>
<td>-0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>z-value</td>
<td>-1.47</td>
<td>-0.73</td>
<td>0.08</td>
</tr>
<tr>
<td>Partial tau ACLSIM, PCP-TI</td>
<td>0.04</td>
<td>0.30</td>
<td>0.18</td>
</tr>
<tr>
<td>(No test available)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>232</td>
<td>30</td>
<td>11</td>
</tr>
</tbody>
</table>

* Sig. (one-tailed) @ .05 for z ≥ 1.64

W ≥ 0.40 for both groups in pair.

† Negatively significant because of reversed sign.

Both groups had concordance, W ≥ 0.40. This eliminated those groups with low homogeneity on the 20 work-related values items. There were 11 pairs of groups that met this condition. The Kendall-tau of 0.18 was not significant. This indicates that the correlation of 0.30 obtained for N = 60 is spurious.
Alternative Test of Pl.2. In the test of Pl.2 above, the individuals were rank-ordered by their actual similarity and PCP scores to obtain the rank order correlation coefficient. The data used in the calculations were the cardinal numbers, 1, 2, 3, etc. The similarity scores were themselves correlation coefficients, as described above. These scores (ACLSIM) were used directly in an alternative test of Proposition Pl.2 by forming a multiple regression equation.* The equation resulting was:

\[ \text{PCP} = 37.5 - 0.55(T1) + 3.58(ACLSIM) \]

The multiple-R for this equation is 0.13, \( R^2 \) is 0.016, and the F-value is 1.82 with 2 and 227 degrees of freedom. The critical F-value is 3.04, so the equation is not significant at the .05 level. Using the tau scores for each individual to form a rank-ordering as we first did, and using them directly, as we did here, provided the same result. A scattergram of PCP vs. ACLSIM is given in Figure 7.6-1 at the end of the chapter.

7.4.6 - Summary of Tests

Anecdotal descriptions of the relations between a few groups and the possible impact of value differences on these relations have been presented in Chapter 6. Here we have tested this concept at the level of individuals (with respect to another group) as expressed in Proposition Pl.2, and at the level of pairs of groups as expressed in Proposition Pl.3. Two different types of data have been used in these tests: a) ratings of importance of 10 values derived as scores based on 76 items (Q02 data), and b) ratings of importance based on the rank ordering of 20 items in a separate instrument (Q09B data). Six statistical tests have been performed--three at the individuals level and three at the pairs of groups level. The propositions have been subjected to disconfirmation by a variety of methods with a variety of data and they have been consistently disconfirmed.

* The use of correlation coefficients as similarity measures was suggested in a discussion with Professor Donald T. Campbell, February 1970. The use of these measures as scores in multiple regression analysis was discussed with Dr. Jack Sawyer and Dr. Marilyn Sorum. Dr. Sawyer approved of this approach. Dr. Sorum advised against using tests of significance in the usual manner for establishing support for a proposition. As noted, tests of significance were made here only to establish "benchmarks" for those propositions worth further investigation.
7.5 - TEST OF "VALUES HOMOGENEITY" PROPOSITIONS P1.4 AND P1.5

Propositions P1.4 and P1.5 are concerned with the effects of the homogeneity of a group's values on the perceived communication problems of the group. The propositions are:

**Proposition P1.4:** For groups with a high level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be much better or much worse than for groups with a moderate degree of homogeneity in their work-related values.

**Proposition P1.5:** For groups with a low level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be worse than for groups with a moderate degree of homogeneity in their work-related values.

The homogeneity of work-related values in a group was measured by calculating the variance of the scores on the 10 value factors about the mean score for all factors. A low variance implies good agreement within the group, whereas high variance implies poor agreement. The corresponding statistic for rank ordered data is Kendall's coefficient of concordance, W (Siegel, 1956). W can vary between 0.0 and 1.0. Its magnitude varies in the opposite manner to the variance statistic. If the agreement in rank ordering for a set of respondents is high, W is large. If the agreement among N respondents is perfect, W = 1.0. If there is no agreement, W = 0.0. When the variance statistic is used, perfect agreement implies no variance; i.e., \( \sigma^2 = 0.0 \). Note that since we are considering the variance of an entire group, it is appropriate to use the actual variance, not the estimated variance of a population. The population in question is the group itself.

7.5.1 - Consideration of a Linear Form

The propositions are essentially non-linear in form. At high levels of homogeneity, P1.4 implies a two-valued function. At low levels of homogeneity, P1.5 implies a curvilinear function or a linear function that would disconfirm P1.4.

Before investigating such functional relationships, following Cronbach's approach (1958) again, we should first investigate the possibility of a simpler relationship. The proposition would be that PCP varies linearly with the homogeneity of values within groups; i.e., that PCP and homogeneity are correlated.
Table 7.5-1

Intercorrelations\* of PCP, Variance, and Concordance Scores for Groups

<table>
<thead>
<tr>
<th></th>
<th>VAR# (Q08)</th>
<th>W (Q09A)</th>
<th>W (Q09B)</th>
<th>PCP-RG</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP</td>
<td>.13</td>
<td>-.14</td>
<td>-.04</td>
<td>.28</td>
</tr>
<tr>
<td>VAR#</td>
<td>-</td>
<td>-.17</td>
<td></td>
<td>-.39</td>
</tr>
<tr>
<td>W(Q09A)</td>
<td></td>
<td>.50</td>
<td>-</td>
<td>-.12</td>
</tr>
<tr>
<td>W(Q09B)</td>
<td></td>
<td></td>
<td></td>
<td>.03</td>
</tr>
</tbody>
</table>

*Significance levels not given. (see text).

#Signs reversed for conceptual consistency. A positive value in both the VAR and W columns and rows denotes increasing homogeneity is associated positively with other variables of the correlation (see text).

The correlations for this linear proposition appear in the upper row of the intercorrelations shown in Table 7.5-1. (Signs of the correlations with variance scores have been reversed so that all signs in the table are consistent with each other.) Q09B refers to the rank ordering of 20 value items on the basis of importance to oneself. Q09A refers to the rank ordering of 20 value items as the respondent believes the members of the Referenced Group would rank them (see Section 4.5.3). PCP refers to the group for which the variance and concordance scores are calculated. PCP-RG refers to the PCP score of their Referenced Group.

This calculation treats variance and concordance statistical measures as scores in order to provide an indication of the degree of association involved in the various measures. It is not appropriate to apply a test of significance. At best, the value of $r$, significant at the usual 0.05 and 0.01 levels, provides only a rough benchmark of the minimum value of $r$ to pay attention to as merit.
further investigation. These values are $r = 0.26$ at the 0.05 significance level and $r = 0.33$ at the 0.01 significance level.

Clearly the correlations of PCP with the three homogeneity measures (0.13, -0.14, and -0.04) show that there is no distinct over-all association between homogeneity and the level of communication problems a group sees as existing between themselves and another group. Two of the three homogeneity measures also show no association with the PCP score of the Referenced Group (-0.12 and 0.03). The correlation of PCP-RG with VAR (variance of scores on the 10 value factors) is -0.39. (The sign has already been reversed.) This weakly implies that the more homogeneous a group's values are, the fewer the problems in communication their Referenced Group will have in dealing with them. But this is not supported by the data from Q09B which measures the same underlying variable. If this were a strong relationship, it should appear in both coefficients.

The linear hypothesis does not provide a simpler explanation of the phenomena postulated in Propositions Pl.4 and Pl.5.

7.5.2 - Test of Proposition Pl.4

Proposition Pl.4 considers the effect of high homogeneity within a group on their perceived communication problems with another group. For the purposes of this study, high homogeneity was defined as the upper quartile of groups ranked on a homogeneity measure. The proposition implies that the PCP scores of the groups in the upper quartile of homogeneity will tend to be either high or low. More particularly, it implies that their scores will not be in the vicinity of the mean. These categories have to be defined more precisely for a statistical test, but before doing so the scattergrams visually displaying the relationship were examined.

Figures 7.5-1 and 7.5-2 show the distribution of PCP scores with the two measures of homogeneity, variance and concordance. In Figure 7.5-1 (variance), the high homogeneity groups are those on the left; in Figure 7.5-2, those on the right. The PCP scores for these groups tend to cluster about the mean and do not tend towards extreme values.

The scattergram of the PCP scores from each group's Referenced Group (PCP-RG) are displayed in Figures 7.5-3 and 7.5-4 against the same two measures of
Fig. 7.5-1 - Scattergram of Group PCP Scores vs. Work-Related Values Variance (Q08 data).

N = 66

Fig. 7.5-2 - Scattergram of Group PCP Scores vs. Concordance (Q09B data).

N = 58
Fig. 7.5-3 - Scattergram of Referenced Group PCP Score vs. Work-Related Values Variance (Q08 data).  
N = 66

Fig. 7.5-4 - Scattergram of Referenced Group PCP Scores vs. Concordance (Q09B data).  
N = 58
homogeneity. The variance measure (Figure 7.5-3) shows the same pattern. Figure 7.5-4 is somewhat different. By definition there are 15 scores in the upper quartile of concordance. Of these, 4 scores are in the upper quartile of PCP-RG, and 6 in the lower quartile. However, there are also 5 scores in the two middle quartiles, so this scattergram does not support the proposition either.

By visual inspection of the scattergrams, it was apparent that a statistical test of Pl.4 would be superfluous. The proposition was clearly disconfirmed. Since this proposition was not supported, data from all of the groups could be used in testing Pl.5. Visual inspection of the low homogeneity scores again indicated that Pl.5 was unlikely to be supported, but the evidence is not so clear-cut. The statistical tests performed are presented in the next section.

7.5.3 - Test of Proposition Pl.5

Proposition Pl.5, quoted earlier, essentially states that groups with low homogeneity (high variance) in their work-related values will tend to have higher PCP scores than other groups.

Procedure. The low homogeneity set is defined as the lower quartile of rank-ordered homogeneity scores for groups. For scores based on the variance in the 10 value factors, this is the quartile of largest VAR scores. For concordance scores based on the Values Ranking questionnaire, Q09B, this is the quartile of smallest W scores. The mean PCP score of the low homogeneity set was compared to the mean PCP score of the remainder. Both the mean PCP score of the group and the PCP score for their Referenced Group (PCP-RG) were tested. The a priori proposition applies only to the former. For VAR data, N = 66; so for the lower quartile, N₁ = 16. For W data, N = 58; so for the lower quartile, N₁ = 15.

Results. None of the differences in mean scores are significant, as shown below.

<table>
<thead>
<tr>
<th>VAR data</th>
<th>PCP</th>
<th>s.d.</th>
<th>PCP-RG</th>
<th>s.d.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lo Homogeneity Set</td>
<td>32.06</td>
<td>6.85</td>
<td>36.49</td>
<td>6.32</td>
<td>16</td>
</tr>
<tr>
<td>All Others</td>
<td>34.86</td>
<td>5.27</td>
<td>33.44</td>
<td>5.44</td>
<td>50</td>
</tr>
<tr>
<td>t-value</td>
<td>-1.68</td>
<td></td>
<td>1.85</td>
<td></td>
<td>d.f. = 64</td>
</tr>
</tbody>
</table>

\[ t_{(64, .05)} = 2.00 \]
The VAR data was retested using only the same groups that were available for the W(Q09B) data with the following results:

**W(Q09B) data**

<table>
<thead>
<tr>
<th></th>
<th>Lo Homogeneity Set</th>
<th>All Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36.16 4.36</td>
<td>36.05 5.91</td>
</tr>
<tr>
<td>t-value</td>
<td>1.58</td>
<td>1.48</td>
</tr>
<tr>
<td>d.f. = 56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ t_{(56, .05)} = 2.01 \]

The difference in PCP scores ascribed by the Reference Groups to the subject groups is significant in this case.

**VAR data**

<table>
<thead>
<tr>
<th></th>
<th>Lo Homogeneity Set</th>
<th>All Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>33.63 6.05</td>
<td>38.12 3.31</td>
</tr>
<tr>
<td>t-value</td>
<td>-0.63</td>
<td>3.60*</td>
</tr>
<tr>
<td>d.f. = 56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ t_{(56, .05)} = 2.01 \]

Discussion. In the last test the N has been reduced. Four group pairs from three organizations were deleted and a significant difference emerged on one variable. While an explanation for the failure to attain significance with the larger N might be sought by exploring the composition of the groups involved or on some other basis, this does not appear to be prudent. It is more likely an artifact, since no significant differences appear in the data based on Q09B or when all the VAR data (based on the 10 value factor scores) is used. When the groups' own PCP scores were used, no significant differences emerge in any of the tests.
7.6 - TESTS OF PROPOSITIONS P2.1 - P2.4

Whereas the previous set of propositions have involved comparisons of the values held by individuals or groups with their Referenced Group's values, propositions P2.1 through P2.4 involve the individual's perceptions, knowledge, or understanding of another's values. Part of the data that the respondent was asked to provide here involved the more difficult task of expressing the response of another person or group.

7.6.1 - Test of Proposition P2.3

Proposition P2.3: An individual will tend to rate values he considers as central to this own self-image as desirable in others with whom he enters a direct relationship.

The values of the individual were measured with Part B of questionnaire Q09 where the respondent was asked to rank order 20 items on the basis of their importance to himself. At least some of the 20 items should have been important to the respondents in each group. The list of items was not a fixed set for the whole study. The items were selected for each group pair so as to include some items that each group agreed were important, using the selection algorithm described in Chapter 4.

The values of a person with whom the respondent would be in a direct working relationship were measured in Part C of the rank ordering. The same 20 items were presented in a different order. The instructions were:

This is a hypothetical situation. In a new organization of which you are a part, you are doing exactly the kind of work you would like to do. You are to hire an associate to work with you. He will be available as much or as little as you need him. Assign numbers from 0 to 99 the way you think the ideal man for this position would do so.

By comparing the two sets of rank orderings, the extent to which respondents tended to consider their own work-related values as being desirable for their ideal associates was determined.

Procedure. The degree of association between the Q09B and Q09C rank ordering was determined by using the Spearman rank order correlation coefficient, $r_s$. When the number of items rank ordered was 10 or more, the significance of an $r_s$ under the null hypothesis was tested by (Siegel, 1956, p. 212):
This applied to each respondent's set of rank orderings, so \( N = 20 \). An \( r_s = 0.38 \) was significant at the 0.05 level, and an \( r_s = 0.52 \) was significant at the 0.01 level. The frequency of occurrence of significant \( r \)'s and the mean \( t \)-value were determined.

**Results.** Of the 235 respondents that filled out the Q09 questionnaire, 230 fully completed Parts B and C. There were:

\[
\begin{align*}
190 & \quad \{ 159 \text{ } r \text{'s significant at the .01 level} \\
31 & \quad \{ 31 \text{ } r \text{'s significant at the .05 level} \\
40 & \quad \{ \text{not significant} \\
\end{align*}
\]

82% of the correlations were significant at the .05 level or better. The mean \( t \)-value of the 230 correlations was 1.84, significant at the .05 level. Proposition P2.3 was not disconfirmed.

**Discussion.** This test of the proposition was made using the respondent's image of his ideal associate. What about their real associates? The data used to develop one of the variables, "perceived similarity," in the next proposition provided the opportunity to make this comparison between the ideal and actual associates of the respondents. Since this data came from groups of people who had been working together over a considerable period of time, presumably they had had opportunities to become familiar with those things which the others in the group considered important. However, if they respected the other person or group, they might also tend to perceive the other as holding their own values (given that P2.1 was not disconfirmed). The net effect would be that Proposition P2.3, when tested against "actual associates" instead of an "ideal associate," as above, should also be supported, but with a smaller number of significant cases. The findings obtained will be discussed in Section 7.6.3.
7.6.2 - Tests of Proposition P2.1

**Proposition P2.1:** The higher the level of respect that an individual has for another person or group, the more he will tend to perceive the other as holding his own positive values.

**Procedure.** The proposition involves two variables and was tested by correlating them. The variables were called "level of respect" and "perceived similarity." Level of respect was measured by question #20 of Q02. A score for perceived similarity (PRCSIM) was derived from responses to Part A and Part B of Q09. In Part A the respondent was asked to order the 20 items as he thought his Referenced Group would. In Part B he ranked them in order of importance to himself. As described in detail in Chapter 4, fifteen of the items were chosen so as to include ones that were important to each group but that were less important or unimportant to the other group of the pair. The PRCSIM score is the Kendall-tau rank order correlation of the respondent's responses to Q09A and Q09B.

The PRCSIM and respect scores were ranked and the Kendall-tau correlation determined. The significance level was determined as referenced in Section 7.4.6.

**Results.** The Kendall-tau correlation between Respect and PRCSIM for 230 respondents was 0.135. The z-value of 3.05 is significant at the 0.001 level. The proposition was not disconfirmed by this data.

**Alternate Test.** The proposition was also tested using the same data in a different manner. A stepwise multiple regression analysis was performed with PRCSIM as the dependent variable and R(LO), R(MOD), and TI as the independent variables. Presumably, increasing task interdependence would increase the opportunities for the respondent to become more aware of the other's values. Increasing task interdependence could then tend to reduce the correlation between the respondent's own values and his perception of the other's values, to the extent that the other's values are different. Therefore, we would expect that the sign of the partial correlation of TI with PRCSIM, or the sign of the regression coefficient, would be negative.

In the first test above, rank order data was used. In order to do the stepwise regression, the Kendall-tau coefficients for PRCSIM were used as scores. The
respect variable was entered as two dummy variables, defined as in Section 7.4.1.

**Results.** In the first step, R(LO) entered the equation. The F-value of 6.04 exceeds the critical F-value of 3.89 at the .05 level. In the second step, TI entered. The F-value of 4.04 for the equation exceeds the critical F of 3.04. In the last step R(MOD) entered the equation. The F-value of 3.05 exceeds the critical F of 2.65. The final equation, with coefficients for raw scores, is:

\[ \text{PRCSIM} = 0.224 - 0.129(R(LO)) - 0.055(R(MOD)) + 0.023(TI) \]

The multiple-R is 0.20 and \( R^2 = 0.039 \). The sign of TI is positive, contrary to expectations, but the t-value for its coefficient is not significant.

The use of this approach to testing the proposition gave the same results as the first one. The major difference was not the inclusion of TI, but the use of the Kendall-\( \tau \) as scores rather than just as a means to perform a rank ordering.

7.6.3 - Second Test of Proposition P2.3

Since Proposition P2.1 was not disconfirmed, the second independent test of Proposition P2.3 was made using the Q09A data about an actual other, rather than the Q09C data about an ideal other. This provided a more severe test of the proposition.

**Procedure.** The z-scores were recorded for the Kendall-\( \tau \)s used as the PRCSIM scores in testing P2.1. For 20 items a \( \tau \) with a z between 1.645 and 2.329 was significant at the .05 level or better. If \( z \geq 2.329 \), \( \tau \) was significant at the .01 level. The mean \( \tau \) was also determined.

**Results.** The mean z-value was 1.775, which has an associated probability level of 0.038, so the alternate form of P2.3 was significant at better than the .05
level. The prediction concerning the smaller number of significant scores was also verified, as shown in Table 7.6-1. For the "ideal associate," 82% of the responses were significant. For the actual associate, 54% of the responses were significant.

Table 7.6-1
Number of Significant Responses for Ideal and Actual Associates' Value Similarity

<table>
<thead>
<tr>
<th></th>
<th>Ideal Associate</th>
<th>Actual Associates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sig. at .01 level</td>
<td>159 }</td>
<td>96 }</td>
</tr>
<tr>
<td>Sig. at .05 level</td>
<td>31 }</td>
<td>33 }</td>
</tr>
<tr>
<td>Not significant</td>
<td>40 }</td>
<td>108</td>
</tr>
</tbody>
</table>

Discussion. Proposition P2.3 was not disconfirmed by either set of data. The reduction in the proportion of significant responses from the individual respondents was also demonstrated. Presumably, this reduction arose in part because the respondents tended to base their rankings in Q09A on their knowledge of the Referenced Group. They had some degree of perceptual accuracy in describing the other group's responses. The extent to which this occurred is discussed in connection with Proposition P2.4 which involves the variable of perceptual accuracy.

