Some Antecedents and Consequences

of Scientific Performance

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ABSTRACT

Relationships between organizational factors and the performance of 151 engineers were studied to determine the extent to which the factors preceded performance and performance preceded the factors.
Four factors were related significantly to subsequent performance: involvement in work, colleague contact, diversity of work activities, and number of subordinates. Every factor studied (these four plus salary and influence on work goals) was related to previous performance. The performance-factor sequence was much more predominant than the factor-performance sequence. An engineer's performance apparently has pervasive consequences for his social-psychological working environment.

Some Antecedents and Consequences of Scientific Performance

George F. Farris

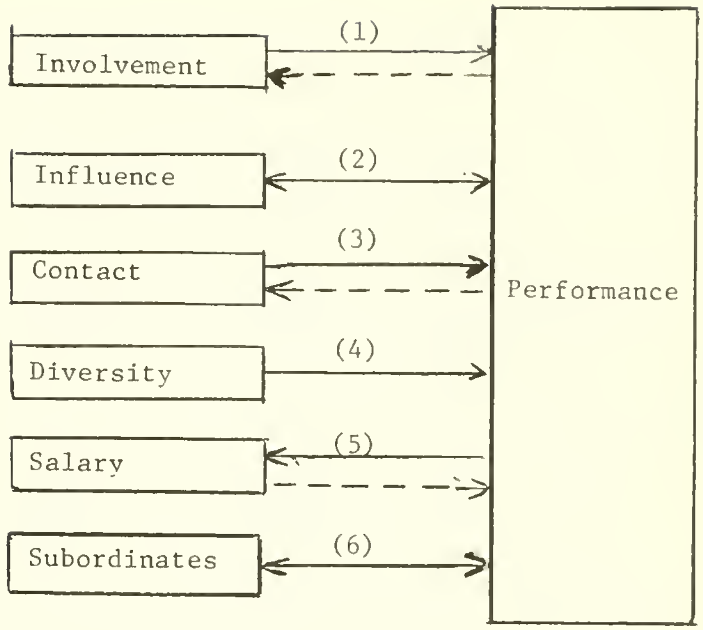
Recently my colleagues at the Institute for Social Research, Donald C. Pelz and Frank M. Andrews, published the major findings of their extensive study of organizational factors and the performance of scientists and engineers. [13] They found that under certain conditions individuals produced more scientific output--patents, publications, and reports--and were judged to have performed better--in terms of contribution to their scientific discipline and usefulness to their organization. Among these conditions were high involvement in their work, high influence on their work goals, contact with a relatively large number of colleagues, a diversity of work activities, a high salary, and a large number of subordinates. For each of these factors they found a consistent pattern of low, but statistically significant relationships to scientific performance.

Despite the careful analyses of their study and the consistency of the correlations they found, a lingering question continually recurred as they discussed the implications of their findings: to what extent did each of these factors precede performance, and to what extent did performance precede the factors. For example, did scientists with high influence on their work goals perform better after receiving this influence, or did they receive this influence after they had performed well? Behavioral scientists have been arguing that the organizational factors come first, but at least one plant manager I talked to disagreed. He said, "If the men would only produce more, then I could leave them alone."

While Pelz and Andrews' book was going to press, I was conducting a study to investigate this question of sequence. The original study was conducted in 1959, involving 1311 scientists and engineers from 11 laboratories in industry, universities, and government. In 1965 I returned to three of the laboratories, all within one corporation in the electronics industry, to obtain new information from 151 engineers who had participated in the original study. Thus, measurements of performance and the organizational factors at two different points in time were available. By relating the measurements made at different points in time, it was possible to investigate the question of sequence. In particular, the antecendents and consequences of four measures of performance--contribution, usefulness, patents, and reports--were examined in terms of the six organizational factors mentioned above: involvement in work, influence on work goals, contact with colleagues, diversity of work activities, salary, and number of subordinates. It was possible to see, for example, the extent to which high influence was followed by high usefulness and vice versa.

PREDICTIONS

On the basis of previous research on organizational behavior and not a little bit of intuition, predictions were made as to which relationship would be stronger--that between the organizational factor and subsequent performance or that between the organizational factor and previous performance. No predictions were made in terms of the particular kind of performance--contribution, usefulness, patents, or reports. The reader may wish to speculate on these himself. Figure 1 summarizes the predictions.



