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# Effects of prior experience of one group member on the performance of the wheel network

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# EFFECTS OF PRIOR EXPERIENCE OF ONE GROUP MEMBER ON THE PERFORMANCE OF THE WHEEL NETWORK

A Thesis
Presented to the
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and the
Faculty of the Graduate College
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In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
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# ABSTRACT

The present study investigated the effects of prior experience of one group member on the performance of the wheel network. Groups participating in the experiment included four experimental groups and a control group. The four experimental groups included combinations of centrally or peripherally trained _S_s transferred to a central or peripheral position in naive wheel networks. Dependent variables were measured in four categories: time, number of messages, number of errors, and individual ratings on a post-communication questionnaire. The position occupied by the experienced _S_s during training had no apparent effect on their transfer group's performance. The network position of the experienced _S_ in the transfer situation had a significant impact on his group's time to complete the task and the number of messages they sent. Wheel network groups consisting of one experienced group member in the central position were significantly more efficient in solving simple tasks than were naive control groups. No significant differences were found between the ratings of the groups on the five questionnaire items. Experienced central members were found to have significantly higher ratings of their satisfaction with position in the group than were experienced peripheral members.

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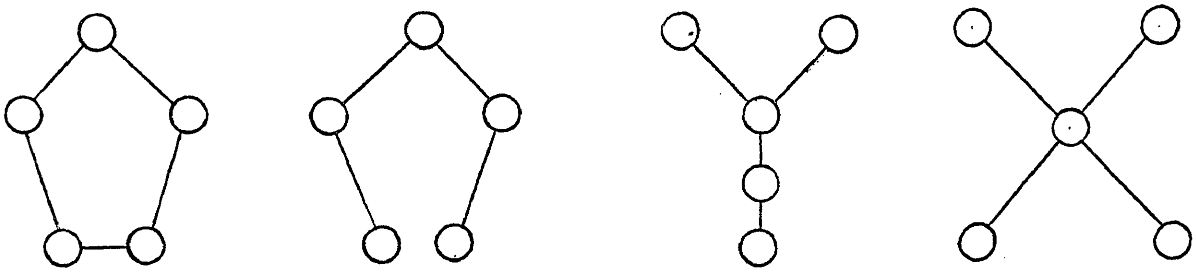
When the nature of a specified task is such that it requires the performance of a group rather than an individual, the problem of relationships among group members arises. In the consideration of group relationships, communication stands out as one of the more important aspects. In certain group structures, interactions between members are restricted and therefore, the type and direction of information flow is limited. In more unrestricted groups, each member may be able to communicate with every other member, thus placing the type of communication structure in the hands of the group itself. The type or pattern of communication channels imposed on a small group is termed a communication net or network (Cohen, 1961). Since any exchange of information between group members must be accomplished through some available communication channel, studies using communication networks as experimental devices have proven beneficial in the examination of the different aspects of small, problem-solving groups.

The introduction of communication network research and the network's subsequent influence on group performance was the work of Bavelas (1948, 1950). Bavelas' early studies both attempted to apply Lewin's concepts of topology to spatial relationships between groups and to investigate the effects of certain communication patterns on group structure and efficiency. Bavelas was also responsible for the suggested technique used for investigating group performance in the laboratory--the communication network apparatus (Shaw, 1964).

The initial network studies, conducted for the most part at the Massachusetts Institute of Technology, include works of Bavelas and Barret (1951), Leavitt (1951), and Christie, Luce, and Macy (1952). In general, the early approach taken toward communication network research is well illustrated by the experiment reported by Leavitt. He investigated several different dependent variables including problem-solving efficiency, group satisfaction and structural properties of the group in four different five-man network organizations; the circle, chain, "Y", and the wheel (Fig. 1). The tasks used in the study were simple symbol-identification problems. Each member of the group received a card containing five different symbols (a square, circle, diamond, etc.) out of a possible set of six symbols. Each member received a different combination of five symbols, but one symbol was common to all cards. The task was to identify the symbol commonly held by all five members. Leavitt's measurement of group performance included time to solution of problem, number of errors, and the number of individual messages sent. The study identified some of the differences between the various types of communication patterns. The "Y" network made the fewest errors (2.6), the circle net made the greatest number of errors (16.6), with the wheel and chain both producing intermediate error scores. Although the average problem solving time did not differ significantly, a measure of the fastest single trial indicated that the wheel was considerably faster than the circle. More general conclusions drawn by Leavitt include observations that the communication pattern within each group affected their problem solving ability, and that the characteristic which best correlated with problem solving differences was the extent to which the groups formed a centralized communication pattern.



