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**THE RELATION OF
OPEN HEARTH FOREMEN'S INTERPERSONAL PERCEPTIONS
TO STEEL PRODUCTION**

WALTER A. CLEVEN and FRED E. FIEDLER

TECHNICAL REPORT NO. 11

**A NOTE ON PSYCHOLOGICAL ATTRIBUTES
RELATED TO THE SCORE ASSUMED SIMILARITY
BETWEEN OPPOSITES (AS₀)**

EILEEN F. GOLB and FRED E. FIEDLER

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**PROJECT ON
SOCIAL PERCEPTION AND GROUP EFFECTIVENESS**

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The Relation of Open-Hearth Foremen's Interpersonal Perceptions to Steel Production

Walter A. Cleven and Fred E. Fiedler¹
University of Illinois

This investigation is one of a series of studies on the relationship of interpersonal perception and group effectiveness (2, 3). It was designed to test hypotheses which grew out of earlier studies on military aircraft and tank crews (3). The research was conducted in open-hearth shops of a large steel company in which the personnel, in contrast to military crews, is highly stable over time, and where carefully maintained production records are available.

Interpersonal perception is measured here by means of the score, Assumed Similarity between Opposites, or ASo. This score reflects the extent to which the subject (S) differentiates between the man with whom he can work best, and the man with whom he can work least well. We infer that ASo is related to the psychological distance which S perceives between himself and his co-workers. Supervisors who perceive much similarity between their best- and least-liked co-workers (high ASo) are, by this interpretation of ASo, more accepting, approachable individuals,

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9 Jan 50 g. A. r. Fred Fiedler

while supervisors who perceived little similarity between these workers (low ASo) are presumably more critical and analytic in their work relationships.

Previous studies of informal teams (2) and of Air Force bomber crews and army tank crews (3) led to two hypotheses concerning the relationship between leader ASo and group effectiveness.

Hypothesis I. More effective groups have supervisors who tend to perceive larger differences in the personalities of their most and their least preferred co-workers (low ASo), than do supervisors of less effective groups.

Hypothesis II. More effective groups have supervisors who maintain a moderate amount of psychological distance between themselves and their co-workers. This hypothesis consists, operationally, of two parts:

Hypothesis IIa. More effective groups have supervisors with low ASo only when the supervisor is well-liked and when he in turn likes certain key personnel in the group. (As can be seen, Hypothesis IIa is a special case of Hypothesis I.)

Hypothesis IIb. More effective groups have supervisors with high ASo when the supervisor is well-liked but does not like certain key subordinates in the group. (This hypothesis limits the generality of Hypothesis I.)

The two parts of the second hypothesis assume an interaction between supervisor ASo and supervisor preferences for important subordinates in the group. By this hypothesis, effective groups have either low ASo supervisors who sociometrically prefer their key subordinates, or high ASo supervisors who do not sociometrically choose their key subordinates.²

²Hypotheses I and II are postulated as valid only for tasks which require "direction-giving leadership behavior" (3, p. 234). In contrast, the study of military aircraft groups suggested the hypothesis that more effective groups on tasks which require receptive leadership behavior have supervisors with high ASo, regardless of the supervisor's preferences for key subordinates. We had hoped to shed further light on this hypothesis in the present study using incidence of accidents to subordinates as a criterion, but this criterion proved unreliable.

Hypothesis II in part overlaps with Hypothesis I. Our studies of informal groups, i.e., basketball and surveying teams, lead us to expect a negative correlation between the ASo of the group's informal leader and his group's effectiveness. Our studies of formal, military groups, as indicated by Hypothesis II, lead us to anticipate a more complex leader-follower interaction. Specifically, we found a negative correlation between the leader's ASo score and the criterion of effectiveness for groups in which the accepted leader chose his keyman, and a positive correlation between the two variables for groups in which the accepted leader did not choose his keyman. Both Hypotheses I and II were considered in this study of steel shops because our knowledge and understanding of group processes seemed insufficient to judge, a priori, which hypothesis would best fit the case of these relatively long-lived industrial work groups.

Procedure

Sample. Management personnel in four open-hearth shops of a large steel company participated in the study. These four shops are engaged in similar operations, although equipment varies somewhat from shop to shop.