A ⟶ B   A is followed by B

A ⟷ B   A is followed by B and
B is followed by A

A ⇄ B   A is followed by B, and
B is followed by A, and the
first relationship is stronger

The numbers refer to the six hypotheses.

Figure 1. Predicted Relationships.

Involvement. A rich body of literature in psychology suggests that performance is a function of intensity of motivation or involvement. On the other hand, there are a few studies which suggest that performance can be followed by changes in involvement. For example, Solley and Stagner [14] found that palmar sweating, a frequency used measure of motivation, varied with amount of previous success and failure on a problem-solving task. Studies of scientists and engineers have not investigated sequential aspects of this relationship, although Pelz and Andrews [13] did find consistent relationships between involvement and performance measured over the previous five years. Thus, the first prediction is:

Hypothesis 1. Involvement and performance.

a. Involvement is followed by performance.

b. Performance is followed by involvement.

c. Relationship (a) is stronger than relationship (b).

Influence. The argument that changes in influence on work goals are followed by changes in performance is at the heart of many a social scientist's theory of organizations. Evidence for such an argument comes largely from two sources: a number of field studies (e.g., Likert[8], ch. 4, and Tannenbaum [15]) which have found positive associations between influence and performance, and several laboratory experiments (e.g., Lewin, Lippitt, and White, [7] in which experimentally varied amounts of influence led to performance of varying degrees of quality. A similar conclusion may be drawn from a field experiment by Morse and Reimer [11].

On the other hand, promotions to positions of greater influence are often used to reward performance. In the case of scientists, Pelz and Andrews [13] and Meltzer and Salter [10] found positive associations between influence and performance. Thus, the second prediction is:

Hypothesis 2. Influence and performance.

a. Influence is followed by performance.

b. Performance is followed by influence.

c. No difference in the strengths of relationships (a) and (b) is expected.

Contact. A number of the current theoretical formulations about creativity (for examples see Anderson [2]; Taylor and Barron [16]; or Mednick [9]) state that exposure to a number of ideas enhances creative thinking. Such exposure would be expected to increase with the number of colleagues a scientist contacts in his daily work and with the frequency with which he contacts them. Since creativity is often an important aspect of scientific performance, we would predict that more contact is followed by better scientific performance.

On the other hand, it can be argued that scientists seek contact with their high-performing colleagues, whose high performance indicates that they have ideas which can stimulate the thinking of others. Pelz and Andrews [13, ch. 3] found positive associations between their measures of communication with colleagues and scientific performance. Although their data did not allow them to study sequential effects, they were able to examine situations in which different scientists initiated the contact. When they considered only scientists who themselves initiated the contacts, omitting those whose contacts were

primarily results of their being sought after by others, the positive associations between contact and performance held up. Thus, the third prediction states:

Hypothesis 3. Contact and performance.

a. Contact is followed by performance.

b. Performance is followed by contact.

c. Relationship (a) is stronger than relationship (b).

Diversity. Closely allied with theoretical statements, such as Mednick's [9], that contact with many ideas stimulates creativity, is the argument that creativity is enhanced by contact with a diversity of ideas. To the extent that creativity involves integrating ideas in a novel manner, it is facilitated by ideas which are relatively unrelated or diverse in the first place. Such a diversity of ideas would be apt to occur when the engineer engages in several different kinds of professional activities or associates with people of different backgrounds or personality charactersitics. Some experimental evidence [e.g., Hoffman, 6] supports the contention that diversity affects performance on cognitive tasks like those carried out by the engineer.

It is difficult to argue that high performance is followed by a diversity of ideas or activities. Although the high-performing engineer may be asked to engage in additional activities (administrative duties or traning, for example) or sent to professional conferences where he contacts colleagues of different backgrounds, such opportunities are probably available to the low performer as well. Many professionals attend conferences, regardless of their performance, and one administrative strategy is to "saddle" the low performers with teaching and administrative responsibilities.