7.6.4 - Tests of Proposition P2.4

Proposition P2.4: The greater the discrepancy between the work-related values imputed to B by A and B's self-reported (i.e., "actual") values, the greater the perceived communication problems with B.

The variable "discrepancy between ... values imputed ... and ... actual values," can also be described from another viewpoint as "perceptual accuracy." The former is the complement of the latter. The proposition was tested using this variable which was designated PRLACC. The form of the proposition in a
Correlation test was then: PRLACC is negatively correlated with PCP.

Procedure. The PRLACC score for each respondent was based on a Kendall-tau correlation coefficient. It was taken between the response to Q09A and the mean rankings for Q09B of the respondent's Referenced Group; i.e., between how the respondent perceived the Referenced Group would respond and how they actually did. This set of PRLACC scores was then correlated with the PCP scores from each respondent. Again, a second Kendall-tau was calculated.

Results. The Kendall-tau correlation between PRLACC and PCP for 232 respondents was -0.01. The result is clearly not significant.

Alternative Test of P2.4. An alternative test was again performed in a similar manner as before. The PRLACC scores were utilized directly, instead of as a means to forming a rank ordering, and the Pearson-r correlation between PRLACC and PCP determined. The value obtained was $r = -0.09$. The value of $r$ required for significance at the .05 level with 228 degrees of freedom is 0.138, so this result also is not significantly different from 0.0. The scattergram of perceptual accuracy vs. PCP is shown in Fig. 7.6-2 located at the end of this section.

Discussion. The number of respondents whose perceptual accuracy was significantly better than 0.0 was determined. 38% of the correlations were significant at the .05 level or better. The results were:

- 41 pairs significant at the .01 level
- 46 pairs significant at the .05 level
- 145 pairs not significant
7.6.5 - Tests of Proposition P2.2

**Proposition 2.2.** (A) The more an individual perceives another as holding his own (positive) values, the fewer the communication problems he will tend to perceive, but

(B) the less the actual similarity, the more perceived communication problems will tend to increase with increasing perception of similarity of values.

This two-part proposition relates perceived similarity of values (PRCSIM) and actual similarity (ACLSIM) to PCP. Ignoring the effect of ACLSIM, P2.2A predicts a negative correlation between PRCSIM and PCP. The relationship expressed in P2.2B in conjunction with P2.2A is that the correlation of PRCSIM with PCP will change sign between those high on ACLSIM and those low on ACLSIM:

```
PRCSIM

Lo ACLSIM

Hi ACLSIM
```

**Procedure for P2.2A.** The method by which the variables were formed has already been described in previous sections. The proposition was tested by correlating PRCSIM with PCP and testing that the result was significantly different from zero.

**Results.** The correlation of PRCSIM with PCP for 230 respondents was $-0.20$. This result was significant at the 0.01 level. The scattergram is shown in Fig. 7.6-3.

**Procedure for P2.2B.** The intended method was to compare the sign of the PRCSIM: PCP correlation for those with positive ACLSIM scores significantly different from 0.0 to the sign of the correlation for those with negative ACLSIM scores significantly different from 0.0. While there were 129 cases of significantly positive ACLSIM scores, there were only 7 cases of significantly negative ACLSIM scores. Seven cases were not considered sufficient to establish a meaningful correlation, so it was not possible to test P2.2B.

* Discussion with Dr. M. Sorum, July 1970.*
Discussion. The method of selecting items for Q09 was designed so as to include items that were valued by one group, but not the other. This procedure was designed to minimize inflation of the perceptual accuracy and perceived similarity scores. While serving a useful purpose for several of the propositions, it may have been a cause of not obtaining enough cases to be able to test P2.2B. Five of the items were picked on the basis of maximum difference in importance between the groups. These items would likely tend to provide cases useful for testing this proposition. But 10 of the items, five for each group, were picked because of their importance to one group or the other with the restriction that they not be in the upper quartile for the counterpart group. The effect was to pick 10 items that were high in importance to one group and of "moderate to moderately high" importance to the other group of the pair. These 10 items tended not to provide cases for testing P2.2B. The other five items were common to all Q09 instruments. Thus, only 5 of the 15 items were likely to provide opportunities for differences of sufficient magnitude to emerge.
Propositions P1.2, P2.2A, and P2.4 all share the same dependent variable, PCP. P2.2A was supported; the other two were not. However, the partial correlations of each with PCP, eliminating the effect of the other two, was not determined in the previous analyses. A multiple regression equation may be formed to do this analysis. The model tested was:

\[
PCP = B_0 + B_1(\text{PRCSIM}) + B_2(\text{ACLSIM}) + B_3(\text{PRLACC})
\]

This is a statement of the combined propositions. To be consistent with P1.2, P2.2A, and P2.4, each coefficient must be negative.

Procedure. The method for determining the variable scores has already been described. Use of these scores, which are actually correlation coefficients, in a non-parametric test and then in a parametric test has consistently produced the same results of support or disconfirmation of a proposition. On the weight of this evidence, and discussions with Professors Donald T. Campbell (February, 1970) and Jack Sawyer (June, 1970), the multiple regression technique using correlation coefficients as scores was employed.

Results. The multiple-R of the equation is 0.24 accounting for 5.6% of the variance in PCP scores for 230 respondents. The F-value is 5.44 with 3 and 226 degrees of freedom. The critical F-value at the 0.01 level is 3.88. The values and characteristics of the coefficients are shown in Table 7.6-2. Two of the coefficients are significant at the .05 level or better and one at the .10 level. Scattergrams of the three independent variables against PCP are shown in Figures 7.6-1 through 7.6-3.

Discussion. When the effects of the other variables are taken into account, Proposition P2.4 involving perceived similarity (PRCSIM) is clearly not disconfirmed with a significance level of .001; Proposition P2.2A involving perceptual accuracy (PRLACC) is marginally not disconfirmed with a significance level of .10; and Proposition P1.2 involving actual similarity (ACLSIM) is disconfirmed with a positive coefficient instead of a negative one. However, this latter coefficient is significant at the .05 level. This implies that differences in values, at least as measured with this instrument (Q09), in this sample, tend to reduce the communication problems individuals perceive in dealing with another group when the effect of perceived similarity (i.e., projection) and perceptual accuracy are removed.
Table 7.6-2
Regression Coefficients for Propositions P1.2, P2.2A, and P2.4 Combined

<table>
<thead>
<tr>
<th>X</th>
<th>b</th>
<th>B</th>
<th>Std. Error</th>
<th>t-value</th>
<th>Partial Corr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>35.86***</td>
<td>.80</td>
<td>44.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRCSIM</td>
<td>-.226</td>
<td>-6.04***</td>
<td>1.74</td>
<td>-3.46</td>
<td>-.22</td>
</tr>
<tr>
<td>ACLSIM</td>
<td>.117</td>
<td>5.39*</td>
<td>2.59</td>
<td>2.08</td>
<td>.14</td>
</tr>
<tr>
<td>PRLACC</td>
<td>-.036</td>
<td>-1.17#</td>
<td>.72</td>
<td>-1.62</td>
<td>-.11</td>
</tr>
</tbody>
</table>

Multiple-R = 0.24
Std. error of PCP·X = 7.59
Multiple R² = 0.056
N = 230

*** sig. @ p ≤ .001
* sig. @ p ≤ .05
# sig. @ p ≤ .10

Fig. 7.6-1 - Scattergram of Actual Similarity of Values vs. PCP
N = 230
Figure 7.6-2 - Scattergram of Perceptual Accuracy vs. PCP

Figure 7.6-3 - Scattergram of Perceived Similarity vs. PCP
Chapter 8

DISCUSSION OF FINDINGS AND OBSERVATIONS

8.1 - OVERVIEW

This study was designed to test in depth a limited number of propositions specifically concerned with the information exchange process taking place between technical groups. The propositions have been tested using multiple methods, multiple sources of data and multiple levels of analysis as described in the previous chapter. These results will now be consolidated. The results of proposition tests can be no better than the measures of the variables involved. The characteristics of the variables are reviewed in section 8.2. In section 8.3 the tests are summarized for each proposition. Some of the additional findings noted in the development of the material for proposition testing are discussed in Section 8.4. In the concluding section implications for planned future activities growing out of this research are presented.

8.2 - DISCUSSION OF THE VARIABLES

The variables used in testing the propositions and their characteristics are briefly discussed in this section. The dependent variable for most of the propositions was Perceived Communication Problems (PCP). The nature of the perceived task relationship between groups was measured in terms of four components: Work Initiation and Influence (WI), Input/Output Dependence (DEP), Mutual Dependence (MTD), and Advice and Consultation (ADV). The sum of DEP and MTD was used as a measure of Task Interdependence (TI). These components of the perceived task relationship were included as parameters in the tests of several of the propositions.

The independent variable was Similarity (or differences) in Values. This was measured in two ways: a) in terms of ten work-related value categories, and b) by comparisons of the rank-orderings of 20 items (ACLSIM). Two other variables, Perceived Similarity (PRCSIM) and Perceptual Accuracy (PRLACC) were based on rank-order data.
Insofar as it has been possible to evaluate the characteristics of the measures of the variables from this one study, it appears that they were acceptable to use in testing the propositions.

8.2.1 - Perceived Communication Problems (PCP)

It should first be noted that low or high perceived problems in communication are not necessarily "good" or "bad." Either few or many problems can exist for a variety of reasons. Few problems can just as well mean that little useful work is being done as that everyone is well-informed on a timely basis with each producing effectively.

The measure of PCP was a single score based on 15 items. The items measured adequacy of current information, time lags in receiving information, and clarity, accuracy, and completeness of information received. The distribution of scores approximates that of a normal curve covering a range of 6.0 standard deviations for individuals and 4.8 standard deviations for groups. This indicates that the instrument is capable of eliciting a range of responses that could be expected to exist,* and that the sample of respondents, even though not a random sample, is not likely to be a strongly biased representation of the population of R&D engineers and scientists working in project groups. (These two observations are not independent of each other. However, if one condition or the other had been grossly violated, it is likely that either the normal distribution property or the $6\sigma$ range, respectively, would have been quite different.)

The inter-item reliability of the PCP scale was 0.82 based on the data from respondents in the field study. The consistancy of the responses was further demonstrated by examining the pattern of inter-correlations among more and less closely related items.

In Chapter 6 the validity of the PCP scale was indicated by relating the measured PCP scores of eight groups to their activities and relationships as expressed in interviews with respondents and managers.

* "The standard deviation of a sample will ordinarily be from about one-third to one sixth of the range, tending to be relatively smaller as the sample size increases. ... We may expect the range to embrace about $4\sigma$ when n = 30, $5\sigma$ when n = 100, and $6\sigma$ when n = 450." (Diamond, 1959, p. 84).
8.2.2 - Task Interdependence Measures

Four dimensions of task interdependence describing the nature of the task relationship between the groups were measured by 25 items in Douds' Q02 instrument and 26 items in Barth's Q09.2 instrument. The four dimensions were Work Initiation and Influence (WI), Input/Output Dependence (DEP), Mutual Dependence (MTD), and Advisory and Consulting Interdependence (ADV). The scores on these scales in the two instruments covered a range from 4.5 to 5.7 standard deviations. The inter-item reliabilities ranged from 0.68 to 0.85 (with one exception in the ADV scale as discussed in section 5.4.3). Test-retest reliability on eight identical items ranged from 0.51 to 0.69.

The single scale for Task Interdependence (TI) was formed from the sum of DEP and MTD, each score being equally weighted. The distribution of scores approximated that of a normal distribution with a somewhat extended tail in the low scores.

The validation of the four dimensions was partially established by showing the convergent and discriminant validities of the scales as measured by the two instruments. The multitrait-multimethod matrix approach of Campbell and Fiske (1959) was used in this process. The validity of these scores was further indicated in the detailed examination of eight groups based upon interviews with respondents and managers from the organizations involved.

8.2.3 - Work-Related Value Measures

Ten work-related value categories were selected on the basis of a factor analysis of 80 items. The abbreviated and full names for the scales established from these factors were as follows (in rank order):

1. INTEGRITY - Professional and Personal Integrity Values
2. COLLEGIAL GROWTH - Collegial Growth Values
3. PROJECT DIRECTION - Project Direction or Guidance Values
4. WORK FULFILLMENT - Scientific or Technological Work Fulfillment Values
5. ENGINEERING - Engineering and Technological Performance Values
6. PERSONAL RELATIONSHIP - Personal Interaction or Relationship Values
7. ORGANIZATION - Organizational Performance Values
The scores on each of the ten work-related values scales had ranges of 5.1 to 6.2 standard deviations with a mean of 5.7 standard deviations. The range of scores for groups is similar—from 4.5 to 6.4 standard deviations with a mean of 5.6 standard deviations. Again, this indicates that the instrument itself actually elicits a diversity of responses, and simultaneously that the sample of respondents and groups of the study is not likely to be a strongly biased representation of the R&D population.

Both the inter-item reliability and test-retest reliability of the ten scales were determined. Based on data from respondents in the field study, the inter-item reliability of the values instrument as a whole was 0.92. For the individual scales the inter-item reliability ranged from 0.50 to 0.87 with a mean of 0.74.* Test-retest reliability was established with a group of 27 engineers and 23 night school business students. The test-retest reliability for the instrument as a whole was 0.83. For the individual scales the test-retest reliability ranged from 0.58 to 0.88 with a mean of 0.77.*

One measure of the similarity or difference in values between two groups of a pair was formed by taking the difference in the mean scores of the groups (or of an individual and his Referenced Group) on each of the ten scales.

A second measure of the actual similarity of values (ACLSIM) was based on the comparison of the rank ordering of two sets of 20 items selected from the 80 items. The measure of similarity was the non-parametric correlation (Kendall-tau) between the two sets of rank orders.

8.2.4 - Other Measures

Four items in CD Q02 concerned frequency of contacts between the groups of a pair. The eight response categories for each item were selected such that a

* This is not a simple algebraic mean since reliability values are correlation coefficients. The mean was calculated by converting them to z values (McNemar, 1962, pp. 139-140).
roughly normal distribution of responses was obtained. The inter-item reliabilty of the items treated as a unit was 0.86.

One question dealt with the respect that an individual had for another group's knowledge and judgment. Five response categories were provided, but only the top three categories were utilized by nearly all (92%) of the respondents. Accordingly, the data was treated as a three-point scale. Even with this limited number of categories, the response to this one question proved to be quite important in explaining the level of perceived communication problems measured, as will be discussed later in this chapter.

Three measures, related to various aspects of value similarity, were derived by comparing sets of 20 items which had been rank ordered under different sets of instructions. One of these, ACLSIM, was described above. The other two, perceived similarity (PRCSIM), and perceptual accuracy (PRLACC) were based on non-parametric correlations in the same manner as ACLSIM. PRCSIM compares the similarity between a respondent's own values (from CD Q09B) with his view of his Referenced Group's values (from CD Q09A). PRLACC compares his view of the other group's values (from his Q09A) with their own mean rank order of the same 20 items from their Q09B responses.

8.2.5 - Evaluation of the Measures and the Sample

From the summary above and the detailed information presented in Chapters 5 and 6, it appears that the measures established for the variables were reasonably successful. The scores were approximately normally distributed. The range of the scores, measured in terms of the number of standard deviations they covered, was at least as large as that which usually occurs for the size of the samples in this study. The reliabilities of the scores on most of the scales were satisfactorily high. The reliabilities of two of the values scales--Organizational and Project Direction--were lower than the others (0.50 and 0.54) as measured on an inter-item basis, but had test-retest correlations of 0.63 and 0.68. Considering both inter-item and test-retest coefficients, the reliability of all the values scales was adequate.

The PCP scale was of particular importance since it was the dependent variable for several propositions. The inter-item reliability of 0.82 attained with it was quite satisfactory.
Information obtained from interviews with managers and respondents indicated that the measurements of the perceptions of the respondents was in agreement with these verbal reports. However, this does not mean that the PCP and four task relationship scales necessarily measure the "actual" levels of these variables. A separate project of different design would be required to establish the relationship between these two sets of variables (the perceived and the "actual").

From the characteristics of the range of the responses and the shape of the distributions for PCP, TI, and the values, it may be conservatively stated that it is not likely that the sample of respondents and groups is a strongly biased sample of the R&D population in government laboratories. However, it was not a random sample and so this basic requirement for the application of significance tests in evaluating propositions was not met. It is likely that the propositions here which are shown to be not significant would also be disconfirmed with data from a random sample. Propositions that are strongly supported may be supported with data from a random sample. However, the best chances for future confirmation come from those propositions that are multiply-supported in tests using different methods and different sources of data. The sample of R&D groups here appears to be adequately representative to be useful in selecting those propositions that merit further investigation.

8.3 - DISCUSSION OF TESTS OF THE PROPOSITIONS

The various tests performed on the propositions were described in the preceding chapter. These tests are summarized in Table 8.3-1. The proposition tested is indicated in the first column. The section of Chapter 7 in which the test was described is noted in the second column. The column headed "Level" refers to the unit of analysis used in the test--individuals, groups, or pairs of groups. The nature of the test performed is given under "Method." The "Source" column indicates the origin of the data used. PCP scores were obtained from CD Q02. TI scores were also obtained from that instrument and from RB Q09.2. The ten work-related values and corresponding value difference scores were obtained from CD Q08. A "V" in that column refers to scores based on the within group variance in value scores. The A, B, and C under Q09 refers to the three sets of rank orders performed with different instructions in that instrument. "W" refers to the within group agreement measure, Kendall's coefficient of concordance. The
Table 8.3-1

Summary of Proposition Tests

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Sec.</th>
<th>Level</th>
<th>Source</th>
<th>Method</th>
<th>Result</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1.2</td>
<td>7.2</td>
<td>X</td>
<td></td>
<td>Partial Corr.</td>
<td>X</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>B,B n.s.</td>
</tr>
<tr>
<td>P1.3</td>
<td>7.2</td>
<td>X X</td>
<td></td>
<td>Correlation</td>
<td>X</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>B,B Neg. Sig.</td>
</tr>
<tr>
<td>P1.3</td>
<td>7.2</td>
<td>X</td>
<td></td>
<td>Visual</td>
<td>X</td>
<td>Possible 5 of 10</td>
</tr>
<tr>
<td>(lower bound)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res., Freq.</td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>Sig.</td>
</tr>
<tr>
<td>TI alone</td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>Sig.</td>
</tr>
<tr>
<td>10 values</td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>Sig.</td>
</tr>
<tr>
<td>alone</td>
<td>7.4</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>Sig.</td>
</tr>
<tr>
<td>Linear Rival</td>
<td></td>
<td></td>
<td></td>
<td>Correlation</td>
<td>X</td>
<td>V W n.s.</td>
</tr>
<tr>
<td>to P1.4 &amp; P1.5</td>
<td>7.5</td>
<td>X</td>
<td></td>
<td>Correlation</td>
<td>X</td>
<td>V W n.s.</td>
</tr>
<tr>
<td>P1.4</td>
<td>7.5</td>
<td>X</td>
<td></td>
<td>Visual</td>
<td>X</td>
<td>V W n.s.</td>
</tr>
<tr>
<td>P1.5</td>
<td>7.5</td>
<td>X</td>
<td></td>
<td>t-test</td>
<td>X</td>
<td>V W n.s.</td>
</tr>
<tr>
<td>P1.5</td>
<td>7.5</td>
<td>X</td>
<td></td>
<td>t-test</td>
<td>X</td>
<td>V W n.s.</td>
</tr>
<tr>
<td>P2.3</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>B,C Sig.</td>
</tr>
<tr>
<td>P2.3</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>B,A Sig.</td>
</tr>
<tr>
<td>P2.1</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>B,A Sig.</td>
</tr>
<tr>
<td>P2.1</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>B,A Sig.</td>
</tr>
<tr>
<td>P2.4</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>BAB n.s.</td>
</tr>
<tr>
<td>P2.4</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>BAB n.s.</td>
</tr>
<tr>
<td>P2.2A</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>B,A Sig.</td>
</tr>
<tr>
<td>P2.2B</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Rank Corr.</td>
<td>X</td>
<td>BAB —</td>
</tr>
<tr>
<td>Combined P1.2, P2.2A, P2.4</td>
<td>7.6</td>
<td>X</td>
<td></td>
<td>Mult. Reg.</td>
<td>X</td>
<td>BAB Sig. 2 coeff. Sig. 1 Neg. Sig.</td>
</tr>
</tbody>
</table>
significance of the results is interpreted in the text with necessary qualifications.