Each shop is operated on a 24-hour, seven-day-week basis with each shift or "turn" working eight hours. Every turn has a full complement of first- and second-line supervisors and their crews. Since one turn is off duty in any one 24-hour period, each shop requires four turns. A total of 16 turns thus constitutes our sample.³

Four supervisors are in charge of each turn: one General Foreman, one Stock Foreman, one Pit Foreman, and one Senior Melter. The General Foreman, along with the Stock and Pit Foremen, directs the supporting operations of raw material assembly and final steel pouring. The Senior Melter is in charge of steel manufacture. Depending on the number and size of furnaces in the shop, the Senior Melter supervises one or two

³All four turns within a shop are under the direction of a single shop superintendent and his assistant superintendent. These men were not tested, but only completed the performance ratings which are discussed below.

Junior Melters and their crews. In three of the four shops (or 12 of the 16 turns), the Senior Melter has two Junior Melters reporting to him.

Test instruments. Two test instruments were administered to all available foremen and melters. The first requested each S to predict the responses of two men: (a) the man with whom he can work best, and (b) the man with whom he can work least well. These ratees could be anyone with whom S had ever worked; S was not asked to specify their names. The test consisted of 40 statements such as: "I tend to join many organizations," "I am often bored with people," and "I am generally regarded as optimistic." Each item was answered on a six-point scale ranging from "definitely true" to "definitely untrue." The similarity of these two predictions, computed by the statistic $D(1, 6)$, yields the index Assumed Similarity between Opposites (AS_o).

The second test was a sociometric questionnaire. Each S was asked to nominate in order of his preference three men for each supervisory position other than his own. These nominations could be made irrespective of the nominee's position or the shop in which he was employed at the time of testing. Nominations were made for three criterion situations: (a) "three men who you think would be best able to help you improve the turn's safety record," (b) "three men with whom you would want to work on a special job which needs to be done very quickly," and (c) "three men whom you like best personally."

Criterion

The index of group effectiveness is based on the time elapsed from one "tap" (pouring of molten metal from the furnace) to the next tap on a particular furnace. For economic reasons, company officials regard short "tap-to-tap time" as the most important production goal. The primary importance of this production goal is recognized and accepted by the foremen as well as their subordinates.

The average tap-to-tap time is about ten hours; two turns are, therefore, involved in preparing each batch of steel, or "heat," for tapping. However, the tap-to-tap time scores are uniformly assigned to the Junior Melter and crew in charge of the furnace at the time the tap is made, regardless of

the length of time the shift has actually worked on the heat. This seems justifiable because the last hours of the heat are regarded as more critical in the manufacturing process than the first few hours. In addition, randomization takes place because the turns of Junior Melters and their crews do not systematically follow one another or use the same equipment.

Using an analysis of variance of ranked data, we found significant differences between shops in tap-to-tap time. Since these differences can be attributed to different furnace capacities, the tap-to-tap time data were standardized within shops by means of T scores to permit intershop comparison.

Criterion reliability. The reliability of tap-to-tap scores was based on an analysis of 25,000 heats based on the three to 16 months period preceding testing. We excluded the summer months on recommendation of company officials because of extensive personnel shifts due to vacation schedules. An even-month vs. odd-month split-half procedure was employed. The estimated reliability of tap-to-tap time over the 16 turns is .82. In order to minimize the effects of long-range changes, e.g., in personnel or company policy, the criterion scores used below are based on only a part of these data, namely the three- to ten-month period immediately preceding testing.

Results

Table 1 presents the correlations between the average turn tap-to-tap time and the ASo (Assumed Similarity between Opposites) of the General, Pit and Stock Foremen, and Senior Melters. As the table shows, the correlation between average turn tap-to-tap time and ASo is significant in the case of Senior Melters and Pit Foremen. The correlation falls short of an acceptable significance level for Stock Foremen, and is negligible for General Foremen. The average ASo of the foremen and Senior Melter on each turn is also significantly related to average turn tap-to-tap time.⁴

⁴The ASo of Junior Melters was not significantly related to their individual tap-to-tap scores. No a priori hypothesis was formulated regarding this correlation, since the relationship of group effectiveness to ASo of group members other than the formal or informal leader has not been systematically examined.

TABLE 1

Correlations (Rho) between ASo of Various Supervisors and Average Turn Tap-to-Tap Time

Supervisor ASo	N*	Rho	p
General Foreman	15	-.13	---
Stock Foreman	15	-.42	---
Pit Foreman	14	-.72	< .01
Senior Melter	15	-.54	< .05
Supervisor average	16	-.71	< .01

*N varies due to missing data.