Pelz and Andrews [12, 13], and Meltzer and Salter [10], found associations between scientific performance and a variety of measures of diversity. The fourth hypothesis states:

Hypothesis 4. Diversity and performance.

a. Diversity is followed by performance.

b. No relationship is expected between performance and subsequent diversity.

Salary. Merit increases--salary raises based on performance--are commonly used as incentives for scientists. In a study of 13 pharmaceutical laboratories, Chalupsky [3] found that all laboratories used them. On the basis of such policies, we would expect that changes in performance are followed by changes in salary.

On the other hand, the lack of such increases could also have consequences. Rewards, such as salary, can also cause performance. Such reasoning is undoubtedly implicit in the philosophy of merit salary increases. (A study by Adams and Rosenbaum [1], in fact, indicated that overpayment can be followed by performance at a rate much higher than one would expect on the basis of past performance!)

Hypothesis 5. Salary and performance.

a. Salary is followed by performance.

b. Performance is followed by salary.

c. Relationship (b) is stronger than relationship (a).

Number of subordinates. Among the resources available to a scientist to help him accomplish his work activities are technicians and professional scientists who work for him. Having subordinates would

be expected to facilitate the work of the supervisor. On the other hand, higher performing scientists may be rewarded by making them supervisors of others.

Hypothesis 6. Number of subordinates and performance.

a. Number of subordinates is followed by performance.

b. Performance is followed by an increased number of subordinates.

c. No difference is expected in the strengths of relationships (a) and (b).

METHOD

Following the procedures of Pelz and Andrews, a self-report questionnaire was used to measure the organizational factors and scientific output. In addition, panels of colleagues familiar with the engineer's work judged its contribution and usefulness.

Measurements of performance.

Judgments. Senior people from both the supervisory and non-supervisory levels judged the performance of all respondents with whose work they were directly familiar. They provided rankings of these respondents on two separate measures of performance over the last five years: contribution to general technical or scientific knowledge in the field and overall usefulness in helping the organization carry out its responsibilities. Because the ratio of one judge for every five respondents was maintained, the work of the great majority of respondents was judged two or more times. Although each judge worked individually, there was substantial agreement among them. These rankings by individual judges were then combined into an overall ranking of all the respondents within a laboratory using a computer program based on Ford's [5] solu-

tion to this situation of incomplete comparison. The final output was a percentile rank for each respondent on contribution and usefulness. Details of this procedure may be found in Pelz and Andrews [13], Appendix A).

Output. Respondents indicated the number of "Patents or patent applications" and the number of "Unpublished technical manuscripts, reports, or formal talks (either inside or outside this organization)" which they had produced over the last five years. This information was obtained in both 1959 and 1965. In addition, a question was included in 1965 asking the respondent to report his output for the last two and one-half years. By subtracting responses to this question from those to the previous one, the respondent's output for the first two and one-half years of the five-year period was determined. Thus, measures of output were available for the time periods 1954-1959, 1960-1965, 1960-1962, and 1963-1965.

Adjustment of performance scores. Three factors extraneous to the areas of primary research interest were found when taken together to account for an average of 8 per cent of the variance in the performance scores. They were: (1) highest degree earned, (2) time since receiving highest degree, and (3) time with laboratory. Following the procedures of the larger study (Pelz and Andrews [13], Appendix C) the performance scores were each adjusted to compensate for deviations from the grand mean of groups at various levels of these three predictor factors.

Measurements of organizational factors.

Involvement. The item measuring involvement asked:

Some individuals are completely involved in their technical work--absorbed by it night and day. For others, their work is simply one of several interests. How involved do you feel in your work? CHECK ONE answer. (6-point scale)

Pelz and Andrews [13] found more consistent relationships to performance with this item alone than with a five-item index which included involvement, interest, identification with task, the importance of his work, and challenge in the scientists present work.

Influence. The engineer was asked to name the person other than himself who had the most influence on his work goals. Then he was asked to report:

To what extent do you feel you can influence this person or group in his recommendations concerning your technical goals? CHECK ONE. (5-point scale)

Cases where only the scientist had influence on his work goals were scored as cases of "complete" influence.

Contact. The item measuring contact asked:

About how many people in your immediate groups (sections, projects, teams, etc.) do you work with closely--in the sense of exchanging detailed information from time to time that is of benefit either to you or to them? (Exclude subprofessional assistants or clerical personnel.) (7-point scale ranging from "None" to "20 or more.")