Circle Network

Chain Network

"Y" Network

Wheel Network

Fig. 1. Five-Man Network Organizations

The results of the experiments performed by Bavelas (1950) and Bavelas and Barrett (1951) generally agree with the conclusions drawn by Leavitt. The work of Christie et al. (1952), however, attempted to investigate a different aspect of the network research (Shaw, 1964). Christie and his associates were primarily interested in certain mathematical models connected with the networks. The tasks utilized in the groups were number-identification problems similar to the common symbol task mentioned earlier. To aid in testing their models, the procedure was action-quantified. Subjects prepared and transmitted messages simultaneously at specific times. Besides the mathematical implications, the study found no differences in the group work process of the chain or circle groups and concluded that task completion with the smallest number of messages transmitted was found in the wheel.

These early works demonstrate quite well that group performance is clearly influenced by the pattern of communication imposed upon them. Also clear from this research is the fact that other variables influence group behavior besides imposed network structures.

Since the introductory work, communication network studies have dealt with a wide variety of communication variables. For the most part, the majority of ensuing network research concentrated on dependent variables in four categories: (1) overall group efficiency measured by number of errors made in each group, time required to complete the task, or the number of messages conveyed; (2) organization of groups in terms of structures utilized in handling information, and the development and change of such structures over time; (3) leadership in the group including both appointed and emergent leaders; (4) individual member satisfaction of the group recorded by reported morale or their desire to remain group members (Candland, 1968).

Although the majority of network studies have included one or more of the four dependent variable categories mentioned above, many other dependent variables have been studied (Glanzer & Glaser, 1961). Guetzkow and Simon (1955) looked at message content as well as organizational stability. Heise and Miller (1951) investigated the number of words transmitted, concluding that number of words was a function of network structure. Actual message content was looked at by several investigators, including Leavitt (1951), Guetzkow and Simon (1955), and Guetzkow and Dill (1957). The majority of network studies have not been limited to one dependent variable, measuring instead two or more variables with speed of task and number of errors clearly being the most widely utilized measures.

Since the early MIT studies, the network structure naturally has been the most widely used independent variable. However, other important variables have also been considered. Noise in the network and the type of task were manipulated in a study by Heise and Miller (1951) along with network, noise, and task interaction. Communication restrictions during organizational periods were changed in a study by Guetzkow and Dill (1957). Distribution of information was the independent variable used in several studies working with a four-man network (Shaw, 1954, 1956; Gilchrist, Shaw, & Walker, 1954). Several investigators have manipulated types of leaders or leadership influences on group performance (Shaw, 1955; Schein, 1958). Lawson (1964a, 1964b) studied the effects of two types of reinforcements on network behavior.

In summary, many dimensions of communication networks have been investigated, with network structure being the most widely used independent variable and time and number of errors being the most frequent dependent variable. It has been generally concluded that the major network differences are found between centralized (e.g., wheel) and decentralized (e.g., circle) structures. Also, differences in network performance are, in part, determined by the type of task used, complex or simple (Shaw, 1964). Centralized networks required less time to complete simple tasks than did decentralized networks. The reverse was true when complex tasks were used. Some of the behavioral differences noted by Leavitt (1951), and generally confirmed by subsequent studies, indicate that decentralized networks (e.g., circle) are characterized by high activity (send many messages), lack of organization, and erratic performance, but they are nets most enjoyed by the members. Centralized networks (e.g., wheel) appear to be less active, more stable in performance, and more likely to develop a distinct leader, but the group members are generally unsatisfied with the net.

In the past ten years, a series of studies have focused on an important aspect of communication that received little attention during early network research; namely, the effect of changing communication networks (Cohen, 1961, 1962; Cohen & Bennis, 1961; Cohen, Bennis, & Walkon, 1961, 1962a, 1962b; Lawson, 1965). Cohen was interested in the influence of past work structure on subsequent network behavior. To investigate this problem, Cohen, Bennis, and Walkon (1962) ran subjects for 30 trials in both wheel and circle networks. After the initial trials, they changed the wheel group to a circle structure and the initial circle network to a wheel network and recorded 30 additional trials. Wheel-to-wheel and circle-to-circle combinations were used as control groups. The study revealed that network behavior was influenced by prior network experience. The wheel-to-circle group correctly solved more problems than did the circle-to-circle control group. Circle-to-wheel groups took longer to solve problems than did the wheel-to-wheel control groups. Cohen explained these differences on the grounds that wheel-to-circle groups gained organization experience that circle-to-circle groups did not have access to, and that circle-to-wheel groups performed slower than wheel-to-wheel groups because of unsuccessful attempts to continue the circle work pattern in the wheel network.