Discussion of main findings. Hypothesis I states that more effective groups have supervisors with low ASo. The overlapping hypothesis, Hypothesis II, states that group efficiency is related to supervisor ASo, but that the direction of relationship is a function of the supervisor's preferences for his key subordinates. The significant correlations of Senior Melter and Pit Foreman ASo, as well as average supervisor ASo, with average turn tap-to-tap may be interpreted as supporting Hypothesis I rather than Hypothesis II. It is unlikely that the distributions of points comprising these significant correlations would break down (on the basis of sociometric analysis) into two subdistributions with opposite slopes, as the interaction hypothesis requires. We shall return to this point below.

Of particular interest is the high correlation between mean turn tap time and ASo of Pit Foremen. On the surface, the melters appear to determine tap time, since it is their decision as to when the heat is ready to be tapped. The results suggest, however, that variance in tap-to-tap time may also be a function of the Pit Foreman, although, conversely, the ASo of these supervisors may be a function of the turn efficiency or of some related variable. On the other hand, the low correlation in the

case of the General Foremen may indicate that these men have the least influence on turn efficiency as measured by tap-to-tap time. However, it should be noted that the limited number of cases in our sample does not enable us to reject the hypothesis that all differences among the obtained correlations are a matter of chance.

The fact that mean turn tap-to-tap time is negatively related to the mean ASo of the turn's four foremen suggests the possibility that ASo scores within turns may be homogeneous. A ranked analysis of variance test shows this to be the case. The long-lived nature of these groups could cause this co-variation of ASo, either as a result of selective factors in the personnel placement process, or because changes in interpersonal perception occur as a result of group processes within the turns. The possibility of such changes is suggested by the recent findings of Steiner and Dodge (7) which indicate that Assumed Similarity may be in part a function of the nature of the group.

While the present data support Hypothesis I rather than Hypothesis II, a current study of another non-military group, viz., an analysis of board-management relations of a farm cooperative (4), gives results consistent with Hypothesis IIa (which, as pointed out above, may be regarded as a special case of Hypothesis I). However, the farm cooperative study also does not provide any evidence in support of Hypothesis IIb. Barring the possibility that previous findings were due to chance, this suggests that Hypothesis IIb may be particularly germane to the military situation, or to some special condition inherent in it, such as the short-lived nature of the groups, or the restricted freedom of choice in "who works with whom." It therefore seems advisable to use military groups for further validation of Hypothesis II.

Additional Findings

In addition to the main criterion of tap-to-tap time, we obtained performance ratings by shop superintendents and objective indices related to the quality of output. The reliability of these criteria, their interrelations, and their relation to the interpersonal perception score, ASo, are briefly summarized in this section.

Ratings. Each shop superintendent and assistant shop superintendent ranked all the foremen and melters in his shop on safety-mindedness; overall efficiency or productivity; and ability to handle men and maintain high morale. The men were ranked by position, i.e., each superintendent rank-ordered the four Senior Melters in his shop, then rank-ordered the four General Foremen, and so forth. Reliability was estimated by comparing the Superintendent's ratings of Junior Melters with those of his assistant superintendent. Table 2 shows these correlations for each of the three rankings on safety-mindedness, productivity, and personnel management skills. These estimates indicate generally high rater agreement on the latter two criteria, but rather low rater agreement on the safety-mindedness criterion.

TABLE 2

Correlations (Rho) between Superintendents' and Assistant Superintendents' Ratings of Junior Melters

Criterion	Correlation by shop (rho)				Median (rho)
	A (N=8)	B (N=8)	C (N=8)	D (N=4)	
Productivity	.95	.90	.92	.20	.91
Safety mindedness	.21	.57	.50	.20	.36
Personnel management	.79	.93	.95	.40	.86

Objective records on quality of output. In addition to the output criterion, tap-to-tap time, the company maintains records on two secondary production criteria which are essentially indices of the quality of the heat. The first of these indices, called skulls, is the proportion of heats which, because of inadequate temperature control, leave a residue of steel in the

ladle. The second score, called distressed heats, is the proportion of heats which fail to meet the prescribed chemical specifications of the intended consumer. Distressed heats are not total waste since they are usually marketed to other consumers with less exacting chemical requirements or remelted for scrap. It should again be emphasized that skulls and distressed heats are considered much less important than the tap-to-tap criterion by company officials.