Diversity. Respondents were asked to report how they allocated their time to various activities including (a) Research for general knowledge relevant to a broad class of problems, (b) Research for specific knowledge for solution of particular problems, (c) Improvement of existing products or processes, (d) Invention of new products or processes, and (e) Technical services to help other people or groups. Consistent with procedures used by Pelz and Andrews [13] diversity was measured by counting the number of activities in which the respondent spent 6% or more of his time (more than 2 hours of a 40-hour week).

Salary. Respondents were asked to indicate their professional income last year from all sources on a nine-point scale.

Number of subordinates. The respondents indicated the number of professional and non-professional subordinates reporting directly to them. This information was then converted to a four-point scale ranging from "None" to "Nine or more."

Procedure

Before testing the hypotheses, some preliminary analyses were made. In the first it was determined that the organizational factors are not very highly correlated with each other--that is, they apparently measure different aspects of the engineers' working environment. (In 1959 the median correlation was .18. In 1965 it was .09.) Similarly the measurements of performance were found to correlate only modestly with each other (median correlations of .30 in 1959 and .23 in 1965). The judgments of performance were intercorrelated most highly, as one

would expect (.63 in 1959 and .56 in 1965), and the measure of reports correlated the lowest with the other measurements. On the basis of these analyses it was decided to use the six organizational factors and the four measures of performance separately. No index of "overall performance" was determined.

A second analysis indicated that between 1959 and 1965 there were considerable changes in the levels of the organizational factors and performance. (Median correlation was .32 for the organizational factors, ranging from .10 for contact to .71 for salary. For performance the median correlation was .46, with a range from .39 for patents to .49 for reports.) Thus, a considerable portion of the levels of the second measurements of the organizational factors and performance are not due to their initial levels.

The 151 engineers who participated in this study were a small sample of the 1311 scientists and engineers in Pelz and Andrews' original study. Moreover, unlike so many of the other 1160, they were still working with the same laboratory which had employed them in 1959. Therefore, a third analysis was carried out to determine whether the relationships which Pelz and Andrews had found for the 1311 scientists still held up for the particular sample of 151 engineers in this study. They did. Using the measurements taken in both 1959 and 1965, small but consistent positive associations were found between the organizational factors and performance. Pelz and Andrews found the same general pattern for the 1311 scientists and engineers.

In order to test the hypotheses, Pearson product-moment correlations were computed between the organizational factors and previous and subsequent measurements of performance. Rather than examining the actual size of these correlations, it was decided to display the findings according to the level of statistical significance attained. Table 1 shows the symbol used for each level of confidence and the approximate size of the correlation coefficient needed to be significant at this level of confidence for the two most common sample sizes of this study.[1] In general, the more plusses, the stronger and more significant the relationship.

RESULTS

The general pattern of findings is summarized in Table 2. Note the predominant tendency for more plusses to appear in the right-hand side than the left. When relationships between performance and subsequent levels of the organizational factors are examined, 11 of the 24 relationships are significant at the .05 level of confidence. When relationships between the factors and subsequent levels of performance are examined, only 4 are significant at the .05 level. The general pattern indicates that for these six organizational factors and these four measures of performance the predominant sequence is performance-followed-by-factor rather than factor-followed-by-performance. Let us turn now to an examination of the hypotheses to determine how much the general pattern held up for particular factors and different conditions of measurement.

Hypothesis 1. Involvement and performance. Part a (Involvement is followed by performance) was confirmed only when performance was measured by patents. Part b (Performance is followed by involvement) was confirmed when performance was measured by usefulness or patents.