8.3.1 - Tests of Value Similarity Propositions Pl.2 and Pl.3

**Proposition Pl.2:** For a given level of task interdependence perceived by an individual between his working group and another group, the less the similarity of his work-related values to those of the other group, the greater the communication problems he will perceive as existing between the two groups.

**Proposition Pl.3:** For a given level of task interdependence perceived to exist between two working groups by the members of those groups, the less the similarity of the work-related values of the two groups, the greater the communication problems each will perceive as existing between the two groups.

Propositions Pl.2 and Pl.3 concern the effects of similarity or dissimilarity in work-related values between an individual and another group, or between two groups, upon their perceived communication problems.* The perceived level of task interdependence is given as an explicit parameter. Data from two separate instruments (Q08 and Q09) administered at different times was used to test the propositions. The relationship among the variables is diagrammed in Figure 8.3-1 as tested with the ten work-related value clusters from Q08 data, and in Figure 8.3-2 as tested with rank order data from Q09B.

Pl.2 and Pl.3 were tested four ways. In the first test the correlation of PCP with each of the ten value difference scores was determined. None of the correlations were significantly different from zero. While the full set of partial correlations, including the effect of TI, was not formed, it was shown that the partial correlation coefficients would be negligibly different because the correlation between TI and PCP was small and not significantly different from zero. For Pl.3, the analysis was repeated using both groups and group pairs as the unit of analysis. Essentially the same results as above were obtained at both levels. For groups and group pairs, a difference in the Science value was negatively correlated with PCP, contrary to the proposition. At the level of individuals, this result was not obtained.

Visual inspection of the scattergrams for PCP "lower bound" vs. value difference scores provided weak evidence that the postulated effect might exist in the data.

* Proposition Pl.1 is concerned with the same phenomena as it may exist between individuals. The research project was not designed to test this proposition.
if the effects of other variables were removed (Figures 7.2-1 to-10). This was attempted by using multiple regression analysis. In the multiple regression analysis, data was included on each of the four dimensions of task relationship (WI, DEP, MTD, and ADV), on the four aspects of frequency of contact, on the level of respect felt for the other group, and on the values themselves.

The multiple regression analysis was done in three stages for each of the three levels of analysis--individual, group, and group pair. First, the effect of the work relationship, frequency, and respect variables was determined. It was noted that propositions involving variables based on differences (as Pl.2 and Pl.3 are) or higher order terms, always have as a rival hypothesis that the variable itself, rather than the difference score, explains the phenomena. So, the second step was to determine the effects of the ten values, per se, on PCP. The final step was to determine the effect of the ten value differences. In this last step, as many as possible of the other variables which had shown significant effects on PCP were included. The number of variables which could be included was limited by the size of the sample at the group level (N = 66) and group pairs level of analysis (N = 33).

The results of the first and second steps showed significant effects of some of the variables on PCP. These will be discussed in Section 8.4.1. The second step showed that Science had an effect at the individual and group levels, Career at the individual and pairs levels, and Work Fulfillment at the group level. No dominant effects were obtained.

The results of the third step showed consistently at all levels of analysis that none of the value differences had a significant effect on PCP even when the effects of other variables were removed. These results are shown graphically in Figure 8.3-1.

The second series of tests were carried out using the rank order data from Q08B. An actual similarity, ACLSIM, variable was formed for each case using a non-parametric correlation coefficient as a score. These scores were then used to rank order the cases. At both levels the correlation of ACLSIM with PCP was not significant. At the pairs level the correlation was +0.30. This was negatively significant in that its absolute magnitude exceeded the critical value for the .05 level, but the sign was wrong for the sense of the proposition. When the test was repeated using only those eleven pairs where both groups of a pair had
Level of analysis:
I = Individuals
G = Groups
P = Pairs

Methods:
1) Partial Correlation
   (3 variables)
2) Multiple Regression

Fig. 8.3-1 - Schematic of Pl.2 and Pl.3 Tests Based on Value Difference Scores
better than mean agreement on the rank ordering ($W \geq 0.4$) of the Q09B items, the correlation between ACLSIM and PCP was not significant. We concluded that the negatively significant result was spurious. Partialling out the effect of TI did not change any of the results.

In the tests just described, the correlation coefficients for each case were used solely as a means to form a rank ordering. An additional test was performed in which the scores were used directly in a multiple regression equation with the TI scores. This result also was not significant.

In all of the tests performed above, using several methods of testing, two different sources of data, and three levels for units of analysis, we found no significant effects of similarity or differences in values on perceived problems in communication. Propositions Pl.2 and Pl.3 have not received support from the data in this sample of R&D groups. These results are indicated graphically in Figure 8.3-2.

![Diagram]

Methods:
1) Rank Correlation
2) Multiple Regression

Fig. 8.3-2 - Schematic of Pl.2 and Pl.3 Tests Based on ACLSIM Scores
8.3.2 - Tests of "Values Homogeneity" Propositions Pl.4 and Pl.5

Proposition Pl.4: For groups with a high level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be much better or much worse than for groups with a moderate degree of homogeneity in their work-related values.

Proposition Pl.5: For groups with a low level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be worse than for groups with a moderate degree of homogeneity in their work-related values.

Propositions Pl.4 and Pl.5 are concerned with the effects of homogeneity of a group's values on the perceived communications problems of the group. Two sources of data were used—the ten value factors from Q08 and the Q09B rank ordered items. The homogeneity of work-related values in a group was measured by calculating the variance of the scores on the ten value factors about the mean score for all factors. For the rank ordered data, Kendall's coefficient of concordance, W, was used as the measure of homogeneity.

Pl.4 implies a non-linear relationship, so the simple hypothesis that PCP and within group homogeneity are linearly correlated was tested first. It was not supported so it was reasonable to consider Pl.4. However, inspection of the scattergrams (Figures 7.5-1 through -4) clearly indicated that Pl.4 was disconfirmed with both the Q08 variance data and the Q09B concordance data.

Pl.4 was also tested in the same manner using the PCP scores of the Referenced Group (PCP-RG) in each case instead of the PCP scores. This essentially put the proposition into the form: "If the members of a group have quite similar values, people in another group will either have few or many problems communicating with them." This form of the proposition fared no better than the first. It was evident from visual inspection that it, too, was disconfirmed. It should be noted that the correlation of PCP-RG with within group homogeneity was -.39 for the variance measure, but only -.12 for the concordance measure. Since it was supported in one case but not the other, it was considered to be disconfirmed.

Pl.5 essentially states that groups with low homogeneity in their work-related values will tend to have higher PCP scores than other groups. It was tested using both PCP and PCP-RG scores as dependent variables, and the variance and concordance measures of homogeneity as independent variables. The groups were split at the upper quartile on homogeneity (i.e., the groups with low homogeneity
were tested against all others) and the mean PCP or PCP-RG scores of the two sets compared by a t-test. No differences were significant so P1.5 was disconfirmed.

We conclude that the homogeneity of work-related values within a group, over the range of homogeneity present in this sample, does not have an effect on the communication problems that one group perceives itself to have with another group. There is also no evidence that the homogeneity of values within a group affects the communication problems that another group perceives in dealing with the focal group. The results are indicated in Figure 8.3-3.

8.3.3 - Propositions P2.1 - P2.4

This group of propositions involves the individual's perceptions, knowledge, or understanding of another's values. The data for the propositions is derived from the three parts of the Q09 instrument and the propositions are tested only
at the level of individuals. The responses to these three parts by the individuals and their Referenced Group are used to form the scores of three variables as indicated by the dashed lines in Figure 8.3-4. The hypothesized relationships among the variables are shown by the solid lines. The various tests of the propositions are considered individually in sections 8.3.4 through 8.3.7. In section 8.3.8, three of the propositions are combined into one multiple variable proposition.

8.3.4 - Test of Proposition P2.3

Proposition P2.3: An individual will tend to rate values he considers as central to his own self-image as desirable in others with whom he enters a direct relationship.

This proposition was tested two different ways—once comparing each respondent's values to those that he described for his "ideal associate," and once comparing his values to those of a group of actual associates. He described his own values by rank ordering a set of 20 items in Q09B, the values of an ideal associate in Q09C, and those of his actual associates in his Referenced Group in Q09A. The Q09B responses were correlated with the Q09C responses and the Q09A responses to evaluate the proposition. It was anticipated that the proportion of significant responses would be lower in the case of the "actual" as compared to the "ideal."

For the test, with respect to ideal associates, 82% of the correlations were significant at the .05 level or higher, and the mean correlation for all respondents was significantly different from zero at the .05 level. For actual associates, 54% of the correlations were significant at the .05 level or higher and the mean correlation was again significantly different from zero at the .05 level. P2.3 was supported by these two tests.

These findings may be challenged on the basis that the Q09A, B, and C forms were in one instrument set which would lead to a tendency to respond the same way on all pages. Several steps were taken to counter this effect. The instructions requested the respondents to allow some time between each page. The forms had been mailed to them so it was possible for them to do some other task between each page. How many did so is not known. The items were arranged in a random order on each page to further minimize carry-over, and the first task was to describe the other group's values.
Fig. 8.3-4 - Relationship of "Values Perception" Propositions and Data Sources
The results of these tests are shown in Figure 8.3-5. P2.3 was supported by these tests as indicated by the proportion of significant responses and the mean correlations for all respondents with both types of data.

If the perception or mis-perception by an individual or a group has significant effects upon their perception of the quality of communication, this proposition becomes important in understanding their working relationship.

![Diagram of P2.3 Test Results](image)

**Fig. 8.3-5 - Schematic of P2.3 Test Results**
8.3.5 - Test of Proposition P2.1

**Proposition P2.1:** The higher the level of respect that an individual has for another person or group, the more he will tend to perceive the other as holding his own positive values.

The scores for perceived similarity (PRCSIM) were the Kendall-tau correlations between the Q09A and Q09B responses of each individual. In the first test of the proposition, the Kendall-tau rank order correlation between PRCSIM and RESPECT was significant at the .001 level.

The proposition was tested by a second method using the actual PRCSIM scores in a multiple regression equation. TI was included with the expectation that increased task interdependence would affect the respondents' perceptions of the Referenced Groups values.

The equation was significant at the .05 level. However, the coefficient for TI was not significant indicating that the perceived level of task interdependence had no effect upon perceived similarity of values.

Ignoring the lack of a random sample, P2.1 is strongly supported by the first test and also supported by the second test. It should be noted that since Kendall-tau correlation coefficients were used as scores in the second test, the error term used to determine the significance level can be questioned.

8.3.6 - Test of Proposition P2.4

**Proposition P2.4:** The greater the discrepancy between the work-related values imputed to B by A and B's self-reported (i.e., "actual") values, the greater the perceived communication problems with B.

The independent variable was defined in terms of perceptual accuracy (PRLACC) and formed by correlating the Q09A response of each respondent with the mean Q09B scores of his Referenced Group. The Kendall-tau correlation between PRLACC and PCP was -0.01 which is clearly not significant. The proposition was also tested using the PRLACC scores directly. These results were also not significant.
8.3.7 - Test of Proposition P2.2

**Proposition P2.2:** (A) The more an individual perceives another as holding his own (positive) values, the fewer the communication problems he will tend to perceive, but

(B) The less the actual similarity, the more perceived communication problems will tend to increase with increasing perception of similarity of values.

The independent variable of this proposition, perceived similarity (PRCSIM), was determined for each respondent by correlating his Q09A and Q09B responses with each other and using the Kendall-$\tau$ correlation coefficients as the score. The PRCSIM scores were then correlated with the PCP scores. The correlation of -0.20 was significant at the .01 level indicating moderate support for P2.2A.

P2.2B could not be tested because there were not enough cases of respondents with negative ACLSIM scores.

8.3.8 - Test of Combined Propositions

Three of the propositions indicated in Figure 8.3-1 have PCP as the dependent variable. In P2.2 the association of PRCSIM with PCP was significant. In P2.4 the association of PRLACC with PCP was not significant, and in P1.2 the association of ACLSIM with PCP was not significant. None of these tests removed the effect of the other variables. This was done in a separate test by combining the variables into a multiple regression equation. The results are diagrammed in Figure 8.3-6.

The resulting equation was significant at the .01 level. The coefficient for PRCSIM is significant at the .001 level. (In the rank order test the correlation was significant at the .01 level.) The coefficient for ACLSIM was significant at the .05 level. (In the rank order test and the test using the ACLSIM scores directly, the correlation was not significant.) The coefficient for PRLACC was negatively significant at the .10 level, contrary to P1.2. (It was not significant previously in two tests.)

If we take the results of the multiple regression equation at face value, they may be interpreted as indicating: 1) If a person sees members of another group as holding values similar to his own, he will experience fewer problems in communication with them than in the opposite case. 2) If the other's values are
actually similar, he will also experience fewer problems. 3) But if he actually perceives the others' values accurately, there is a chance that he will experience greater problems in communication.

However, these results cannot be taken too seriously. Kendall-tau correlation coefficients were used as the scores for the variables. It would be necessary to show that the error term resulting from their use in the equation was normally distributed to accept the test of significance. However, it may be noted that all the tests in which these scores were used both as interval measures and as a means to generate ordinal (rank) measures provided the same results. Also, the data does not come from a random sample. Perhaps more important than either of these reasons, though, is the failure of the multiple regression equation to explain an appreciable amount of the variance in PCP. Only 6% of the variance is accounted for. The level of significance for PRCSIM is high enough (.001) that it may be worth further investigation. The level for ACLSIM (.05) is marginal, and for PRLACC the level is sub-marginal (.10). On the basis of this evidence, it would not be worth investigating the relation of these latter two variables to PCP in another study unless they could be incorporated with negligible marginal cost to the respondents and the researcher.

Fig. 8.3-6 - Schematic of Combined Propositions P1.2, P2.2, and P2.4A Test Results
8.4 - ADDITIONAL FINDINGS

During the work involved in the development of the propositions tests a number of quantitative findings of interest were observed. These are reported in sections 8.4.1 to 8.4.3. The combination of the respect, frequency of contact, and task interdependence variables allows reasonably good predictions of PCP to be made (8.4.1). The level of importance a person or group attaches to certain work-related values, per se, also appears to have a small effect on communication (8.4.2). The values of engineers and scientists are of interest in areas other than communication. A better understanding of their values may be helpful in the over-all management of laboratories as suggested in section 8.4.3. During the interviews and experiences in the field sites, as well as in the data analysis, a number of other observations pertaining to the coupling process were made by the author. Some of these are briefly reported in section 8.4.4. A few speculations concerning the propositions of this study are given in section 8.4.5. The text closes with a brief discussion of the implications for future research.

8.4.1 - Effects of Respect, Frequency, and Task Relationship on PCP

In Chapter 7 it was demonstrated that several variables had a significant effect upon the perception of communication problems by individuals and groups. These results are consolidated in Table 8.4-1. The standardized ("b") coefficients are shown so that their magnitudes may be directly compared.

The multiple-R for the equation based on the scores of individuals was 0.58, and for the equation based on group scores it was 0.75. (Note in the latter case that there are 11 variables and 66 groups.) Both equations are significant at the 0.01 level.

The Respect variable has the strongest effect in determining the level of PCP. It was introduced into the multiple regression equation as two "dummy" (i.e., binary or 0,1) variables--R(LO) and R(MOD). The third level, R(HI), is redundant in the equation. Low respect, as used here, is associated with a score of 3 or less from a five-point scale in response to a question concerning respect for the knowledge and judgment of the other group. This single question, which
Table 8.4-1

Comparison of Task Relationship, Frequency, and Respect Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Individuals</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WI</td>
<td>.121</td>
<td>.158</td>
</tr>
<tr>
<td>DEP</td>
<td>.148#</td>
<td>.377*</td>
</tr>
<tr>
<td>MTD</td>
<td>-.182*</td>
<td>-.284#</td>
</tr>
<tr>
<td>ADV</td>
<td>-.059</td>
<td>-.109</td>
</tr>
<tr>
<td>DIR</td>
<td>.019</td>
<td>-.153</td>
</tr>
<tr>
<td>FRQ GP</td>
<td>.155*</td>
<td>.365*</td>
</tr>
<tr>
<td>FRQ 2</td>
<td>.055</td>
<td>.198</td>
</tr>
<tr>
<td>FRQ 3</td>
<td>-.303**</td>
<td>-.357*</td>
</tr>
<tr>
<td>FRQ 4</td>
<td>.285**</td>
<td>.141</td>
</tr>
<tr>
<td>R(LO)</td>
<td>.592**</td>
<td>.580**</td>
</tr>
<tr>
<td>R(MOD)</td>
<td>.304**</td>
<td>.262#</td>
</tr>
</tbody>
</table>

# Sig. @ p .10
* Sig. @ p .05
** Sig. @ p .01

Note: Standardized coefficients are listed.
Source: Tables 7.4-1 and 7.4-5.
was adapted from an interview question used by Kahn, et al (1964), was consistently the most important item in the various multiple regression equations.

The next most important group of variables in explaining the perceived communication problems are the four aspects of frequency of contact between the groups.* The first two (FRQ GP and FRQ 2) concern the general frequency of contact of the group--as estimated by the respondent--and the respondent himself. Since these two questions are relatively highly correlated (0.60 among individuals and 0.79 among groups), one of them tends to dominate the other in the multiple regression equation because they account for much of the same variance. This means that even though the FRQ 2 (frequency of individual contact) coefficient is small, it is not unimportant. Rather, it is roughly substitutable for FRQ GP and would likely be significant if FRQ GP were deleted.

Of the four frequency of contact variables, the third one is consistently the most important one. It implies that the more frequently a group has to seek out information about changes affecting them that another group is making, the more they are going to have other problems in communication as well. The fourth question parallels it, but in the opposite sense. It implies that the more frequently information is provided by the other group about such changes, the fewer the other problems in communication. Presented in this manner, these statements seem blatently obvious, if not redundant. But this was not the case for the respondents. The correlation of FRQ 3 with PCP is 0.01 and of FRQ 4 with PCP is 0.14. It is only when the effect of other variables in the equation is removed that "the obvious" becomes evident.

The four components describing the task relationship between groups do not play the major role originally anticipated in the perception of communication problems. The coefficients for WI and ADV are not significant in either case.

The two components of the variable named Task Interdependence in this study, DEP and MTD, play a relatively weak role in the equations. One or the other is significant at the .05 level in the two equations. The coefficient for DEP indicates that as a group's perception of its dependence upon another group

*Note that numerically larger values of frequency indicate less frequent contact, so a positive sign on the coefficient implies INcreasing problems with DEcreasing frequency.
increases, the group tends to perceive more communication problems. However, if they see the relationship as one of mutual interdependence, communication problems tend to decrease. But neither of these effects is strong. However, the net effect of these variables in conjunction with the others is to provide an equation with a multiple-R of 0.58 explaining 1/3 of the variance in the PCP scores.