As can be seen in Table 3, the reliabilities of these criterion scores are fairly high and compare favorably with tap-to-tap time.

TABLE 3
Reliability Estimates of Junior Melters' Tap Time, Skulls,
and Distressed Heat Criteria

Criterion	Reliability estimates	
	Junior melters N = 28	Turn average N = 16
Tap-to-tap time	.82	.82
Skulls	.84	.82
Distressed heats	.54	.72

The intercorrelations among the three objective criterion indices and productivity ratings are presented in Table 4. It will be noted that the superintendents' ratings of productivity are not significantly related to any objective production indices. This is all the more remarkable since the superintendents' offices are responsible for collecting these productivity data and for forwarding them to the main office. These findings raise the question anew whether we should place any credence in productivity ratings by superiors, and to what foreman behavior or attributes these ratings refer.

TABLE 4

Intercorrelations of Junior Melters' and Turn Tap Time, Skulls, Distressed Heat Criteria and Productivity Ratings**

	Skulls	Distressed heats	Productivity ratings
<u>Over Junior Melters (N=28)</u>			
Tap-to-tap time	-.46*	-.16	.14
Skulls		.17	-.16
Distressed heats			.12
<u>Over turns (N=16)</u>			
Tap-to-tap time	-.26	.08	-.41
Skulls		-.53*	.10
Distressed heats			.13

* $p < .05$

** All criterion scores have been converted to T scores and where necessary reversed so that high scores indicate good performance. These intercorrelations are based on analyses of over 25,000 heats.

It is also worth pointing out that tap-to-tap time and heat control (skulls) criteria computed for Junior Melters are negatively related, while the heat control and metallurgical quality (distressed heats) criteria are negatively related over turns (see Table 4). While we cannot be certain of all the implications of these findings, this, as well as other studies which utilize objective criterion scores (3, 5), suggest that team performance may not be general over different tasks or even over different aspects of the same task. A group which performs well on one criterion may or may not perform well on another. This means that generalizations cannot be drawn about "effective team performance" in general, but only about effective team performance on a given task X as measured by specific

operations a, b, c, ..., etc. This is a severe limitation to development of a general theory of group effectiveness but may be of only minor importance in a given field setting such as this, in which the prediction of a single criterion appears justified because of economic considerations.

Table 5 shows the correlations between ASo of the various supervisors and skulls, distressed heats, and productivity ratings. Only one of these 15 correlations reaches an acceptable significance level, viz., between production ratings and ASo of Stock Foreman. The correlation indicates that Stock Foremen with high ASo (small perceived differences between most and least preferred co-workers) tend to be rated good on productivity. Since only one correlation of 15 reaches the five per cent significance level, no importance can be attached to this finding without further investigation.

TABLE 5

Correlations (Rho) between ASo of Various Supervisors and Skulls,
Distressed Heats and Productivity Rating Criteria

Supervisor ASo**	Skulls	Distressed heats	Productivity ratings
General Foreman	-.38	.38	.03
Stock Foreman	-.01	.09	.62*
Fit Foreman	.30	-.02	-.40
Senior Melter	.37	.00	-.20
Supervisors' average	-.06	.13	.28

*p < .05

**N varies from 13 to 16, due to missing data.

Summary and Conclusions

A study was conducted relating the interpersonal perceptions of open hearth shop foremen to the productivity of their work units. Interpersonal perception was measured by means of Assumed Similarity (ASo) tests which reflect how similar or different a person describes his most and his least preferred work-companions. Group effectiveness measures were based on output as indicated by "tap-to-tap" time, the time required to complete a "heat" of steel. This criterion measure has considerable stability and is regarded as the most important production index by company officials.

Management personnel of four open-hearth shops of a large steel company participated in this study. Interpersonal perception (ASo) and sociometric tests were administered to all available Ss.

Significant relations were found between supervisor ASo and the tap-to-tap time index. These results are consistent with the hypothesis that more effective groups have supervisors who perceive relatively large differences between their most- and least-preferred co-workers. The study did not support the alternative, partially overlapping hypothesis that more effective groups have supervisors who maintain a moderate amount of psychological distance between themselves and their co-workers.

Additional criteria of secondary importance, including ratings by superintendents and criteria related to the quality of the output, were obtained and analyzed. The reliability, interrelations, and the relationships of these secondary criteria to ASo are discussed in light of the primary data of this study.

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