TABLE 1

SIZES OF CORRELATIONS FOR VARIOUS LEVELS OF CONFIDENCE IN THE PRESENT STUDY

Symbol	Level of confidence	Approximate size of correlation coefficient needed to be significant at this level for N of:	
		50	125
++++	.01	.28	.20
+++	.05	.22	.15
++	.10	.18	.13
+	.15	.14	.10

TABLE 2. SUMMARY OF RESULTS

Factor	Factor → Performance				Performance → Factor			
	Contribution	Usefulness	Patents	Reports	Contribution	Usefulness	Patents	Reports
Involvement	0	0	+++	-	+	+++	++++	-
Influence	++	0	0	0	++++	+	-	+++
Contact	0	+++	0	0	0	++	+	0
Diversity	+	-	+	+++	+	--	+++	0
Salary	0	++	0	0	+++	++++	+++	+++
Number of subordinates	+	+++	0	++	++	++++	+++	++

For patents the relationship was stronger in the patents-followed-by-involvement direction. It appears, then, that relationship b is stronger than relationship a. The tendency for performance to be followed by involvement is stronger than that for involvement to be followed by performance. Apparently, engineers who are more involved in their work produce more patents subsequently, but, more than that, engineers who are seen as useful to their organizations or who produce more patents become more involved in their work.

Hypothesis 2. Influence and performance. Part a of the hypothesis is not confirmed. Only a trend exists for influence to be related to subsequent contribution. Part b is supported. Contribution and reports are significantly associated with subsequent influence. Apparently, the higher performing engineers subsequently received more influence on their work goals. Greater influence on work goals, however, was not followed by increased subsequent performance.

Hypothesis 3. Contact and performance. There is a significant relationship between number of people contacted in 1959 and rated usefulness over the next five years. No significant relationship was found between number of contacts and previous performance, although trends occurred for usefulness and patents. When a measure of frequency of contact (data not shown) was used, a significant relationship occurred with previous usefulness and a stronger trend occurred with previous patents. Tentatively, the findings suggest that engineers who have greater contact perform better subsequently, and high performing engineers subsequently come into more frequent contact with their colleagues.

<u>Hypothesis 4. Diversity and performance</u>. Diversity of work activities was related significantly to subsequent reports. Moreover, when output was measured for only 2 1/2 years, diversity was related significantly to patents during the immediately subsequent period and to reports only after a time lag of 2 1/2 years (data not shown). Of the performance measures patents alone was related significantly to subsequent diversity. Thus, it appears that greater diversity is followed by higher performance and higher performance is followed by a greater diversity of work activities. Engineers who engage in a greater number of work activities perform better subsequently; those who perform better then engage in a greater number of work activities.

<u>Hypothesis 5. Salary and performance</u>. Only a trend occurs for salary to be followed by usefulness. On the other hand, each kind of performance is significantly associated with subsequent salary. Apparently, engineers who perform well subsequently are paid more, but there is no evidence that those who get paid more subsequently perform better.

<u>Hypothesis 6. Number of subordinates and performance</u>. There is a significant relationship between number of subordinates and subsequent usefulness and trends for subsequent contribution and reports. Subsequent number of subordinates is significantly related to previous usefulness and patents, and trends occur for contribution and reports. (In the information collected in 1965, the relationship with contribution was highly significant.) Thus, the findings indicate that engineers with more subordinates subsequently perform better, but, more than that, engineers who perform well subsequently receive more subordinates.

Hypothesis 4. Diversity and performance. Diversity of past activities was related with [illegible] subsequent reports. However, when output was measured for only 2 1/2 years, diversity was related significantly to patents during the immediate subsequent period and to reports only after [illegible] (data not shown).

Of the performance measures [illegible] was only significantly [illegible] to subsequent diversity [illegible] and greater diversity is followed by higher [illegible] and higher performance is followed by a greater diversity [illegible] in a greater number [illegible] who patented [illegible]

[illegible]

Further analyses. This pattern of findings is surprising. Not one of the six predictions was confirmed in its entirety. Moreover, the mismatch between the predictions and the findings is a consistent one: the findings show stronger relationships between performance and subsequent amounts of the organizational factors than were predicted.

In order to determine how stable these surprising findings are, several additional analyses were performed. Since the data shown in Table 2 are based on the measurements of the organizational factors made in 1959, the relationships between performance from 1960-1965 and the organizational factors in 1965 were examined. The findings were very similar to those based on performance from 1954-1959 and the organizational factors in 1959: a consistent pattern of relationships between performance and subsequent amounts of the factors.