8.4.2 - Work-Related Values in the Laboratory

In this field study 260 engineers and scientists rated eighty items on a five-point scale from "extremely important" to "not important, irrelevant" in response to the question, "In order to do your kind of work well in this group, how important are each of the following to you?" Analysis of their responses, guided by the technique of factor analysis, yielded the clustering of the items as listed in Table 5.2-1. These clusters were given the names previously listed in section 8.2.3. The clusters are independent of each other, each item appearing only once, and a score potentially ranging from 0 to 4 was developed for each cluster, weighting each item equally.

These ten clusters indicate major independent components of the values of engineers and scientists. Some of the items are relatively unique to their profession; others are undoubtedly shared with many other organizational members, though we do not know how they would compare in importance. The literature reviewed in Chapter 3 indicates that further knowledge of the value patterns and relationships in specific laboratories should provide the manager or administrator with a better understanding of his problems and potential actions in dealing with engineers and scientists. Differences in values appear to give rise to differences in how individuals, groups, professions, and cultures view the world. In coupling organizational activities such differences in outlook can be accommodated—perhaps by capitalizing on shared similarities; or, probably in most cases, by inserting some sort of accommodating mechanism. The latter implies a range and variety of managerial technology that is still very much an art, not well understood.

Of the ten work-related values identified in this research, greatest importance was given to the Professional and Personal Integrity cluster. This is not

* An earlier draft of this section appeared in Rubenstein (1970).
surprising for these items as a group represent strong ideals of our culture and of professionals. In a sense, collectively they are the "motherhood" items of the eighty. But there was by no means unanimous agreement among the individual respondents as to their importance: scores on the cluster range from 0.5 to 4.0 and there is as much variance in the scores for this cluster as any other (Table 5.5-2).

Second in importance was a cluster of items named Collegial Growth for they appear to be related with learning through the sharing of knowledge, information, and experiences with one's colleagues.

The third ranked cluster involves a group of items that appear to be related primarily to the kinds of decisions and approaches needed for successful Project Direction or Guidance. In such a situation one must be aware of the progress being made by the several people or groups involved, maintain control of the work, yet remain flexible and consider trade-offs. All this to be done working through people as reflected in item #33 of this cluster which had a negative loading. The implication of this is, that when directing a project, it is relatively important to value "Working with people moreso than things."

The cluster next in importance seems to represent values associated with the satisfaction of doing work itself. They are the sources of Work Fulfillment for the individual himself, beginning with the freedom to decide for himself how he will carry out his responsibilities.

The items specifically of concern in Engineering and Technology Performance appeared in the fifth cluster. They reflect the engineer's concern with design, meeting specifications, schedules, and so on. Note that some of these items are also of concern to the scientist even when he is doing basic research.

The next cluster of items reflects the way one interacts with others--including the group of which he may be a part--Personal Interaction or Relationship values. These are concerned with the social aspects of working in an organization.

Early in the history of organizations there appeared a set of values that manifest themselves here in seventh rank--Organizational Performance values, or what might be termed the organizational "credo." One item in this group had a negative loading which means it is conceptually opposite, in some sense, to the
others. The item as stated is "To have freedom to choose what one will work on." Its semantic opposite might be "To be assigned to what one is to work on," or "To obediently accept an assignment." The credo would then be: efficiency, loyalty, obedience, and cut costs; a desirable set of norms when kept in balance with others.

Value items derived primarily from the norms of Science appear in the eighth cluster. These items are relevant to engineers—scientific method is a part of good engineering performance—but perhaps less relevant to them than to persons highly trained in science.

The difference in importance between adjacent clusters up to this point has been relatively small (See Table 5.2-2.) However, the step to the next cluster, Career, in ninth rank, is five times as large as the mean difference between the prior steps. This cluster of items clearly represents values pertaining to Career advancement or stability. Its position in ninth place reaffirms that simple economic returns or advancement are not primary values for reward. However, this does not imply that the Career value is not primary for some people or for any given person at certain times. Note that this cluster has the largest variance.

In last place, and again with a relatively large difference in mean score from the preceding value, was a set of items that when taken together imply an orientation for doing work so as to obtain a Quick Payoff. The last place ranking of this cluster, and the high value placed on Work Fulfillment, may indicate part of the source of the difficulty commonly experienced by managers when they attempt to get an item built with off-the-shelf components.

The value structures of the three agencies and one industrial firm were examined in Chapter 6. There were enough respondents and organizations in Agency I included in the study to examine them in some detail. The value structures of the engineers and scientists in Agency I appeared to reflect, in part, the characteristics of the organization in which they were embedded. When examined at the Agency level, some significant differences emerged, perhaps indicating this agency's concern with getting the material out and into action. But within the agency, further patterns emerge from the various organizations characterizing each of them ... from organizations concerned with quickly moving from advanced
development into production to an organization emphasizing mission-oriented basic and applied research.

Again, from the literature, it would seem that further understanding of value patterns and their association with the type of work being performed, with decisions about the tactics and strategies in doing the work, and with communication patterns and working relationships, should prove to be helpful in understanding the dynamics of organizational processes. One could then make use of information about values to determine the feasibility and appropriateness of organizational policies, designs, and actions. As already discussed, information about similarities or differences in work-related values (as measured here) did not explain the communication problems experienced by working groups. The effect on communication arising from the importance placed on specific value clusters themselves is considered in the next section. Some of these other relationships are considered in section 8.4.4.

8.4.3 - The Effect of Values on PCP

The effect of the values themselves upon perceived communication problems was determined prior to testing P1.2 and P1.3. In this section we shall consider the effects that were obtained from the multiple regression analysis. The standardized coefficients for the ten values at the three levels of analysis are given in Table 8.4-2.

The values of Engineering, Personal Relations, and Integrity consistently had a negligible effect upon perceived communication problems at all three levels of analysis.

It appears, interestingly enough, that those who rate the values of Science highly tend to see themselves as having fewer problems in communication with their Referenced Groups. On the other hand, those who place high importance on the Career value tend somewhat to have more problems in communication. The Science coefficient is negative and significant at the .01 level. The Career coefficient is positive and significant at the .05 level. The signs of both are consistent at all three levels of analysis.

It is difficult to predict what the results would be if the study were extended to a larger number of pairs. Since there are ten variables, and only 33 pairs
Table 8.4-2

Effect of Work-Related Values on PCP

<table>
<thead>
<tr>
<th></th>
<th>Individuals N = 234</th>
<th>Groups N = 66</th>
<th>Pairs N = 33</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERSONAL RELATIONSHIP</td>
<td>.005</td>
<td>-.021</td>
<td>-.077</td>
</tr>
<tr>
<td>ENGINEERING</td>
<td>-.070</td>
<td>-.006</td>
<td>.071</td>
</tr>
<tr>
<td>WORK FULFILLMENT</td>
<td>.013</td>
<td>.208</td>
<td>.140</td>
</tr>
<tr>
<td>CAREER</td>
<td>.137*</td>
<td>.307*</td>
<td>.287</td>
</tr>
<tr>
<td>SCIENCE</td>
<td>-.196**</td>
<td>-.197</td>
<td>-.018</td>
</tr>
<tr>
<td>PROJECT DIRECTION</td>
<td>.056</td>
<td>-.041</td>
<td>.256</td>
</tr>
<tr>
<td>QUICK PAYOFF</td>
<td>.105#</td>
<td>-.050</td>
<td>-.201</td>
</tr>
<tr>
<td>COLLEGIAL GROWTH</td>
<td>-.011</td>
<td>-.245</td>
<td>-.313</td>
</tr>
<tr>
<td>ORGANIZATION</td>
<td>-.107#</td>
<td>.110</td>
<td>.114</td>
</tr>
<tr>
<td>INTEGRITY</td>
<td>-.026</td>
<td>-.012</td>
<td>.056</td>
</tr>
<tr>
<td>Multiple-R</td>
<td>0.28*</td>
<td>0.43 (n.s.)</td>
<td>0.44 (n.s.)</td>
</tr>
<tr>
<td>Multiple-R²</td>
<td>0.08</td>
<td>0.18</td>
<td>0.20</td>
</tr>
</tbody>
</table>

# Sig. @ p ≤ .10
* Sig. @ p ≤ .05
** Sig. @ p ≤ .01
of groups, only very strong variables would have significant coefficients. None of the coefficients were significant at the pairs level, but we may speculate about the possible results with a larger sample by examining the pattern of the coefficients going from one level of analysis to another.

In addition to Career and Science, Collegial Growth and Work Fulfillment have a consistent pattern of signs, but Work Fulfillment does not show a consistent pattern in the magnitude of its coefficient. It appears that among those pairs of groups that value Collegial Growth, communication will tend to be better. More insight into this value, which was one focus of attention by Shepard (1954), could be gained by a detailed examination of the individuals, groups, and pairs with high scores on this variable.

It does not appear that values, per se, or the differences in values between R&D groups in the same organization have an appreciable impact on the perceptions of the communication process. But this study has not explored the decision making processes involved in the course of an R&D project. The "real-time" studies outlined in section 4.1.5 would provide an opportunity to determine which values became salient under what circumstances and to determine their effect.

8.4.4 - Some Observations From the Field*

This study was designed to test in depth a limited number of propositions specifically concerned with the information exchange process taking place between technical groups. A number of other observations pertaining to the coupling process are provided here based on data obtained from interviews with the respondents and managers as well as the questionnaire responses. Some of the conclusions presented here can only be considered speculations at this time.

1) It is commonly recognized that where groups are physically separated, problems in coupling their activities are likely to arise. This proved to be the case for three group pairs in this study. Those groups that were physically remote experienced a high level of problems in communication. However, based on available evidence, it cannot be asserted that physical distance caused the

* An earlier draft of this section appeared in Rubenstein (1970).
problems. Judging from the information provided by the respondents and managers interviewed, it appeared more to exacerbate problems that would otherwise exist and to make their solution more difficult. The nature of the coupling between the groups appeared to be particularly crucial. The nature of the work flow, the timing of the work transfers, and information flow, and the development of the mutual decision processes appeared to require particularly careful attention. In one organization these were being given particularly careful attention at the time this study took place. The reasons given by the managers for their current activities, policies, etc., were largely based on prior problems of this nature. In the other organization similar problems existed (on a smaller scale), but most of the managers and senior staff involved explained their policies in abstract terms, seemingly unaware of what was actually taking place.

When one unit is remote, they may tend to feel—justifiably or not—that they are neglected by management. Where remote location is a factor, more attention is required of management early in the organizational design process. Lacking this attention, it is likely to give rise to considerably more management effort at later times.

2) One case indicated that where the requisite level of coupling with a remote unit was high, a designated liaison man might assist in the coupling process if the groups involved have confidence in him. In this case, several engineers at both locations commented that he was known to be influential in the project manager's office, yet he was also willing and able to keep confidences.

3) When two capable group leaders were in conflict, in one case the solution was to locate their groups in separate buildings and provide them with separate programs. But because of the highly related technologies, skills, and instrumentation involved, there was obvious advantage to maintaining a close advisory and consultation coupling for technology transfer as well as detailed problem solving. In this case, while the leaders tended to avoid contact with each other, they recognized their differences as being primarily personal and freely permitted their men to contact each other informally for advice and assistance. Here self-recognition of the source of the problem, while not leading to a solution on a personal basis, facilitated a limited flow of information between the groups that had been organizationally loosely coupled.
4) Where one group evaluates the work of another--by field testing as in one case in this study--management may decide on a policy of deliberately isolating them from those whose work they evaluate. This appears to create problems in communication and working relations through the implicit attack on the professional values, behavior, or accomplishments of the group whose work is being evaluated. Difficulties are compounded through the resulting restriction of the flow of information needed to get the equipment functioning and by inappropriate criteria being applied in the evaluation process.

5) In one of the organizations coupling of groups in the work flow of a project, from the early development through production or application, was enhanced by involving representatives of all groups potentially involved early in the project cycle and deliberately including those with opposing viewpoints. Comments from the respondents indicated that this strategy appeared to be working successfully.

6) The transition of work from one group to another involves shared responsibilities and an increased level of required coupling, at least temporarily. The experiences reported in one organization and indications from others suggest that an organizational philosophy of clean-cut, non-overlapping assignment of responsibility and authority can lead to problems during transitions. But at the same time, an explicit policy creating overlapping responsibility will cause coupling problems if not operationalized by a sufficiently explicit organizational design. Specific responsibilities can be shared for specified periods.

7) There is some indication in the questionnaire data to suggest that where one group initiates work for a second group, and the latter is comparably dependent upon the initiator (i.e., the initiator is a "manager" or major customer), the relations between the groups will tend to be satisfactory if the initiator also sees itself as being at least moderately dependent upon the "doers." If they do not realize that they are dependent upon them, but rather see themselves as relatively independent, relations will tend to be less satisfactory. This idea was tested in a simple manner by including the "direction of initiation" variable in the multiple regression tests. No effect was obtained, so further work on the operational measure would be required to better test this speculation.

8) Where one group does not respect the work of another, there will be problems in information exchange, as just shown in section 8.4.1, and there will probably be problems in joint decision making. It appears that this can be moderated by
temporarily assigning one person to the disrespected group to work on a specific project of visible importance. In the case observed, the project was of several months duration and culminated in the operation of the equipment in an expedition with a rigid departure schedule involving several organizations.

8.5 - SOME SPECULATIONS CONCERNING THIS STUDY

Propositions P1.2 and P1.3, if they had been supported, would have had direct implications for organizational design propositions. They were of central interest, but they were not supported. This section will briefly speculate about some of the reasons why no effect of value differences on the perceived communications problems between R&D groups was observed. Eight speculations or criticisms are given with comments responding to them.

1.) The propositions are not correct--value differences do not make a difference.
   . . . . The evidence that has been presented supports this statement. The data and tests performed here indicate that differences in work-related values do not make a difference in the communication problems perceived to exist between 33 pairs of groups in nine government and one commercial laboratory.

   . . . . The literature reviewed indicated a strong association between similarity of values and liking. Related studies and theorizing in the literature indicated that similarity of values and information exchange would be associated. The results of this study do not disprove the proposition formulated, as indicated by the various other reasons considered in the following.

2.) The propositions are too simple--value differences make a difference, but act in a more complex manner.
   . . . . To a limited extent this rival hypothesis was controlled by keeping the value clusters separate in the analysis, and by the use of multiple regression analysis. Not one of the value differences had an effect.

   . . . . Multiple regression was also used to remove the variance due to other variables. A distinct possibility is that different variables should have been controlled.
3.) It is not the importance of the values to the respondents that matters, but their salience in the context of the given situation. This rival hypothesis is particularly germane to this study. No measurement was made of the salience of particular values to each group. To do so would require a study of somewhat different design (requiring, as a first step, essentially the study that was performed here).

4.) Values have an effect upon decisions, rather than on communication, per se. The stimulus to communicate or not communicate, to communicate accurately or inaccurately, etc., is determined by other factors. The parallel study performed by Richard Barth (1970) identifies such factors—"inter-group climate factors"—that explain an appreciable part of the perceived communication problems. To determine the effects of values upon decisions would require a different design than this one. The implicit propositions outlined in section 4.1.4, "Potential Natural Experiments," and the designs outlined in section 4.1.5, "Two Design Extensions," would provide starting points for research on the effects of work-related values in the decision processes of R&D groups.

5.) The specific design of this study was inappropriate. Requiring responses with respect to another group may have been a source of difficulty. More positive results might have been obtained if each person had responded with respect to specific individuals. However, much R&D work requires that small groups work closely together, so that groups and group pairs are viable entities for study. In the organization with which the author was affiliated for 11 years prior to joining the Program of Research on the Management of Research and Development, this was true for most of their projects. This was also true for the respondents of the working groups interviewed. It appeared to be less the case for the managers involved in the "cross-organizational" group pairs. (These pairs were excluded from the tests of the propositions—section 5.1.3.)

6.) The sample was incorrectly selected. It has not been claimed that the sample was a random one. The limitations on obtaining a random sample, especially a random sample of group pairs, were discussed in section 4.5. Various indicators were noted that provided some evidence that the sample was a representative one.
Another aspect concerns the "dynamic range" of the sample. The groups of each pair were mature, had worked with each other, and, in many respects, had common backgrounds. While a representative dynamic range of values and value differences may have been obtained across the sample viewed in aggregate, the specific pairings may reflect a more limited range of differences than is apparent from the statistics examined. The sample may have been too limited in the sense that the pairings should have been established between groups in R&D and production, R&D and sales, research and engineering, etc.

7.) The instruments and measures are inadequate.

Considerable attention has been devoted to determining the adequacy of the instruments and the measures for PCP, TI, and work-related values. The available evidence indicates that the instruments and measures are satisfactory.

Variables pertaining to communication and task relationships or task interdependence appear in many sets of propositions and field studies. The author intends to continue using these instruments, and to further develop and evaluate them in future studies.

8.) The method of analysis is inadequate or incorrect.

This implies that the effect is in the data but that it was not elucidated. Several steps were taken to avoid this difficulty. The author consulted with colleagues and professors for their advice and criticism. Multiple sources of data were used in various tests, and various methods of testing the propositions were used--ranging from visual inspection of scattergrams to multiple regression analysis. In all cases, consistent results between the various approaches have been obtained.

8.6 - IMPLICATIONS FOR FUTURE ACTIVITIES

This dissertation is not the endpoint of a study. The research reported here is a part of one area of activities of the Program of Research on the Management of Research and Development at Northwestern University. This area is concerned with coupling the flow of ideas and information about new materials, products, and processes from laboratory through the steps to utilization. The various complex communication phenomena involved--liaison, interface, coupling, technology transfer
(LINCOTT)--are treated in a series of on-going and planned studies. Each has a unique focus and set of variables. They cover a variety of environments--commercial and military labs, U.S. firms overseas, and R&D in developing countries. All the studies share the common goal of increasing understanding of communication and information exchange between functionally-related science, engineering, production, and management groups, with the eventual goal of providing tested propositions for improved organizational design. Within the program, this research is part of a joint project with the author's colleague, Richard T. Barth, that will continue beyond this report.

The next step in the joint project will combine the data of this study with the data obtained by Barth to determine if further additional findings arise and to look for new insights. The four components of task relationship and task interdependence will be treated as dependent variables. The relationship between perceived communication problems, task interdependence, and the estimates of group productivity provided by managers will be explored.

The instruments developed in this project are directly applicable to other studies. They will be further developed and extended.

Coupling involves the transfer and utilization of information between R&D groups in the same or different projects, in the same or different organizations. The "information" itself may be data, solutions to past or present problems, specifications, problems in need of solution, decisions, information about decisions needing to be made, completed units of work (a computer program, a piece of hardware) and the accompanying information and advice or consultation needed to make use of it, and so on. The present PCP instrument treats only the information transfer aspect of the coupling phenomenon. In future studies it will be extended to include the information utilization aspect. It will then provide one measure of coupling effectiveness. The development of such a measure is of central importance to future LINCOTT studies.

In the development of a coupling effectiveness measure alternative indicators of successful and unsuccessful transfer and utilization will be included to provide cross-validation and to identify the relationship between perceptions of coupling effectiveness at various levels of the organization and the "actual" level of effectiveness.
The form of potential data sources includes such items as:

a) The current questionnaire instrument measure for PCP (perceived communication problems).

b) Revised measures: 1) with greater reliability, or 2) of shorter length for use in the real-time phase.

c) Interview/questionnaire for use with higher level managers and other knowledgeable informants.

d) On-site measures for use in observing joint meetings.

e) Idea-flow measures, based on previous studies in this program, to identify critical problems in a project and the sources or "trigger events" leading to the solution of those problems.

f) Organizational records, past and on-going, indicating changes in funding level, manpower level, and time schedules.

g) Organizational records, past and on-going, indicating the flow of information and people between groups and organizations—visitor lists, phone call activity, memos, documents, distribution lists, travel documentation, TDY assignments, etc.