Other analyses included several with different time lags between measurements of performance and the organizational factors, computation of a number of partial correlations, an analysis using eta rather than "Pearson r" as the measure of association, an analysis for 43 engineers who were probably "bench scientists" throughout the duration of the study, separate analyses for each of the three laboratories, and an analysis of some of the data using performance measures unadjusted for education, experience, and time with company. In each of these additional analyses, the findings shown in Table 2 were strongly supported.[2]

DISCUSSION

The most striking finding is that in every instance performance was related to subsequent amounts of the organizational factor with which it was associated. Moreover, in no instance was one of the organizational factors more strongly related to subsequent performance than performance was related to subsequent amounts of the factor. In several cases performance clearly came first.

With the exception of the consistent finding that performance is followed by changes in the engineer's working environment, these findings should be regarded as tentative. They are based upon significant, but very small relationships between organizational factors and performance. However, the magnitude of the relationships is of the same order as those found in Pelz and Andrews'[13] original study, and the patterns of relationships which they found generally held for a population of scientists and engineers much larger than the sample studied here. In addition, the findings of this study held up remarkably well under the additional analyses which were performed.

To the extent that these findings are true, they are not without implications, at least for organizations similar to the engineering laboratories of this study. Apparently performance is followed by definite changes in the social-psychological working environment of such organizations. These consequences of performance probably have not been given sufficient recognition in past theories because they have not been examined in past research. In the performance-oriented organizations of our society it has been treated as an end-result and not as a potential

cause. The findings of this study show, however, that its consequences are extensive. Moreover, different consequences seem to emerge from different kinds of performance. Some of these consequences are exhibited in Figure 2.

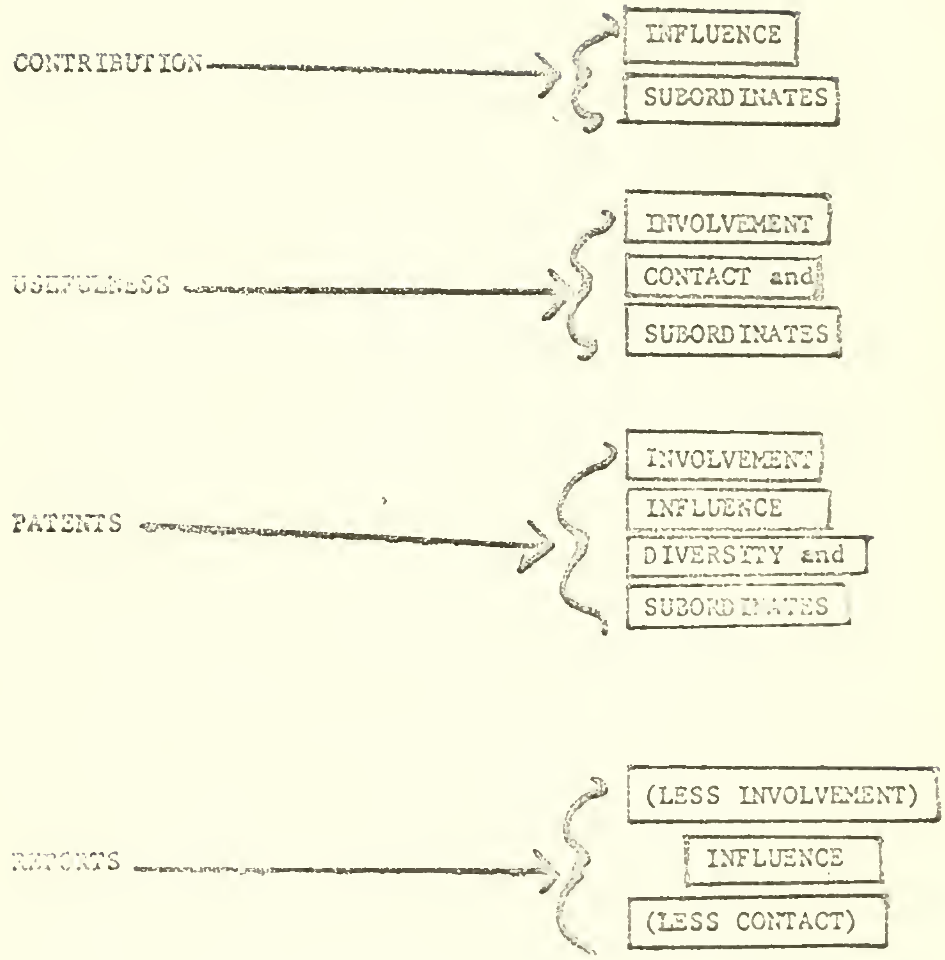
The engineer rated high in contribution to his professional field tends subsequently to have more influence on his work goals and more subordinates.