The key methodological technique involved here in the development of coupling effectiveness measures is the use of multiple sources of information about multiple aspects of the coupling phenomena collected by multiple methods to cross-validate and refine the measures.

The results of these studies should help provide answers to the questions:

1. What criteria can be used in measuring the effectiveness of coupling?
2. How can we identify successful coupling activities?
3. Who should perform the evaluation of coupling effectiveness?
4. How does effectiveness of coupling relate to overall organizational effectiveness?
5. How can communication or coordination gaps be recognized?
6. Are communication problems symptomatic of coupling gaps?

In terms of support indicated for the propositions, the "pay-off" from this study is limited, but it does represent a necessary and useful step in developing the techniques, the instruments, and the research designs to answer these questions.
APPENDIX 3*

THREE POTENTIAL MEASURES OF INFORMATION EXCHANGE

* Number refers to chapter with which appendix is associated.
THREE POTENTIAL MEASURES OF INFORMATION EXCHANGE

3A.1 - LEVELS OF COMMUNICATION ANALYSIS

Communication in general consists of the use of signs by individuals to affect the behavior of one another primarily through the expression of language. The study of this field—"semiotics"—has been dealt with at three levels:

a) Syntactics: signs and relations between signs,

b) Semantics: relations between signs and what they signify,

c) Pragmatics: relations between signs and their users.

Roughly, syntax deals with problems of the basic units—the formation of words and their structuring into phrases and sentences; semantics deals with the meaning of words or groups of words; and pragmatics is concerned with the effects of words and larger communication events upon the people that form and perceive them. Considerable attention has been given to problems of words and language at the level of syntax. Theories are being developed in the field of semantics. But until recently little has been done along comparable lines at the level of pragmatics. This area has been left to researchers approaching it from quite different frames of reference; psychology, speech, drama, literature, etc.

Following the publication of Shannon and Weaver's influential *The Mathematical Theory of Communication* (1949)*, there arose, and continues, a considerable interest in applying the concepts and mathematical techniques of this theory to various areas involving communication. Unfortunately, many of these efforts have been based on a misapplication of the theory. The title would more accurately reflect the area of application if it were "The (statistical Theory of Signal Transmission" (Bar-Hillel, 1964, p. 291). Bar-Hillel, following Carnap (1943, 1947), has developed a complementary "Theory of Semantical Information" (Bar-Hillel and Carnap, 1952, from Bar-Hillel, 1964, p. 221). He makes it clear that these approaches are formal:

I would now say that both these theories can be regarded as different interpretations of a common formal system, the *Calculus of Information*. This calculus consists, reduced to its simplest terms, of two sets of numbers ... fulfilling (certain) conditions, and two functions, ..., each of two variables ..., fulfilling (certain) conditions .... In this calculus, the properties and relations of the negative logarithms of the numbers ..., of various weighted means of the numbers ..., and of the limits to which these means tend, ... are developed. (Bar-Hillel, 1964, p. 291)

* References for Appendix 3 are on page 365.
With respect to these formal theories, Cherry (1966, p. 243) notes:

...as used by logicians (e.g., in the Carnap and Bar-Hillel theory), semantics refers to theory expressed in meta-language, abstracted from all specific human sign users, and concerns rules relating signs and designata. But semantics is also a term frequently employed by others to denote "theories of meaning," discussed in relation to specific sign users in specific environments...

Our concern here is with signs and the users of signs. The formal theories are relevant to this problem but only indirectly. At the pragmatic level we must deal with the use of signs by people in specific situations and environments. Each person brings a given background to the communicative situation and engages in it with certain degrees of belief, expectations, etc., regarding the substance and outcome of the event. He behaves, and affects the behavior of others, often seeking to do so in some predetermined manner. It is in these situations that the whole "effectiveness" problem suggested by Weaver becomes of concern.

To the pragmatic level we must relegate all questions of value or usefulness of messages, all questions of sign recognition and interpretation, and all other aspects which we would regard as psychological in character. (Cherry, 1966, p. 244)*

The pragmatic theory of communication to be discussed below is based upon, in part, notions of selections among alternatives, subjective utility or value of the alternatives and subjective probability of choice. Cherry laid the groundwork for this approach in the following passage (and other sections of his book):

Thus it may be illuminating to consider some of the pragmatic aspects of communication from the point of view of one of the participants, in terms of subjective probabilities interpreted as degrees of belief; we shall be referring to this shortly.

'Information' in most, if not all, of its connotations seems to rest upon the notion of selection power. The Shannon theory regards the information source, in emitting signals (signs), as exerting a selective power upon an ensemble of messages. In the Carnap-Bar-Hillel semantic theory, the

* It should be noted that Cherry is here perhaps more emphatic than he intends when he relegates all psychological problems to the pragmatic level. At least implicitly, he does not do so elsewhere. Further, psycho-linguistics is explicitly concerned with the syntactic and semantic,. (Cf. Osgood & Sebeok, 1954; Saporta, 1961; also Firth, 1957).

# See Weaver's section of Shannon and Weaver (1949).
information content of statements relates to the selective power they exert upon ensembles of states. Again, at its pragmatic level, in true communication situations (and speaking only descriptively now) a source of information has a certain value to a recipient, where 'value' may be regarded as a 'selection power.' (1966, p. 244-5)

From these notions Ackoff has constructed a conceptual and metrical foundation for a theory of human communication at the pragmatic level (Ackoff, 1958) which we shall consider along with the Shannon-Weaver and Carnap-Bar-Hillel theories.

3A.2 - MATHEMATICAL THEORIES OF INFORMATION

3A.2.1 - The Shannon-Weaver Transmission Theory

The Shannon-Weaver theory is concerned with the processes involved in the communication channel between the sender and the receiver. Originally it was an engineering theory, and its most successful applications remain in that field today. It is applied to the transmission of signals and deals not with the signals individually, but rather with the characteristics of sets of signals—signal ensembles. The "meaning" of the signals plays no part in the theory. It deals with the manner in which given strings of signals are selected from their ensemble; the manner in which they are encoded from one representation to another and later decoded; and the effects of extraneous signals introduced into the signal transmission channel, i.e., "noise," but only where the statistical properties of the noise are known. Among other characteristics of the theory that are often overlooked by theorists in other fields seeking to use the theory, one is this latter requirement of knowing the noise characteristics of the signal source and transmission media. (It is seldom mentioned in critiques either; e.g., Cherry, 1966; and Bar-Hillel, 1964.)

The Shannon-Weaver measure of information, now called the "bit," applies only to a statistically stationary source of signals. Cherry (1966, p. 231) notes that this measure "may be applied not only to signals, to ensembles of letters, words, phrases, or to any segments, but also to ensembles of specified things, events, et cetera, or even to ensembles of reactions of the recipient of the signals." But such samplings, no matter how extensively carried out, could only reveal various statistical measures relating to the relationships, and perhaps the structures, among the ensemble of the events observed and sampled. Thus the theory may be properly applied to many types of information
flows in channels and networks including, for instance, the human neural system. But nothing can be learned about the meaning or logical equivalence of the data without going beyond the theory itself. No relationship, other than statistical, can be established between "My uncle is in jail again," and "Uncle Joe is the black sheep of the family."

Apart from its engineering applications, the Shannon-Weaver theory operates at the level of syntax, dealing with the relation of signs to other signs. The measure of information involved deals with the statistical probabilities of codes (or signs) and their rate of occurrence. The information conveyed by a sign must decrease as its probability of occurrence increases.

One other unique, and especially powerful, feature of the theory is that an expression is derived for the maximum information capacity of a channel. But again, it must be emphasized that this refers to the rate of transmission of a finite set of codes with certain probabilities of occurrence and has nothing to do with meaning or effects on the behavior of the human recipient. Only to the extent that the channel and the signals limit the ability of sender to communicate his choice of words, expressions, etc. to the receiver, is there a relevant connection between this theory of signal transmission and the semantic or pragmatic levels of information analysis.

3A.2.2 - The Carnap-Bar-Hillel Semantic Theory

The Theory of Semantic Content developed by Bar-Hillel is based upon the work of Carnap in the syntax and semantics of logic and his work in the development of inductive probability. These treatments are strictly formal treatments, completely divorced from real world events. Carnap states:

Semantics--more exactly, pure semantics as here conceived--is not a branch of empirical science; it does not furnish knowledge concerning facts of nature. It is rather to be regarded as a tool, as one among the logical instruments needed for the task of getting and systematizing knowledge. (1943, p. viii)

In this treatment the information carried by a sentence is considered both by itself and relative to other sentences. But the information which a sender intends to convey to a receiver and the information which a receiver extracts from a message are excluded. The theory presupposes a "state description" which is described by "atomic-statements," stated in a specified formal manner.
The connection between these concepts and that of truth is as follows: There is one and only one state-description which describes the actual state of the universe; it is that which contains all true atomic sentences and the negations of those which are false. Hence it contains only true sentences; therefore, we shall call it the true state-description. A sentence of any form is true if and only if it holds in the true state-description. (Carnap, 1947, p. 10)

Within this framework two measures of information are derived. One relates to the semantic content of a sentence (designated by "cont"), the other to the amount of information in a sentence or set of sentences ("inf"). Both measures are expressed in terms of logical probability.* A fundamental tenet in developing these measures is: "The greater the logical probability of a statement, the smaller its content measure," (Bar-Hillel, 1964, p. 302). The content of a statement is the "class of those possible states of the universe which are excluded by this statement, that is, the class of those states whose being the case is incompatible with the truth of the statement," (p. 299). By design, the amount of information measure is in a form parallel to that developed by Shannon and Weaver for signal transmission. In place of the concept of probability in the statistical sense (relative frequency) used there, the concept of logical probability is used in an analogous manner (p. 244).

It is perhaps not too far from the point if we regard cont as a measure of the substantial aspect of a piece of information, and inf as a measure of its surprise value ... or (objective) unexpectedness. (p. 307)

A number of special cases are treated in the exposition of the theory. One of particular interest in our discussion to follow is the case where the inductive probabilities function is of the form appropriate for deductive logic; specifically, where "observed instances of a molecular property have no influence on the prediction of future instances of this property." Contrary to the general case with inductive probability, "Experience cannot teach us anything about the future if this function is applied," (p. 251). When this function is applied, the principle of assigning equal probability values to all state-descriptions is used. This leads to values of cont that increase in equal steps to a maximum value of 1 as additional atomic state-descriptions are added to the sentence(s) describing the state, and to values of inf that increase such that each step is larger than the preceding. In other words, as each successive logically true statement is obtained both the amount and semantic content of the information increase.

* For a clear and relatively non-technical explanation of logical probability, see Carnap (1953).
These measures are not generally applicable. In their present form they can be applied only to certain conceptual systems. They apply only to restricted language systems, "known in the profession as applied first-order language systems with identity," (p. 299). Further, the theory includes the receiver of the information only to the extent that

The semantic information carried by a sentence with respect to a certain class of sentences may well be regarded as the 'ideal' pragmatic information which the sentence would carry for an 'ideal' receiver whose only empirical knowledge is formulated in exactly this class of sentences. By an 'ideal' receiver we understand, for purposes of this illustration, a receiver with a perfect memory who 'knows' all of logic and mathematics, and together with any class of empirical sentences, all of their logical consequences." (p. 224)

But this does not mean that the theory is irrelevant to empirical problems. Formal mathematics are, at least in part, applied to real world problems; the corpuscular electron model of the atom and the theory of ideal gases are of great use in physics despite the fact that electrons may equally well be treated as wave packets and many gases are far from ideal.

Bar-Hillel sees the possibility of eventually extending these concepts to scientific discourse and language. He has already worked in the fields of linguistics and mechanical translation, but evidently has not directly applied the theory of semantic content to such fields.

3A.2.3 - The Ackoff Behavioral Theory

Ackoff's theory is concerned with the effects of the contents of a message on the state of a receiver of the message. Three modes of communication, or effects of a message, are identified: "information," "instruction," and "motivation." These are defined in terms of the effects on the receiver's probabilities of choice of behavior, the efficiencies of these choices, and the relative importance—or "value"—of these outcomes to the receiver. The formulation involves the notion of a "purposeful state" of an individual which changes as a result of communication. The basic assumption is:

Communication is an activity in which only purposeful entities can engage. Purposefulness exists only if choice is available to the entity involved and if that entity is capable of choice. (Ackoff, 1958)
An individual is said to be in a purposeful state if:

1. There is at least one possible outcome $O_1$ of his behavior which has come relative value to him in that situation; and

2. there are at least two alternative courses of action, $C_1$ and $C_2$, which have unequal and greater-than-zero efficiencies for $O_1$.

An individual then is in a purposeful state if he wants something and has unequally efficient alternative ways of obtaining it. The state consists of: the individual, $I$; the alternative courses of action, $C_1$, $C_2$, ..., $C_i$, ..., $C_m$; and the possible outcomes of action, $O_1$, $O_2$, ..., $O_j$, ..., $O_n$. The state variables are: $P_i$, the probability that $I$ will select $C_i$; $E_{ij}$, the probability that $C_i$ will yield the outcome $O_j$—i.e., the efficiency of $C_i$ for $O_j$; and $V_j$, the relative value of the $j$th outcome to $I$. A purposeful state can be represented as shown in Fig. 3A-1. The alternative courses of action and outcomes are defined to be exclusive and exhaustive—only one can and must be selected at a given time. Hence, the sum of the efficiencies of any course of action over all objectives must be equal to 1.0. The sum of the efficiencies of all courses of action for any one outcome may lie between zero and $m$.

The values of the outcomes may be derived from a wide range of definitions, since only a measure of relative value is used. However, the measure must be unitary in the present formulation. The value of a purposeful state to an individual, $V(S)$, is defined as expected value:

$$V(S) = \sum_{i}^{m} \sum_{j}^{n} P_i E_{ij} V_j$$

Communication occurs when a message produced by one source produces a change in the purposeful state of a receiver of the message; that is, it produces a change in at least one of his state variables $P_i$, $E_{ij}$, or $V_j$. If $P_i$ changes, the message informs; if $E_{ij}$ changes, the message instructs; and if $V_j$ changes, the message motivates. The purposeful state is defined by these variables, so any change in these variables reflects an effect in the potential behavior of the individual. Consequently these may also be viewed as three measures of the content of the message.

*This presentation follows Martin (1964) who credits the summarization to Professor Ackoff.*
<table>
<thead>
<tr>
<th>Relative Values</th>
<th>( V_1 )</th>
<th>( V_2 )</th>
<th>...</th>
<th>( V_j )</th>
<th>...</th>
<th>( V_n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcomes</td>
<td>( O_1 )</td>
<td>( O_2 )</td>
<td>( O_j )</td>
<td>( O_n )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probabilities of Choice</td>
<td>Courses of Action</td>
<td>( E_{11} )</td>
<td>( E_{12} )</td>
<td>...</td>
<td>( E_{1j} )</td>
<td>...</td>
</tr>
<tr>
<td>( P_1 )</td>
<td>( C_1 )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( 1.0 )</td>
</tr>
<tr>
<td>( P_2 )</td>
<td>( C_2 )</td>
<td>( \ldots )</td>
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<tr>
<td>( P_m )</td>
<td>( C_m )</td>
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<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( 1.0 )</td>
</tr>
</tbody>
</table>

Figure 1 - A Purposeful State
"Information," as used here, changes objective probabilities of choice by changing subjective estimates of probabilities of success; that is, information provides a belief, or confidence, in the greater efficiency of choosing one course of action over another.

Instruction is concerned with changing the probability that a given outcome will occur if a particular course of action is taken. The efficiency of a course of action is changed—the objective probabilities of success are modified. That is, the content of the message, or set of messages, provides the receiver with actions he can take that were not available to him in his earlier state.

Motivation is concerned with the relative values of outcomes and in changing belief in the relative importance of outcomes. In this formulation, if the individual equally values all possible outcomes, he has no basis for selection and is said to have no motivation in a given state.

Information refers to what an individual does in a given situation, instruction to how he does it, and motivation to why he does it. A message may inform, instruct, or motivate singly, or it may do any of these in combination.

Each of these aspects of change between states may be measured in terms of the variables already stated.

The amount of information contained in a purposeful state is a point on a scale bounded at the lower end by indeterminism on the part of an individual where he has no basis for choice, and at the upper end by complete determinism where he has a complete basis for choice, whether correct or not. In an indeterminate state, the probabilities of choosing any course of action are equal (all \( p_i = 1/m \)). Therefore, the distance of a state from complete indeterminism is measured by the sum of all the differences between the objective probabilities the individual will choose a course of action and its indeterminate chance of being selected:

\[
\sum_{i=1}^{m} \left| p_i - \frac{1}{m} \right|
\]

The distance between a determinate and indeterminate state is

\[2 - (2/m)\]
The ratio of these two equations provides a measure of the proportion of the maximum information a state can contain to that which it does contain. A measure of the amount of information a state contains is obtained by multiplying it by the maximum amount of information the state can contain. Ackoff (1958) derives this maximum from a consideration of the number of binary choice alternatives that must be made to select one course of action from those available. If there are \( m \) courses, the maximum amount of information is \( m-1 \) units. The number of units of information in a given state is then

\[
A(S) = \frac{m}{2} \sum_{i}^{m} \left| p_i - \frac{1}{m} \right|
\]

and the amount of information communicated, \( A_c \), is given as the difference between the amount of information contained in the receiver immediately preceding the communication and his state immediately following the communication.

\[
A_c = A(S_2) - A(S_1)
\]

Ackoff suggests that these units be called "inbits."

Whether or not the information received is "correct" or not is not at issue here. Only the change in probability of choosing a course of action is measured. Correctness depends upon the value of the information. This measure is relative to a specific receiver in a specific state. The same message may convey different amounts of information to the same individual in different states, or to different individuals in the same state. Therefore, to specify the amount of information in a message, it is necessary to specify the individuals and states relative to which the measure is made.

To inform is to provide a basis for choice--to change the confidence in the choice of a given course of action. Information modifies objective probabilities of choice by modifying subjective estimates of probabilities of success. Instruction, on the other hand is concerned with modifying the objective, \( \text{a posteriori} \), probabilities of success; that is, the efficiency. An individual's state of instruction can be characterized by the amount of control he can exercise over the outcomes in the state. He has maximum control over the outcome if he is capable of bringing about any of the possible outcomes. Instruction, Ackoff states, is the process of imparting such a capability to him where it is lacking.
A measure for control is derived in a similar manner to that given above taking into account the conditional nature of efficiency probabilities. The amount of control, \( B \), hence instruction in a state, is given by:

\[
B(S) = \left[ \sum_c \sum_d (E_{ij} | V_j = 1.0) - (E_{ij} | V_j = 0) \right] - m
\]

and the amount of instruction conveyed by a message is again determined by the change of state:

\[
B_c = B(S_2) - B(S_1)
\]

The units of this measure are termed "hubits."

The measure of motivation is developed in exact parallel with that of information; i.e., the amount of motivation \( C \) in a state is given by

\[
C(S) = \frac{n}{2} \sum_j \left| V_j - \frac{1}{n} \right|
\]

and the change in the amount of motivation resulting from a communication is

\[
C_c = C(S_2) - C(S_1)
\]

The units of motivation are termed "mobits."

Using the formulation for expected value of a state, the value of a communication is also defined in terms of the change in state of a specific receiver, taking into account the change in each of the three variables used to define each state:

\[
v_c = \sum_i \sum_j (P_i + \Delta P_i)(E_{ij} + \Delta E_{ij})(V_j + \Delta V_j) - \sum_i \sum_j P_i E_{ij} V_j
\]

Expanding this results in a string of seven terms which indicate that value can be added to, or subtracted from, the state of the receiver after receiving a message by the "information," "instruction," or "motivation" content of message separately or in combination. The individual measures both add and multiply with each other in providing a measure of value. Thus it would be possible for the value of a message to be positive, negative, or zero.
3A.3 - COMPARISON OF APPROACHES

Each of these theories deals with an aspect of the communication of information by messages. In this section we shall establish some relationships among the theories and compare them with regard to their formalisms and functions.

Each of the theories is primarily applicable at a different level of the semiotic—the theory of signs and the use of signs. The Shannon-Weaver theory functions at the level of the syntactic; the Carnap-Bar-Hillel at the semantic level; and the Ackoff at the pragmatic level. Each deals with certain properties of information messages. The Shannon-Weaver is applicable to the statistical properties of information channels; the Carnap-Bar-Hillel is applicable to the content of certain classes of messages—declarative statements of hypotheses and evidence; the Ackoff theory allows a wide range of messages and deals with the content only by way of the behavior of individuals.

The Shannon-Weaver formulation is founded in a rigorous mathematical analysis that is tied to observed empirical phenomena. In contrast, the Carnap-Bar-Hillel approach is completely theoretical, based strictly on logical conceptualizations. Like theoretical mathematics, which is after all only another form of logic, there is no reason to suppose that there should be any relevance between the theory and real world phenomena. Except for one factor, Carnap and Bar-Hillel have chosen to follow paths of development in the theory that will potentially allow it to become relevant to empirical observations. Ackoff's approach is entirely pragmatic. His starting point is a model that is assumed to be applicable to the world. This, of course, is the way many useful scientific theories are born. The test of their utility is ultimately in their application. However, a model may be derived, among other ways, on the basis of inferential extensions from rigorous analysis, on the basis of insight, or imagination, alone. Shannon-Weaver's theory and Carnap-Bar-Hillel's theory reflect the former approach; Shannon-Weaver's empirically based and Carnap-Bar-Hillel's conceptually based. Ackoff's, on the other hand, is evidently much more the latter, grounded in the philosophy set forth in Churchman and Ackoff(1947) and evidently further stimulated by the appearance of Cherry's book (1966)—judging from Ackoff's (1958) footnotes. This is not to say that one approach is superior to the other. But in the discussion to follow we will note some interesting parallels and extensions among the theories. This apparent
difference in origin indicates that these comparisons should be treated with caution.

The Shannon-Weaver theory has stimulated major extensions in probability theory as well as many practical applications in engineering communication systems, computer systems, and control systems. Apart from the often malapplied efforts in other fields, it has also been used in the study of bio-chemistry, especially genetic structures, neurophysiology, and certain fields of psychology and sociology. It is particularly in the latter two fields that misapplications of the theory, and even the basic model, are wont to arise. Neither of the other two theories have found much application as yet. The coterie of logical semanticists is small and the linguists and behavioral semanticists do not appear to have drawn much upon this theory as yet. Ackoff's theory is pragmatic, not only with regard to its semiotic level, but also with regard to its intent. However, the difficulties in applying it to real world phenomena are quite large, even under controlled laboratory conditions.

In the three theories pertaining to information there are parallel concepts and mathematical structures. Common to all is the notion of information as expressing "selection power;" ("signals have an information content by virtue of their potential for making selections." (Cherry, 1966, p. 244, p. 171))--selection of something from a set, reduction of uncertainty. The more unlikely a code, sentence, or message, the greater its surprise value--the more informative it is. All three formulations deal with change in state of the relevant universe before and after the arrival of the message. The measure of information is determined from the difference in the state values before and after. "Information is always a relative matter--an increase or decrease," (Cherry, 1966, p. 242). This aspect is incorporated into the mathematical formalism of all three.

In considering signal transmission it is reasonable to conceive of a limited set of possible codes for a signal. In semantic (logical) theory a completely specified set of logically true statements about the applicable universe is also reasonable, although somewhat more difficult to accept when it is considered that these statements can represent evidence about truths yet to be discovered by the recipient.

* Ackoff uses "pragmatic" in the sense of its empirical orientation, not specifying a relation to any semiotic level.
However, in the Ackoff behavioral theory of communication, the requirement for fully specifying the purposeful state of the receiver meets with considerable more difficulty since we are here dealing with behaviours of people. The key element in specifying a purposeful state appears to be the set of courses of action; although as Ackoff (1958) notes, there is a relativity between the courses of action and outcomes. "They are conceptual constructs and each may be converted into the other .... Such relativity of concepts is common to all areas investigated by science and hence does not present any unique methodological problems in this context." However, the requirement for specifying all of the potential courses of action of an individual or set of individuals is not so easily dismissed. Two useful and appropriate alternatives to include in any set that may take care of part of the difficulty are the following ubiquitous pair.

\[ C_1 \quad \text{"Do nothing."} \]
\[ C_m \quad \text{"Other."} \]

These are not so quixotic as they may at first appear. Many laboratory experiments, surveys, etc., might produce different results if the participant's behavioral responses were not inadvertently forced into the mold created by observer-investigator--who is supposedly outside the behavioral system. By self-consciously introducing these possibilities the researcher acknowledges that there may be more to the phenomena under investigation than his theory acknowledges. The utility of "other" in this regard is evident since it allows any state apart from the m-1 ones specified. On the other hand, the "do-nothing" possibility has a hidden danger. Namely, that the response may be "do nothing" only during the time of observation. The state variables may have actually changed--a person is no longer the same person after receiving a message.

With respect to measures of information we might well ask: How many measures of information are required? "Information, of some kind or other, certainly appears to be a concept of value in many fields, but this is not to say that the one mathematical theory and one measure have indiscriminate application," (Cherry, 1966, p. 220). At the syntactic level the Shannon-Weaver theory provides a single measure. With the accompanying expressions pertaining to other parameters of the code and technical systems, this single measure--the "bit"--has proven to be adequate to express the quantity of message entities in a channel. In the semantic (of logic) theory Carnap and Bar-Hillel have derived
a variety of measures. But they show that a single measure is inadequate and that two are sufficient to provide the requisite properties of measurement. In the Ackoff theory there are three measures. The 1-2-3 relationship is intriguing and appealing, but has no logical necessity at this point.

On the behavioristic side of the semantic level Osgood has investigated the measurement of "meaning" of words and Phrases (Osgood, Suci, and Tannenbaum, 1957). Meaning as used here would appear to be more related to Carnap-Bar-Hillel's "cont" measure of information than to the "inf" measure. By factor analytic techniques three components of meaning are found. This would tend to indicate a requirement for a three-dimensional content-of-information measure on a behavioristic basis; but this is limited by all the difficulties associated with factor analysis as well as the substance of the particular approach.

Bar-Hillel's work would indicate that at least two measures are required at the pragmatic level since the semantic is conceived of as part of the pragmatic. The three measures of Ackoff are not derived in the sense that Bar-Hillel's are; they are, in essence, defined by the nature of the model chosen to represent the behavioral process. Other models could produce a different number of measures. It can also be noted that the logical necessity discovered by Carnap and Bar-Hillel for two measures further suggests the inadequacy of attempting to directly extend the Shannon-Weaver theory to the semantic or pragmatic level.

One further aspect of the application of communication measures is particularly important to consider at the pragmatic level. This involves the manner in which the communication process takes place, particularly with regard to the presence or absence of feedback in the dynamics of information exchange encounters. This aspect will be considered in the next section.

3A.4 - RELATION TO VALUES AND PRIOR CONDITIONS

The introduction of the concept "value" is both troublesome and necessary--

To the pragmatic level we must relegate all questions of value or usefulness of messages, all questions of sign recognition and interpretation, and all other aspects which we would regard as psychological in character. (Cherry, 1966, p. 244)

Two important aspects of value as used by Ackoff should be noted. One, value is used in a relative sense. The minimum relative value ($V_j = 0$) occurs only when
the absolute value of the associated particular outcome to the individual in the situation is zero. Two, relative value is assumed to reflect motivation to seek this outcome. However, the concept of relative value and, correspondingly, relative motivation causes some confusion when a set of values are equal. Ackoff clarifies this as follows (1958):

If an individual in a state places value equally on all possible outcomes, then he has no basis for selecting among them and we can say that he has no motivation in a relative sense. The individual may desire all the outcomes greatly (in some absolute sense) and equally, or little and equally, and both cases would yield the same relative measures of value. To say he has no motivation in both cases is to abuse normal usage of the term 'motivation.' Yet in either case it can legitimately be said that he is no more motivated to seek one outcome than another. It is in this latter (relative) sense that we use the term.

This approach in the Ackoff theory clarifies the psychological relationship between values and behavior. Behavioral outcomes, \( O_j \), are desired to greater or lesser degrees, \( V_j \). But the behavior that is likely to be enacted, \( P_{ij} \), is also affected by the ability of the individual to attain the outcome, \( E_{ij} \). This is consonant with the view expressed by Albert (1963, p. 20):

Values are by definition criteria, that is, ideals, goals, norms, and standards. Accessible principally through analyses of verbal behavior, values are not the same as the actualities of conduct. Actualization may reveal that... performance does not measure up to intentions; that practice does not vindicate theory. (underscore added)

However, the mechanisms by which values are modified are not apparent in Ackoff's model nor mentioned in his discussion. Tying relative value and motivation together as indicated above seems to be not inappropriate. Certainly communication can affect relative values. But the extent to which values are changed is also affected by the values of the recipient existing prior to the arrival of a message. Ackoff's model neatly by-passes this difficulty by considering the change-of-state prior to and following the message of a specific individual in a given environment.

We have seen how the nature of the variables changes depending upon whether the researcher's interest is in the statistical characteristics of a message across a set of recipients or lies with specified individuals in given environments. In the latter case, a message "informs" a receiver by changing his confidence in the expected outcome of a course of action. This takes place through modifications of expectations (subjective probability). There may exist a similar
relation to relative values. In this view, it is to be noted, there is no relation between value and truth. Value reflects utility of an outcome to an individual. Whatever it is that determines his estimates of utility will mediate his behavior in a way that is taken into account in the model and related to a measure of the value of the message to the individual.

Ackoff's theory explicitly allows for the differences, as well as the commonalities, that individuals bring to the communication situation. "The pragmatic properties of any message depend upon the past experiences of the sender or recipient, upon their present circumstances, their states of mind, and upon all matters personal to them as individuals," (Cherry, 1966, p. 227). "Values are most easily treated as value systems. ... value systems are distinctively culturally patterned. Individual value systems may be treated as variations of the cultural value system," (Albert, 1963, p. 20). These prior conditions of the individual in his environment--his prior knowledge, beliefs, behavioral tendencies, habits, physio-chemical condition, etc.--affect his reception of the message and thereby the "information," "instruction," "motivation," and "value" measures of the message to the individual.

The major weakness in the framework as presented is that it does not provide for interaction between the message source and the receiver. This is not surprising, for only that part of the framework derived from the Ackoff model is considered. The Ackoff theory does not include these interactions--nor does it exclude them. As a before-after state description, interaction effects, as well as extralinguistic and paralinguistic phenomena, do not have to be included although their effects will be present in the measures obtained.

3A.5 - MEASURING ORGANIZATIONAL INFORMATION

There is one further aspect to be considered of the application of measures of information which is particularly important at the pragmatic level, and so in organizational studies. This involves a basic conceptualization of the communication process. It is clear at the technological level that a message is

* These prior conditions may be called the "a priori" of the individual (Thompson, 1956). For a similar viewpoint from a different approach see Shelly (1964). For relations of this to subjective probability and "confidence" see Good (1964) and references to Good therein.
originated at some point and received at another. The process is one way. At the semantic level we can inquire as to the meaning of a message to a receiver or to its sender, or its meaning in a logical system as in the Carnap-Bar-Hillel approach. Again, the relationship has a one-way property relating the message to a particular individual or frame of reference. However, at the pragmatic level, in the communication of human beings, this one way relationship is not the only one to be considered.

At times such a view is adequate. The relation of a speaker to his audience or an author through his book to his readers, and other such aspects of mass communication, can be considered as a one-way communication phenomena in which it would be useful to apply measures of information. But human communication is an active process requiring some degree of participation by both the transmitter and the receiver. The participation of the transmitter is obvious, except perhaps in mind reading. In the one-way situation, the participation of the receiver is less obvious, it being possible for it to be limited to internal conceptual and emotional processes. Most of our communication, especially in organizations, is face to face where all parties are both transmitters and receivers during the course of an encounter. The process that takes place in such encounters and what happens is not necessarily the same, just as analysis and synthesis are not the same. There are two "modes" of intercommunication among people which Thayer calls synchronic and diachronic.

In the synchronic mode, the consequence sought or realized is the "synchronization" of the participants. It is the sort of encounter in which one of the participants, Y, has as his objective either (a) bringing the psychological state of another person, Z, from its present apparent-state-of-affairs to the state-of-affairs desired or intended by Y, or (b) achieving some intended-state-of-affairs through the actions or behavior of Z. In both cases, Z is the "sink" for Y's "message." And the situation is resolved (the "problem" solved) when Z is brought into some satisfactory state of synchronization with Y, or when Z's action brings about a satisfactory state-of-affairs with respect to an intended state-of-affairs between Y and some aspect of his environment.

The other mode of intercommunication is the diachronic mode. The end sought or realized from a communicative encounter in the diachronic mode is either (a) a new state-of-affairs between Y and Z, or (b) a new state-of-affairs between Y and Z and their respective environments. But, unlike the synchronic mode, the diachronic mode does not hinge upon the resolution of one or the other's intended-state-of-affairs, but upon a joint or cooperative effort to achieve whatever result comes from the encounter. (Thayer, 1968, pp. 129-130)
Both of these modes are involved in the pragmatic level of analysis of communication. In the synchronic mode one seeks to impart knowledge, increase skills (the "efficiency" with which something can be done), motivate, or change the value placed on something in someone else. Clearly, Ackoff's model can be applied to synchronic communication situations. In diachronic communication situations something else may take place that is not included here. When one is working with another seeking to develop a plan, to analyze a problem to find a solution, to set a budget, to select personnel, and so on and on, one-way communication is not normally involved. The total process, even that which takes place in one encounter, is not adequately viewed as the sum of a series of synchronic transactions. After the problem is solved and the decisions are made, the communication of the results to those affected may take place in the synchronic mode. The problem-solving, decision-making process that especially characterizes R&D, as well as much other organizational behavior, is a diachronic communication process.

The Ackoff approach is only applicable to synchronic communication as determined by its basic structure. It provides a conceptual paradigm that can be useful to the individual in developing a speech, a paper, or a course, and it is possible that the information measures it provides might be of use, but these measures are not suitable for measuring information exchange in organizations.
REFERENCES


APPENDIX 4A

Initial site letter
Project description
Participant's letter
General Instructions
Summary Request form
Letter accompanying CD Q09
Dear Mr. Davidson:

During his visit on February 11, 1969, Mr. Harold Davidson of the Army Research Office suggested that your organization might be willing to cooperate in a relatively brief study as part of our Program of Research on the Management of R&D. This program is supported in part by Research grants from ARO, ONR, and NASA. We are interested in studying the communication process that develops between scientific or engineering groups working on technologically advanced projects. The study is a part of our continuing sub-program in the area concerned with liaison, interface, coupling, and technology transfer. It is briefly described in the attachment and is being performed by Mr. Charles F. Douds and Mr. Richard T. Barth, both of whom are Ph.D. candidates.

Mr. Douds received his B.S. and M.S. in physics and then worked on and directed various study projects in the field of military electronic reconnaissance systems for eleven years before joining our group. Mr. Barth, before entering the program at Northwestern, earned an M.S. in engineering and worked in the aerospace industry for several years. Both have already done extensive field work in a number of commercial and government R&D organizations as a part of our program.

The study design calls for data collection from 3-8 pairs of R&D groups in each of several government/aerospace organizations. These groups should have from 3 to 15 members. In each organization, data will be collected from members of all 3-8 group pairs, utilizing two questionnaires requiring approximately one hour each to complete. Three or four group pairs will, in addition, be interviewed to augment the questionnaires and to help overcome the inherent limitation of questionnaire data. This interview will last approximately 75 minutes. The elapsed time for this study in each organization will be approximately 2 weeks, excluding the initial orientation visit. Following data analysis, at least two papers will result, hopefully providing answers to the research questions given in the attachment. We will be glad to make copies of the publications available to you. Of course, no organizations or organization member will be identified in any reports or publications.

Most important, however, are the implications of this study and related ones in our program, for organizational design and for advancing the state of the art in the management of Research, Development, and Engineering.

We would appreciate learning of your interest in participating in the opportunity to enhance the understanding of the communication process in R&D. If you have any questions I will be glad to supply you with additional information.

Sincerely,

Albert H. Rubenstein
Professor

Encl.: Study Summary
COMMUNICATIONS AMONG TECHNICAL GROUPS IN R&D

This study is designed to provide information about a number of factors which our prior research in the area of R&D management has indicated may have a significant influence on the flow of technical communications necessary for the efficient planning, coordination, and performance of technical project activities. The successful completion of complex research and development projects is vitally dependent upon the exchange, among technical groups, of timely and accurate information related to progress, problems, changes, plans, design specifications, test results, new discoveries, and so on. Because of the technological complexities characteristic of R&D projects, performance characteristics of one component often affect the performance characteristics of other components. The resulting interrelationship among technical factors creates special problems for management and is reflected in each technical group being more or less dependent upon other groups' skills, knowledge, and work output. Effective and appropriate communication is required to meet project schedules, budgets, and performance requirements.

This study focuses upon the effects on communications between pairs of technical groups of the differences or similarities in decision-making, methods, the work environment of each group, and the bases upon which they make their (separate and joint) evaluations of information and decisions. It will examine, by testing a set of propositions, research questions such as the following:

--Can those people regarded as effective communicators or "coupling agents" with other groups be identified by certain characteristics so that the organization can utilize this ability?

--When and how can the flow of communications between groups be restricted, and when opened up, to avoid difficulties in information exchange?

--How do the similarities and differences in the bases for evaluation affect the flow of information between technical groups and the level of cooperation in their relations?

--What are the specific dimensions along which members of technical groups evaluate their work environment?

--How do the similarities and differences in the dimensions used for evaluation of the work environment affect the flow of information and the level of cooperation between technical groups?

The study will be carried out by (1) selecting a limited number of pairs of groups with certain managerially-identified characteristics, (2) questionnaires filled out by group members, and (3) interviews with members of selected groups. Related background information will also be obtained from a sample of managers of these groups.

Advisor: Professor A. H. Rubenstein

Investigators:
C. F. Douds, Research Fellow
R. T. Barth, Research Assistant
Successfully carrying out complex research, development, and engineering projects requires that a great deal of information be exchanged among various groups. Each group develops its own plans, designs, analyses, tests, etc., in the best way it can. But to a greater or lesser extent, each must receive information from others and provide information to others as designs are developed, experiments carried out, and changes are made, if the total project is to be successful. As the systems that are developed become more complex, the arrangements for the information transfer and decision processes become increasingly critical.

Members of the Program of Research on the Management of Research and Development at Northwestern University are concerned with increasing understanding of how the process actually works - how technical information flows are affected by various aspects of the technical tasks and the organization. Your management has given us permission to study how the communication process works in your organization.

In all of our work the information given to us is treated as confidential. The answers given by you will not be given to anybody in your organization. They will be used only for our research work. Any publication of data or conclusions will not be identified with either individuals or organizational units. Strict anonymity will be maintained throughout the study.

Your assistance in this research effort is greatly appreciated.