The engineer rated high in usefulness tends subsequently to be more involved in his work, have more contact with his colleagues and to have more subordinates.

The engineer who produces many patents tends subsequently to become more involved in his work, have more influence on his work goals, engage in a greater diversity of work activities, and acquire more subordinates.

The engineer who produces many reports subsequently has more influence on his work goals. However, he says that he subsequently becomes less involved in his work and that he has less contact with his colleagues. Does this mean that report writing makes "Johnny a dull boy"--that his work becomes boring and he becomes introverted? We can only speculate on the basis of the trends in this study.

Research should be directed toward determining more precisely the ways in which a person's performance affects his social-psychological working environment. Systematic attention to ways of rewarding performance may pay off handsomely for the research manager.



Tentative Implications: Some "Consequences" of Different Kinds of Scientific Performance.

What organizational factors are followed by changes in the performance of scientists and engineers? The findings of this study indicate that aspects of the working environment are followed by changes in certain kinds of performance. (See Figure 3.)

The engineer who is more involved in his work tends subsequently to produce more patents. And, the engineer tends to become more involved in his work after receiving more influence on his work goals or a higher salary.[3]

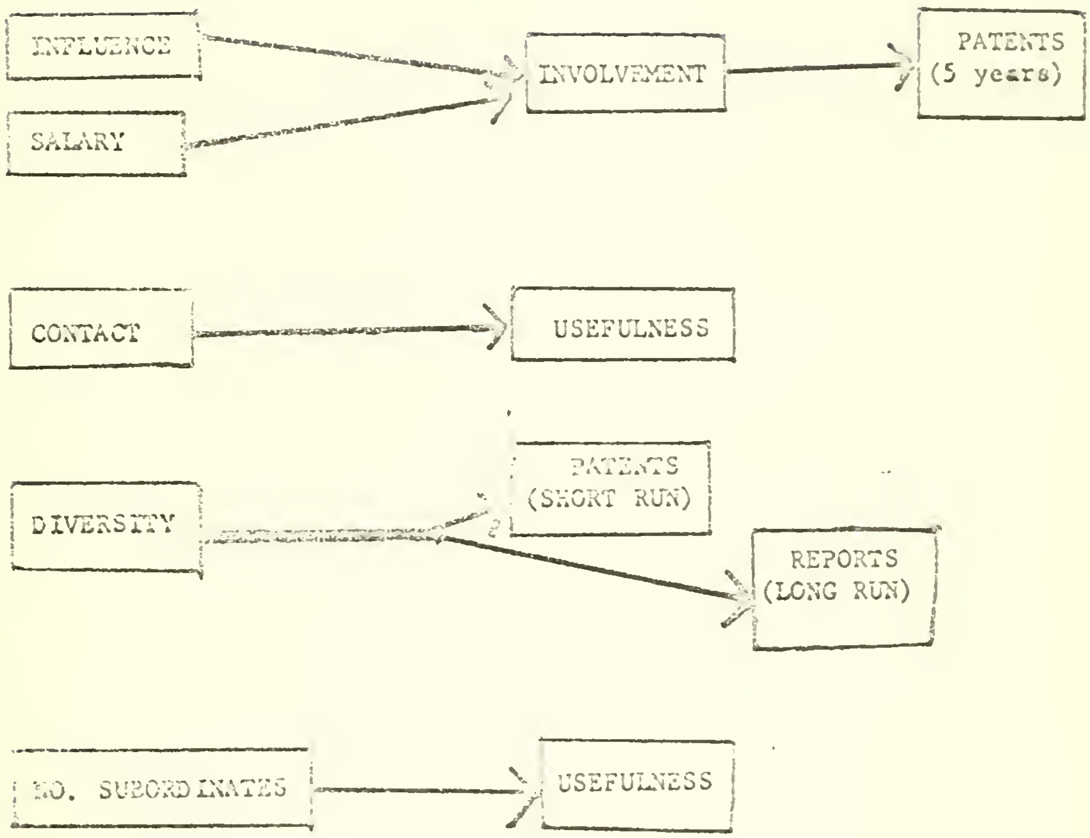
The engineer who has more contact with his colleagues is subsequently rated as higher in usefulness to his company.