Thank you,

Albert H. Rubenstein
Professor

Charles F. Douds
Research Engineer

Richard T. Barth
Research Engineer

AHR/mtd
3/69
STUDY OF THE INFORMATION TRANSFER PROCESS IN RD&E ORGANIZATIONS

GENERAL INSTRUCTIONS

Information for this study is being collected by examining documents, interviews and questionnaires designed to provide data on a number of aspects of information transfer among research, development and engineering groups. Attached are one or more questionnaires which will help provide this information. Specific instructions are given within them. None of the questions require you, nor are they intended for you, to look up data or other information. Answer them quickly after reading them carefully. Only your own reactions are sought.

If you should wish to amplify on a question or to ask a question about an item, place a large checkmark in the right margin. Please feel free to do so.

Do not write your name on the questionnaires. All responses will be coded and the filled-in forms secured so that the identity of individuals will not be revealed. Your name will not be associated with any information you provide to anyone in this organization or anyone in any other organization. The name of this organization will not be revealed in any reports or presentations. Strict anonymity will be maintained throughout the study.

Charles F. Douds
Richard T. Barth
If you would like to receive a summary of our study, we would be glad to send it to you - probably early in 1970. We would also like to send a personal letter of appreciation to you for participating in this study of factors affecting communications in research, development, and engineering.

Send this sheet (in a separate envelope) to:

C. F. Douds / R. T. Barth
Department of Industrial Engineering
Northwestern University
Evanston, Illinois 60201

Your name and address:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

ZIP ______

☐ Please send a copy of the study summary.

If you wish, you may return this sheet with the questionnaires.
Dear Sir:

Enclosed is the final form for my part of the study of some factors affecting communications among technical groups. It contains three questions pertaining to 20 items selected from the 80 items in the Technical Work Values form you and your colleagues completed.

As you may recall from our discussion, this two-step procedure is used to reduce the amount of your time required. It will require only about 15 minutes to complete.

I will appreciate it very much if you can return it in a day or two.

You may also be interested to know that at this time data collection has been completed in 13 organizations with one remaining. Preliminary analysis indicates that the "instruments" are functioning properly in most situations. Analysis to examine the propositions being tested has been started and will continue into the Fall.

If you did not request a summary of the study previously but wish to do so now, feel free to enclose a note with your name and address in the envelope provided for returning the Item Rankings form enclosed.

Thank you for your cooperation.

Yours truly,

Charles F. Douds
Research Engineer

CFD/jlr
Enc.
APPENDIX 4B

CD Q08 - Technical Work Values
CD Q09 - Value Rankings
CD Q02 - Work Communication and Work Structure
CD Q01 - Group Membership
CD Q05 - Background Information
RB Q10.1 - Group Activity Rating
CD Q10.2 - Group Activity Rating
CD Q11 - Recent Changes
RB Q09.2 - Work Structure
A set of 80 items relevant to people involved with technology or science are given below in random order. Some of them will be of lesser importance, some of greater importance, to different people in different jobs. We would like to determine how important they are to you in the work you do in your group and your function in this organization. The combined results from your group and another group will be used to select a shorter list of items for use in the study at a later time.

For each item select a number from the scale below and write it on the line beside the item.

4 - extremely important
3 - quite important
2 - moderately important
1 - slightly important
0 - not important; irrelevant

In order to do your kind of work well in this group, how important are each of the following to you?

1. _____ To have emotional neutrality - keep one's emotions in check.
2. _____ To know how others are progressing on their work.
3. _____ To be able to lead and control.
4. _____ To be sociable.
5. _____ To attain stated specifications.
6. _____ To fully develop ideas theoretically before trying them in practice.
7. _____ To be dedicated (rather than ambitious).
8. _____ To provide functional utility of design.
9. _____ To develop technical competence in others.
10. _____ To meet delivery schedules.
11. _____ To design for quality control.
12. _____ To have reliability of design.
13. _____ To make full use of one's present knowledge and skills.
14. _____ To work by cut-and-try methods.
15. _____ To exceed technical specifications.
16. _____ To be creative, innovative, imaginative.
In order to do your kind of work well in this group, how important are each of the following to you?

17. __________ To be sincere.
18. __________ To be persistent in one's work.
19. __________ To work on difficult and challenging problems.
20. __________ To act as one believes, regardless of contrary opinion.
21. __________ To subject ideas to practical trial as soon as possible.
22. __________ To work with colleagues of high technical competence.
23. __________ To have freedom to choose what one will work on.
24. __________ To provide for safety of design.
25. __________ To learn and develop through interactions with colleagues.
26. __________ To make technical or scientific knowledge openly available to the scientific/technical community.
27. __________ To refine a design; to make it the best possible.
28. __________ To fully report the sources of one's ideas.
29. __________ To have a sense of humor.
30. __________ To discover general principles that apply to many situations.
31. __________ To have an application orientation - pragmatic, empirical.
32. __________ To do rigorous testing.
33. __________ To work with things more so than with people.
34. __________ To have a sense of mission for one's projects.
35. __________ To build one's professional reputation.
36. __________ To have similar interests - sports, religion, politics, etc. - to one's group.
37. __________ To have congenial co-workers or colleagues.
38. __________ To be conscientious.
In order to do your kind of work well in this group, how important are each of the following to you?

39. ___ To reduce total project costs.

40. ___ To know why things are being done the way they are.

41. ___ To operate ethically.

42. ___ To work on problems for which there are ready-made solutions.

43. ___ To be efficient in one's work.

44. ___ To be loyal to one's organization.

45. ___ To provide for manufacturability of design or "implementability" of approach.

46. ___ To contribute to broad technical knowledge in one's field.

47. ___ To advance oneself economically.

48. ___ To have an academic orientation - theoretical, analytical.

49. ___ To have freedom to carry out one's ideas within project objectives.

50. ___ To present and discuss ideas with colleagues.

51. ___ To work on problems of great value to the nation and society.

52. ___ To objectively - not subjectively - judge technical or scientific work.

53. ___ To have enthusiasm.

54. ___ To be loyal to one's work group.

55. ___ To help others.

56. ___ To have a stable, secure future.

57. ___ To anticipate the wishes of one's group before acting.

58. ___ To get acceptable results, adequate to do the job.

59. ___ To be flexible in the approaches one considers.

60. ___ To be unselfish.
In order to do your kind of work well in this group, how important are each of the following to you?

61. ____ To use proven techniques or items.
62. ____ To have aesthetic appeal of design.
63. ____ To have a sense of mission for science or technology.
64. ____ To have social status and prestige.
65. ____ To have self-discipline.
66. ____ To have tolerance.
67. ____ To have understanding or sensitivity.
68. ____ To have sophistication of design or approach.
69. ____ To provide for maintainability of design.
70. ____ To advance and move ahead in organizational position.
71. ____ To probe deeply and thoroughly into technical/scientific phenomena.
72. ____ To promote the welfare of one's work group.
73. ____ To compromise, rather than do exhaustive research, analysis, or development.
74. ____ To be a member of one's professional community outside the organization.
75. ____ To get quick solutions.
76. ____ To have simplicity of design or approach.
77. ____ To have innovative designs or approaches.
78. ____ To have freedom to choose how one will carry out his work.
79. ____ To consider trade-off possibilities.
80. ____ To bring order and simplicity in chaotic or complex material.
Many of the items in the previous pages are quite general. Here we would like to obtain some more specific items. These should be more concrete items of importance to the work of engineers, scientists, or technicians.

Please list at least three specific items of importance to you and your group in your work - items of importance in the kind of projects or work activities you are engaged in.

1. 

2. 

3. 

4. 

Now please list at least two specific items of importance to the Referenced Group as you would judge from the things they say and do, or the things you hear about them.

1. 

2. 

3. 

4. 

Thank you.
ITEM RANKINGS

INSTRUCTIONS

In a previous questionnaire containing 80 items, members of your group and another group in this organization checked off technical work values of importance to them. The 20 most important were selected from the combined results and are used here in three different ways. Please follow the instructions below and at the top of each page.

If at all possible take a break - do something different for a few minutes - between each page.

Answer the items quickly - your first reaction is probably the best. Do not check back to prior pages. There are no "right" answers.

Think in terms of the importance of the items over long time periods. We recognize that at any given time the relative importance of some items will change.

On each page you are to provide information that will allow the items to be ranked from most important to least important. Do this by assigning to each item a number from 0 to 99, depending on how important you think each item is in the situation for that page. Make sure no two numbers are the same. Write the numbers on the line provided.

SUGGESTION: This may go faster for you if you first check (✓) the 4 to 6 most important items and then circle (○) the 4 to 6 least important before assigning the numbers.
PART A

REFERENCED GROUP

Assign numbers from 0 (least important) to 99 (most important) the way you think the people in the Referenced Group - indicated earlier or told to you by the researcher - would do so. Make sure no two numbers are the same.

A. _____ To advance and move ahead in organizational position.
B. _____ To advance oneself economically.
C. _____ To provide for maintainability of design.
D. _____ To help others.
E. _____ To operate ethically.
F. _____ To learn and develop through interactions with colleagues.
G. _____ To design for quality control.
H. _____ To provide for manufacturability of design or "implementability" of approach.
J. _____ To have a sense of mission for one's projects.
K. _____ To have freedom to try new ideas.
L. _____ To have freedom for people to carry out his work.
M. _____ To have emotional stability - keep one's emotions in check.
N. _____ To develop technical competence in others.
P. _____ To be persistent in one's work.
Q. _____ To discover general principles that apply to many situations.
R. _____ To refine a design: to make it the best possible.
S. _____ To be flexible in the approaches one considers.
T. _____ To present and discuss ideas with colleagues.
U. _____ To get quick solutions.
PART B

SELF

Assign numbers from 0 to 99 indicating importance to you. Make sure no two numbers are the same.

A. ___ To present and discuss ideas with colleagues.
B. ___ To be flexible in the approaches one considers.
C. ___ To advance oneself economically.
D. ___ To have emotional neutrality - keep one's emotions in check.
E. ___ To have a sense of mission for one's projects.
F. ___ To help others.
G. ___ To develop technical competence in others.
H. ___ To learn and develop techniques to communicate with colleagues.
J. ___ To discover general principles that apply to many situations.
K. ___ To have freedom to carry out one's ideas within project objectives.
L. ___ To get quick results.
M. ___ To be persistent in one's work.
N. ___ To have a sense of humor.
O. ___ To operate ethically.
P. ___ To provide for maintainability of design.
Q. ___ To refine a design: to make it the best possible.
R. ___ To advance and move ahead in organizational position.
S. ___ To provide for manufacturability of design or "implementability" of approach.
T. ___ To design for quality control.
PART C

IDEAL ASSOCIATE

This is a hypothetical situation. In a new organization of which you are a part, you are doing exactly the kind of work you would like to do. You are to hire an associate to work with you. He will be available as much or little as you need him. Assign numbers from 0 to 99 the way you think the ideal man for this position would do so.

A. ____ To advance oneself economically.
B. ____ To help others.
C. ____ To advance and move ahead in organizational position.
D. ____ To learn and develop through interactions with colleagues.
E. ____ To have freedom to choose how one will carry out his work.
F. ____ To get quick solutions.
G. ____ To have freedom to carry out one's ideas within project objectives.
H. ____ To develop technical competence in others.

**Specific items selected for specific group pairs.**

I. ____ To operate effectively with other group members.
J. ____ To keep one's emotions in check.

See section 4.5.4.

K. ____ To provide for maintainability of design or "implementability" of approach.
L. ____ To provide for maintainability of design.

M. ____ To design maintainability control.

N. ____ To present and discuss ideas with colleagues.
P. ____ To refine a design: to make it the best possible.
R. ____ To be flexible in the approaches one considers.
S. ____ To discover general principles that apply to many situations.
T. ____ To have a sense of humor.
U. ____ To provide for maintainability of design.
V. ____ To have a sense of mission for one's projects.
W. ____ To be persistent in one's work.
REFERENCE GROUP: ____________________________

WORK COMMUNICATION AND WORK STRUCTURE

In the following questions we are seeking to learn something about the information exchange that takes place between your group and the one named above. We also want to discover something about the nature of the work relationship between the groups. The words "this group", "the other group", "they", and "them" refer to the group named above or told to you by the researcher. Answer all questions with respect to the Referenced Group. Unless otherwise stated, "you" refers to the members of your whole group.

Answer the questions in terms of your present impressions based on your typical experiences over the last six months to a year (or since you first began dealing with them, if less.)

Pick the number of the response you feel is most appropriate from the list provided with each set of questions and write it on the line to the right of each question. There are no "right" answers. Answer as you truly believe to be the case.

Your answers will be treated with strict confidentiality.

1 - Several times a day
2 - Once or twice a day
3 - Several times a week
4 - About once a week
5 - A few times a month
6 - About once a month
7 - Less often than once a month
8 - Never

1. How often does your group talk with people from the Referenced Group about the project, or technical work?

2. How often do you personally talk with people from their group about the project, or technical work?

3. How often does your group attempt to learn from them about changes being made or proposed in their work which might affect you or your group?

4. How often does your group receive information from them about changes being proposed or made in project or technical work relevant to your group's responsibilities?
1 - Almost immediately
2 - Always by the time it is needed
3 - Usually as soon as it is needed
4 - Frequently there are delays
5 - Often there are serious delays
6 - I've stopped asking them. I never find out.
9 - Does not apply. No reason to find out.

5. When your group asks them for information, how long does it usually take to receive it?

6. When you ask them for information relevant to making a change on some item or aspect of the project, how long does it usually take for your group to receive a specific answer from them?

7. When they make a change in their work that significantly affects you, how long does it usually take for your group to find out about it?

This is a strictly hypothetical question.

Assume that for some reason suddenly no information were available from the other group to anyone - in essence, they ceased to exist.

8. What is the longest time your group could wait without too much disruption to its normal work before you or someone else would have to begin doing their work - or at least that part of it which pertains to your group?

1 - One day or less
2 - One week or less
3 - One month or less
4 - Three months or less
5 - Six months or so
6 - A year or longer

9. How adequately is your group informed on the status of those aspects of their current activities relevant to your work?

1 - Not at all adequately
2 - Barely adequately
3 - Moderately
4 - Very adequately
5 - Completely adequately
9 - Don't need to know

10. How adequately is your group informed of that they expect to achieve and by when?

11. How adequately do you know what they expect of you in doing your work?
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not at all</td>
</tr>
<tr>
<td>2</td>
<td>To a very little extent</td>
</tr>
<tr>
<td>3</td>
<td>To some extent</td>
</tr>
<tr>
<td>4</td>
<td>To a considerable extent</td>
</tr>
<tr>
<td>5</td>
<td>To a very great extent</td>
</tr>
<tr>
<td>9</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

12. To what extent are the communications with them handled by...

13. ...one or two people from your group?

14. To what extent does your group need to know the status of their current activities?

15. To what extent does your group need to know what they expect to achieve?

16. To what extent does your group need to know what they expect of you?

17. To what extent do they make requests for information that come unexpectedly to your group (and require significant effort to fulfill)?

18. To what extent do they make changes affecting your work that come unexpectedly (and require significant effort)?

19. When you receive requests, recommendations, instructions, or other such information from the other group, generally to what extent is it clear as to what is needed, what to do, etc.?

20. We all respect the knowledge and judgement evidenced by the actions of some groups more than others. To what extent do you have this kind of respect for their group?

21. To what extent are the communications with them handled by...

22. ...one or two people from their group?

23. To what extent does their group need to know the status of your group's current activities?

24. To what extent does their group need to know what your group expects to achieve?
Please indicate the extent to which each of these statements is the case.

1 - Not at all
2 - To a very little extent
3 - To some extent
4 - To a considerable extent
5 - To a very great extent

25. They have to "finish" a major task before we can go very far on a major task we have to perform.

26. We have to "finish" a major task before they can go very far on a major task they have to perform.

27. Both of us must work concurrently (perhaps because each needs information from the other to complete their respective assignments, or perhaps because possible trade-offs can importantly affect the success of both groups).

28. They provide us with advice or information not generated specifically for the project(s) we work on.

29. We provide them with advice or information not generated specifically for the project(s) they work on.

30. They have the responsibility to check or approve items, designs, recommendations, or actions made by others on the project.

31. We have the responsibility to check or approve items, designs, recommendations, or actions made by others on the project.

32. They work on relatively short term activities at our request.

33. We work on relatively short term activities at their request.

34. They work on long term activities originating from us.

35. We work on long term activities originating from them.

* * * * * * * * * *

If none of the above describe the relationship of what they do to what you do, please describe what the relationship is:
Here we distinguish between the completeness of communication and the accuracy or distortion in the content of what is communicated.

- 1 - Not at all
- 2 - Not very
- 3 - Somewhat
- 4 - Moderately
- 5 - Quite
- 6 - Very

36. When changes in work or a project are being considered with them, how doubtful is it that the information is as complete as your group needs it?

37. When changes in work or a project are being considered with them, how doubtful do you tend to be of the content provided on key issues - that it is as accurate as it can be at the time?

1 - No pressure at all
2 - A little pressure
3 - Some pressure
4 - Quite a lot of pressure
5 - A great deal of pressure

How much pressure does your group feel from this group to:

- [ ] Generally increase performance - the quality of work you are responsible for on the project. 38. ___
- [ ] Generally work more efficiently on the project. 39. ___
- [ ] Provide your work output sooner. 40. ___
- [ ] Help with problems on the project. 41. ___
- [ ] Minimize changes in the project. 42. ___
- [ ] Meet tighter specs or more difficult goals. 43. ___
- [ ] Reduce dollar costs. 44. ___
- [ ] Change certain characteristics (specs, design) of what you are now working on. 45. ___

46. - 52. Rank order these seven items on the basis of their importance to yourself in your present work. In the boxes on the left place a "1" for the item that is most important to you, a "2" for the next most important, etc.
1 - Not at all
2 - To a very little extent
3 - To some extent
4 - To a considerable extent
5 - To a very great extent

In order for YOUR GROUP to adequately perform its work on this project, to what extent does your group need to:

53. Make use of their regular technical output - e.g., designs, hardware, software, test facilities/results, documents, drawings, etc.?

54. Receive or obtain rulings on specific points (e.g., permission to use a specific material), formal direction, or authorization from them?

55. Work in parallel with them - exchanging information and deciding on things together?

In order for YOUR GROUP to adequately perform its work on this project, to what extent does the Referenced Group need to:

56. Be informed of activities you are responsible for or be informed of your specialized knowledge?

57. Make use of your technical output?

58. Make use of rulings on specific points, formal direction, or authorization provided by you?

In order for THEM to adequately perform their work on this project, to what extent do they need to:

59. Make use of your regular technical output - e.g., designs, hardware, software, test facilities/results, documents, drawings, etc.?

60. Receive or obtain rulings on specific points (e.g., permission to use a specific material), formal direction, or authorization from you?

61. Work in parallel with you - exchanging information and deciding on things together?
Circle one number for each question. Note the key words: accuracy, completeness, usefulness, and confirmation.

62. In terms of your group's needs, how accurate has the content of what they tell your group usually turned out to be - how well has it reflected the situation discussed?

<table>
<thead>
<tr>
<th>Extremely accurate</th>
<th>Neither accurate nor misleading</th>
<th>Grossly misleading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>9 - They rarely tell us anything.</td>
<td></td>
</tr>
</tbody>
</table>

63. In terms of your group's needs, how complete has the information provided by the other group turned out to be - do they usually provide all the information available to them which you need?

<table>
<thead>
<tr>
<th>Extremely complete</th>
<th>About half the story</th>
<th>Extremely limited</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>9 - They rarely tell us anything.</td>
<td></td>
</tr>
</tbody>
</table>

64. In terms of your group's needs, how useful is the information they provide to your group?

<table>
<thead>
<tr>
<th>Extremely useful</th>
<th>About half useful</th>
<th>Rarely useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>9 - They rarely tell us anything.</td>
<td></td>
</tr>
</tbody>
</table>

65. If they were to make a somewhat unusual request or provide a somewhat unexpected response to you (in their assigned area of responsibility), if the item were of concern to you, to what extent would you seek to confirm it?

<table>
<thead>
<tr>
<th>Very much more than usual</th>
<th>Somewhat more than usual</th>
<th>Not at all more than usual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

66. What is your individual over-all evaluation of the effectiveness of the communications between your group and the other group?

<table>
<thead>
<tr>
<th>Couldn't be better</th>
<th>So - So</th>
<th>Couldn't be worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
These questions involve your communications to them.

1 - Not at all adequately
2 - Barely adequately
3 - Moderately
4 - Very adequately
5 - Completely adequately
9 - Don't need to know

67. How adequately are they informed on the status of those aspects of your group's current activities relevant to their work?

68. How adequately are they informed of what your group expects them to achieve and by when?

69. How adequately do they know what your group expects of them in doing their work?

1 - Not at all
2 - To a very little extent
3 - To some extent
4 - To a considerable extent
5 - To a very great extent
9 - Not applicable

70. To what extent does your group make requests for information that come unexpectedly to them (and require significant effort to fulfill)?

71. To what extent does your group make changes affecting their work that come unexpectedly to them (and require significant effort)?

72. When they receive requests, recommendations, instructions, or other such information from your group, to what extent do they seem to understand what you need, what they are to do, etc.?
Thank you for doing this questionnaire. We would appreciate your noting here any additional comments you might have about communications with this group and how it affects your work. Comments about the questionnaire would also be helpful.
GROUP MEMBERSHIP
WORKSHEET INSTRUCTIONS

Here we want to find out who comprises your own immediate work group and the Referenced Group (told to you by the researcher or named on the Worksheet) as you see them. Because different people see "the same" group in different ways it is important to find out specifically who you see as belonging to these groups.

The membership of groups working on tasks may be, or may not be, the same as the official assignment of people to sections, branches, or other formal administrative units. Sometimes people work independently, sometimes the work group or team is much the same as the official group, and sometimes the team includes people from various places. It is also necessary to obtain your responses to some characteristics of these individuals. Prior studies have shown that these items can affect communications and so we must take them into account.

This data will be kept strictly confidential. You may mail it directly to the researcher. The individual data will only be used for statistical analysis. Both individuals and organizations will remain anonymous.

INSTRUCTIONS

(A.) On the attached Worksheet, please print the names of those people whom you consider to belong to your immediate work group or team - the more-or-less close group that works together in carrying out the responsibilities they share. This may or may not include people from other divisions, sections, or firms; subordinates or supervisors.

(B.) Now please print the names of the people you think of as belonging to the Referenced Group. (If you use a phone book or other source to get the names right, DO NOT add other names you find. This is not a test of memory or accuracy. We only want to know whom you associate with this group.)

(C.) For each person check off the appropriate response to the following items in the spaces provided on the Worksheet.

FREQUENCY - your typical frequency of contact with him whether initiated by him or you.

STATUS - the status of his organizational position relative to yours.

EXPERIENCE - his depth or extent of technical experience in the type of work he is now doing.

CLOSE FRIEND - check any persons you would consider as close personal friends of yours.

ESTEEM - follow the instructions on the page following the Worksheet where you will construct your own "thermometer."
## GROUP MEMBERSHIP WORKSHEET

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>STATUS</th>
<th>EXPERIENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Several times a day</td>
<td>Higher</td>
<td>Very extensive</td>
</tr>
<tr>
<td>Once or twice a day</td>
<td>Same as me</td>
<td>Well experienced</td>
</tr>
<tr>
<td>Several times a week</td>
<td>Lower</td>
<td>Normal amount</td>
</tr>
<tr>
<td>About once a month</td>
<td>Very inexperienced</td>
<td>Inexperienced</td>
</tr>
<tr>
<td>About once a month</td>
<td>Irregularly #</td>
<td>Experienced</td>
</tr>
</tbody>
</table>

### OWN GROUP MEMBERS

<table>
<thead>
<tr>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own group members</td>
</tr>
</tbody>
</table>

### REFERENCED GROUP

<table>
<thead>
<tr>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Referenced group</td>
</tr>
</tbody>
</table>

* Please do not use this column.
* Frequently for limited periods at irregular intervals.
ESTEEM SCALE

Think of the person whom you know of, either through personal acquaintance or his works, for whom you have the highest respect for his technical or scientific activities. He may be presently living or dead; a member of this organization or not.

(A) Write his initials beside the top of the scale below.

(B) Think of a particular person with technical responsibilities that you have known whom you definitely do not respect. Place a "D" at the bottom of the scale to symbolize him.

(C) Now think of the technically trained "ordinary Joe" you might bump into anywhere. At what you consider the appropriate bar on the scale, place a "J" to indicate your level of respect for him.

(D) Now number the bars on the scale any way you wish to.

(E) From this scale now assign a number to each person on the Worksheet in the column labeled ESTEEM.
BACKGROUND QUESTIONS

1. Name (optional): ____________________________________________________________

2. Job Title: ________________________________________________________________

3. Department (or equivalent): ________________________________________________

4. Job type (check one):
   - Individual contributor or team member
   - Project head, group leader, supervisor, or other management or technical direction position
   - Technical or scientific advisor or fellow
   - Other (please describe): ____________________________________________________

5. Age: □ 20-29 □ 30-39 □ 40-49 □ 50+

6. Employed by our present organization:
   - less than one year
   - 1-2 years
   - 3-5 years
   - 6-10 years
   - 11+ years

7. Degree: __________ Year: __________ Major field: ____________________________

8. Would you describe yourself primarily as a: (Check one)
   - scientist
   - engineer
   - supervisor or manager
   - other: ______________________

9. My technical field is: (Check one)
   - Aeronautics
   - Astronautics
   - Chemistry
   - Electrical power
   - Electronics
   - Materials
   - Other:

   - Mathematics
   - Mechanical eng'g
   - Metallurgy
   - Physics
   - Computer programming
   - Systems engineering

10. My particular specialty, if any, is: __________________________________________

11. Please circle the one scale value which most describes the extent to which you think of yourself as a SPECIALIST (relative to colleagues in your own department or division):
   Not at all    1    2    3    Somewhat    4    5    6    Very much    7
12. How long have you been a member of your present group? ___________

13. How long has this group been made up of more-or-less the same people? ___________

14. In the last year have there been any major changes in the responsibilities of your group, such as starting new major projects, ending major projects, major changes in workload?
   YES  NO  If so, please describe briefly: ___________

15. In the last year have there been any major changes of management or policy affecting your group?
   YES  NO  If so, please describe briefly: ___________

16. Is there anything special that might particularly set you apart from other members of your group in terms of what you work on, how you spend your time, your responsibilities, etc.?
   YES  NO  If so, please describe briefly: ___________
**GROUP ACTIVITY RATINGS**

Your rating of the group pair identified above is desired. Please answer the questions by considering how one group compares with the other. Your answers will remain strictly confidential.

1. **What is your individual over-all evaluation of the quality of the relations between these groups?** (Circle one number)

<table>
<thead>
<tr>
<th>Couldn't be better</th>
<th>So-So</th>
<th>Couldn't be worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. What is your individual over-all evaluation of the unity of effort achieved by these groups in performing work affecting the activities of both?

<table>
<thead>
<tr>
<th>Couldn't be better</th>
<th>So-So</th>
<th>Couldn't be worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>3</td>
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<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. To what extent are these groups innovative in their approach to the solution of technical problems?

- Group (a) __________
- Group (b) __________

4. To what extent are these groups successful in reducing target date uncertainty, i.e. uncertainties connected with getting the work completed on time?

- Group (a) __________
- Group (b) __________

5. To what extent are these groups successful in reducing technical uncertainty, i.e. uncertainties connected with whether or not a problem is solvable?

- Group (a) __________
- Group (b) __________

6. To what extent do you feel certain of these answers? (Exclude "8's" and "9's")

- Group (a) __________
- Group (b) __________
GROUP ACTIVITY RATING

Your rating of a few groups, one of which is named above, is desired. Answer the questions below considering how this group compares with other groups with which you have had experience in this organization and elsewhere. Your answers will remain strictly confidential.

5 - To a very great extent
4 - To a considerable extent
3 - To some extent
2 - To a very little extent
1 - Not at all
8 - Insufficient knowledge to reply
9 - Not applicable

1. To what extent does this group effectively carry out its own work?

2. To successfully do its work, to what extent is it necessary for this group to work with other groups:
   2) in their own department?
   3) outside their own department?

4. To what extent does this group actually work effectively with other groups:
   4) in general?
   5) in their own department?
   6) outside their own department?

7. To what extent is this group productive:
   7) for their department?
   9) for other departments that could or do find their work useful?
   9) for the organization as a whole?
   10) for (potential) customers or users outside the organization?

11. To what extent is the work of this group important to:
    11) the major project(s) to which they contribute?
    12) your present responsibilities?
    13) the organization as a whole?

14. To what extent do you feel certain of these answers? (Exclude "8's" and "9's")
This study is being conducted in two parts. In order to determine if the data collected at different times is comparable, we would like you to tell us of any changes that may have occurred. If you filled out a set of forms more than a week ago for Mr. Douds or Mr. Barth please complete this page; otherwise skip it.

SINCE THE PREVIOUS FORMS WERE FILLED OUT ...

1. Have there been any major changes in the responsibilities of your group - major changes in workload, starting new projects, ending major projects, etc.? (Circle one)

   YES  NO

2. Have there been any major successes or failures affecting you, your group, or the Referenced Group?

   YES  NO

3. Has your work or their work entered a new stage, perhaps affecting the relationship between the two group?

   YES  NO

4. Have there been any incidents, non-technical crises, new policies, changes in personnel, etc., affecting you and/or the Referenced Group?

   YES  NO

5. Has the amount of written or verbal communication between the groups changed?

   INCREASED  DECREASED  ABOUT THE SAME

6. Has the quality of information moving between the groups changed?

   INCREASED  DECREASED  ABOUT THE SAME

7. Has the quality of the relationship between the groups changed?

   BETTER  WORSE  ABOUT THE SAME

8. BRIEFLY DESCRIBE these changes, or any others relevant, indicating the causes or effects as you see them. (Continue on back, as necessary.)
WORK STRUCTURE

Using the following scale, please indicate the extent to which each of the statements applies:

1 - Not at all
2 - To a very little extent
3 - To a moderate extent
4 - To a considerable extent
5 - To a very great extent

1. Work or project changes initiated by us influence their work activities.

2. Work or project changes initiated by them influence our work activities.

3. They have to "finish" a major task before we can go very far on a major task we have to perform.

4. We have to "finish" a major task before they can go very far on a major task they have to perform.

5. We can do the following without consulting them:
   (a) define our task/project objectives
   (b) set deadlines/completion dates for our work
   (c) set deadlines/completion dates for their work

6. They can do the following without consulting us:
   (a) define their task/project objectives
   (b) set deadlines/completion dates for their work
   (c) set deadlines/completion dates for our work

7. They have the responsibility to check or approve items, designs, recommendations, or actions made by us and others on the subject.

8. We have the responsibility to check or approve items, designs, recommendations, or actions made by them and others on the project.

9. Because of the nature of their work, they can influence decisions affecting our work activities and progress.
10. Because of the nature of our work, we can influence decisions affecting their work activities and progress.

11. They provide us with advice or information not generated specifically for the project(s) we work on.

12. We provide them with advice or information not generated specifically for the project(s) they work on.

13. Both of us must work concurrently because the two groups:
   (a) are working on tasks with shared specifications and requirements
   (b) trade-offs can importantly affect the success and timely completion of the tasks of both groups
   (c) the completed work of both groups is passed on to a common third group

14. Unity of effort is achieved in completing work affecting both groups.

15. They work on relatively short term activities at our request.

16. We work on relatively short term activities at their request.

17. Work or project changes initiated by us require much effort on their part (to respond to and accommodate such changes).

18. Work or project changes initiated by them require much effort on our part (to respond to and accommodate such changes).

19. Both of us must work concurrently (perhaps because each needs information from the other to complete their respective assignments, or perhaps because possible trade-offs can importantly affect the success of both groups).

20. They work on long term activities originating from us.

21. We work on long term activities originating from them.

If none of the above describe the relationship of what they do to/with your work (or what you do to/with their work), please describe what the relationship is:

* * *
APPENDIX 4C

Program WORKVAL
PROGRAM WORKVAL (INPUT, OUTPUT, TAPE3, INPUT)
DIMENSION IMAGE (10), NGPB (9), NRESP (10), ITEM (80), A (80),
1 ARO (80), B (80), RSO (80), T (80), SQ (80), NUMA (80), NUMB (80), NUMT (80), SAME
2 SAM (80), SNAME (80), NUMA (80), AVAR (80), BVAR (80), ADVAR (80), TVAR (80),
3 DISC (80), TEMP (80), B V (80), NUMD (80), ADMEAN (80), BDMEAN (80)
KGP = 0
7 NBLANK = 5555555555555555555
DO9 K = 1, 10
9 NRESP (K) = NBLANK
DO8 K = 1, 80
AVAR (K) = ADVAR (K) = BVAR (K) = BDVAR (K) = 0.0
A (K) = B (K) = T (K) = ASQ (K) = RSQ(K) = TSQ(K) = 0.0
NA = NH = NT = 0
KTR = 1
C READ WHOLE CARD IMAGE
10 READ (0, (IMAGE(I), I=1, 10)) IF (ECF (3)) 105, 1111
800 FORMAT (K1, R7, 7A10e R2)
C CHECK IF "NON-DATA HEADER CARD (* 25555555 IN COL. 1)
1111 IF (IMAGE(1) .EQ. 47B) 11, 20
11 IF (KGP .EQ. 1) 12, 15
12 DC13 J = 1, 9
13 NGPB (J) = IMAGE (J + 1)
PRINT 803, (NRESP(K) + K = 1, 10)
KTR = 1
DC14 K = 1, 10
14 NRESP (K) = NBLANK
PRINT 805, (NGPB(J), J = 1, 9)
805 FORMAT (/X, 9A10)
KGP = 2
GC TO 10
C NOW STARTING NEXT GP A, BUT FIRST MUST CALD AND PRINT PRIOR PAIR
15 IF (KGP .EQ. 0) 16, 18
C ABOVE TAKES CARE OF FIRST TIME THRU START UP
16 KSTART = 1
PRINT 804
804 FORMAT (1H1, 57X, 9Q08 WORK VALUES SORT/#//# RESPONSENTS)
PRINT 805, (IMAGE(J), J = 2, 10)
DC 17 J = 1, 9
17 NGPB (J) = IMAGE (J + 1)
KGP = 1
GC TO 10
18 PRINT 803, (NRESP(K) , K = 1, 10)
803 FORMAT (10(3XA10))
KTR = 1
DC19 K = 1, 10
19 NRESP (K) = NBLANK
KGP = 1
GC TO 105
C DATA EXTRACTION FROM R-FIELDS
20 IF (IMAGE(10) .EQ. 5535B) 21, 25
21 JK = 1
JL = 40
C STORE RESPONDENT NUMBER (AND QN R NUMBER)
NRRESP(KTR)=IMAGE(9)
KTR=KTR+1
C IF LINE IS FULL, PRINT IT
IF (KTR.EQ.11) 22, 24
22 PRINT 103v (NRRESP(K), K=1,10)
KTR=1
DC 23 K=1,10
NRRESP(K)=NBLANK
24 IF (KGPEQ.1) NA=NA+1
IF (KGPEQ.2) NB=NB+1
GO TO 26
25 JK=41
JL=80
26 DECODE (52,801,IMAGE) (ITEMP(J), J=JK*JL)
801 FORMAT (9X,11X,3X,7L1,32I1)
GO TO (101,103) KGPE
101 DC 102 I=JK*JL
ATP=FLOAT(ITEMP(I))
A(I)=A(I)+ATP
ASQ(I)=ASQ(I)+ATP
T(I)=T(I)+ATP
102 TSQ(I)=TSQ(I)+ATP
GO TO 10
103 DC 104 I=JK*JL
ATP=FLOAT(ITEMP(I))
B(I)=B(I)+ATP
BSQ(I)=BSQ(I)+ATP
T(I)=T(I)+ATP
104 TSQ(I)=TSQ(I)+ATP
GO TO 10
105 DC 106 I=1,80
NUMA(I)=NUMB(I)=NUMD(I)=NUMT(I)=I
AMEAN(I)=A(I)/NA
BMEAN(I)=B(I)/NB
TMEAN(I)=T(I)/(NA*NB)
IF (NA.EQ.1) GC TO 1051
ADVAR(I)=AVAR(I)=(ASQ(I)-A(I)*A(I)/NA)/(NA+1)
1051 IF (NB.EQ.1) GC TO 1052
HDVAR(I)=BVAR(I)=(BSQ(I)-B(I)*B(I)/NB)/(NB+1)
1052 CONTINUE
TVAR(I)=(TSQ(I)-T(I)*T(I)/(NA*NB))/(NA*NB+1)
DISC(I)=ABS(AMEAN(I)-BMEAN(I))
106 CONTINUE
CALL RANKS(NUMA,AMEAN)
CALL RANKS (NUMB,RMEAN)
CALL RANKS (NUMT,TMEAN)
CALL RANKS (NUMD,DISC)
DC 107 I=1,80
107 TEMP(I)=AVAR(I)
DC 108 I=1,80
AVAR(I)=TEMP(NUMA(I))
108 ADVAR(I)=TEMP(NUMD(I))
WORKVAL FORTRAN EXTENDED VERSION 2.0 07/19/69

DC 109 I=1,90
TEMP(I)=HVAR(I)
DC 110 I=1,90
AVAR(I)=TEMP(NUMB(I))
100 BDVAR(I)=TEMP(NUMD(I))
DC 111 I=1,90
110 TEMP(I)=TVAR(I)
DC 112 I=1,90
TVAR(I)=TEMP(NUMT(I))
ADMEAN(I)=A(NUMD(I))/NA
112 BDMEAN(I)=B(NUMD(I))/NB
C NAMES OF GROUPS AND RESPONDENT CODES HAVE BEEN PRINTED ALREADY
PRINT 910
910 FORMAT(///30X "DISCREPANCY IN IMPORTANCE"
PRINT 911
911 FORMAT(* RANK ITEM AIMP AVAR BIMP BVAR DISREP*)
PRINT 912*(I*NUMD(I),ADMEAN(I),ADVAR(I),BDMEAN(I),BDVAR(I),DISC(I)
2* I=1,90)
912 FORMAT(4X,I2,5X,I2,2F7.2,2X,2F7.2,5X,F4.2)
PRINT 913
913 FORMAT(1H1)
PRINT 805*, (NGPA(I), I=1,9)
PRINT 805*, (NGPB(I), I=1,9)
DC 113 I=1,9
113 NGPA(I)=IMAGE(I+1)
PRINT 914
914 FORMAT(16X*FIRST GROUP* 31X *SECOND GROUP* 32X *COMBINED*)
PRINT 915
915 FORMAT(X, 6(*RANK ITEM IMP VAR *))
DC 114 I=1,90
114 PRINT 916; I*NUMA(I),AMEAN(I),AVAR(I),
2* I*NUMB(I),BMEAN(I),BVAR(I),
3* I*NUMT(I),TMEAN(I),TVAR(I)
916 FORMAT (X,3(I3,I6,2F6.2*22X))
IF (EOF(3)) 115, 116
116 PRINT 804
PRINT 805*, (NGPA(I), I=1,9)
GO TO 7
115 CONTINUE
END
APPENDIX 5

Work-Related Values Factor Loadings
### Varimax Rotation Factors

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