The engineer who engages in a diversity of work activities produces more patents in the short run--that is, over two-and-one-half years--and more reports in the long run--that is, over a time lag of an additional two-and-one-half years, between two-and-one-half and five years later.

The engineer who has more subordinates is subsequently regarded as more useful to his company.

Thus, this study indicates that there are factors which the laboratory manager can change in the working environment of his engineers and expect changes in performance to follow. On the whole, these changes will probably be small, long-term, and related to particular kinds of performance. In individual instances, especially cases where a factor such as contact with colleagues is badly lacking, changes in the organizational factor would be expected to have a much more substantial impact on performance.

T E N T A T I V E   I M P L I C A T I O N S



Tentative Implications: Some Antecedents of Different Kinds of Scientific Performance.

Probably Sir Francis Bacon was right when he said:

"It is enough to check the growth of science, that efforts and labours in this field go unrewarded..."

The findings of this study indicate that in the three laboratories of the electronics company, "efforts and labours" were being rewarded with changes in the social psychological working environment. On the average these engineers reported that they were "strongly" to "very strongly" involved in their work. Had the company not rewarded performance so extensively, it is likely that relationships between aspects of the working environment and subsequent performance would have been stronger. Following Bacon, my hunch is that the increased number of engineers having small amounts of the organizational factors would have performed at a much lower level, causing the overall relationship between the organizational factor and performance to become more substantial.

To find substantial relationships between organizational factors and subsequent scientific performance, then, we may well need to study a company which fails to reward performance with changes in organizational factors. Then the reward-performance as well as the performance-reward sequence could be demonstrated. Somehow, I doubt that there is a company willing to give it a try!

SUMMARY

Relationships between six organizational factors and scientific performance were studied over time to determine the extent to which the factors preceded performance and performance preceded the factors. For example, do higher-paid engineers perform better after being paid more, or do they get paid more after performing better?

Predictions were made about relationships between several organizational factors and the performance of 151 engineers from three laboratories of a large electronics company. Performance was measured by output of patents and reports and colleague judgments of scientific contributions and usefulness to one's organization. The organizational factors were measured by a self-report questionnaire.

On the basis of low, but statistically significant associations, the following organizational factors were found to be related to one measure of subsequent performance: involvement in work, colleague contact, diversity of work activities, and number of subordinates. Influence on work goals and salary were found <u>not</u> to relate significantly to any measure of subsequent performance. The most striking finding, however, was that <u>in every instance performance was found to be related significantly to subsequent levels of the organizational factor with which it was associated</u>. In <u>no</u> instance was an organizational factor more strongly related to subsequent performance than to previous performance.

These findings were supported strongly by several further analyses using different time lags, outside-factor controls, samples of engineers, and measures of association.

It was concluded that an engineer's performance has pervasive consequences for his social-psychological working environment. These should be

considered both in interpreting associations between organizational factors and performance and in designing and implementing the reward system of the scientific laboratory.

FOOTNOTES

This paper is based upon the author's dissertation, submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree at the University of Michigan. The author is grateful for the comments and suggestions of the members of his committee: Robert L. Kahn, Chairman, Frank M. Andrews, Basil S. Georgopoulos, Abraham Kaplan, and J. E. Keith Smith. Part of the research was supported by grant NSG-28-014 from the National Aeronautics and Space Administration.

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[1] The sample size varies because of missing data and because 60% of the engineers answered only questions on involvement and performance on a short-form questionnaire in 1959. Thus, for influence, contact, diversity, salary, and number of subordinates in 1959, the sample is at least 50. For involvement and performance in 1959 and all measurements in 1965 it is at least 125.

[2] For details, see Farris [4].

[3] Data not shown. See Farris [4].

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