Working with changes from wheel-to-all-channel (completely) connected network) and all-channel-to-all-channel, Cohen and Bennis (1961) concluded that change in the network affected organization stability with the wheel-to-all-channel group being more stable than the control group. This study again emphasized the importance of prior experience in the organization of networks.

In addition to studying organizational differences, Cohen attempted to measure an individual's satisfaction with his job and satisfaction with other group members after changing networks (Cohen, 1962). The results indicated that highest satisfactions were found when members were released from previously restricting networks and developed efficient problem solving procedures by themselves (e.g., wheel-to-circle). Cohen noted that the most important kinds of increases and decreases in network opportunities were those involved in changes from peripheral positions in the wheel networks to positions in the circle network and vice versa. No changes in satisfaction were found when changing from central positions in wheel networks to positions in the circle network. Cohen concludes that the number of channels added or taken away is not as important in change of satisfactions as is the quality of change (e.g., going from a position of less than equality in the wheel to a position of equality in the circle).

The work of Cohen and his associates on the effect of prior experience in different communication networks raised many questions, some of which were investigated in the following study. Can one experienced member in a group significantly affect initial group performance? Will the impact of the experienced person depend on his location in the network? Does the type of prior experience influence an individual's capability of affecting group performance? Unlike the prior studies, the following research focused on individual rather than group influence on network performance. The wheel network was utilized to further investigate whether experience in, or transfer to, a peripheral or central position affected network performance.

# METHOD

## Subjects

Three hundred and fifteen male subjects (Ss) drawn from the introductory psychology class at the University of Nebraska at Omaha participated as volunteers in the project. Subjects in the study were fulfilling research participation requirements which accompanied the introductory course. The Ss were randomly assigned to network groups, and students having knowledge of network research were not allowed to participate in the study.

## Apparatus and Instruments

The apparatus used during the research was basically the same as that used in the Leavitt study (1951). Subjects were seated around a circular table in such a manner that each was separated by a vertical partition running from the center past the edge of the table. The center of the table contained a seven-layer pentagonal box with slots in the layers connecting all booths. The slots in the various layers enabled Ss to push written messages to those with whom they were permitted to communicate. Although the apparatus allowed for the arrangement of any type of five-man network, the wheel network was used throughout the study (See Fig. 1).

Each booth in the wheel network contained a set of six switches, each of which was properly labeled to correspond to one of the possible six answers. By pushing a switch, a subject would light up a colored light on the master control board, thus indicating his answer. A stopwatch was used to record the length of time of each trial.

### Problem to Be Solved

The problem solving task used in the study was the well-known common symbol problem developed by Leavitt (1951). Each group member was presented with a set of ten numbered cards representing the ten trials. Five symbols out of a possible set of six were found on the back of each card. The six possible symbols included the diamond, square, triangle, asterisk, circle, and plus sign. On each trial, the five subjects had one of the symbols in common. Their task in the study was to indicate which symbol they shared with the other four group members. When all five *S*s had indicated their answer, a trial terminated even though the selections made may have been incorrect. At the end of each trial, *S*s were given instructions to begin the next trial, at which time they began the problem solving task using a new set of symbols. Each five-man group received ten consecutive trials.

### Procedure

Twenty-one groups of five *S*s worked in the initial training network using the wheel structure. In the wheel network, four group members (peripheral positions) can communicate with the fifth person (central position), but to no one else (See Fig. 1). The group member in the central position has the capability of communicating with all other group members directly. If a peripheral member of the group wished to communicate with another peripheral member, he did so via the central position. The procedure which generally develops in the wheel is called the central-hub system (Cohen & Bennis, 1962). In this system, peripheral members send their information to the central position member who formulates an answer and sends it back to the four peripheral members.

After the training situation, in which 21 groups completed ten successive trials, 21 Ss had central position experience and 84 Ss had experience in the peripheral position. A random set of ten of the 21 centrally trained Ss were then placed in the central position of a naive (inexperienced) wheel group (C-C), and a set of ten of the remaining centrally experienced members were placed in the peripheral position of a naive wheel group (C-P). Each of the naive groups (with one experienced member in each group) then underwent ten successive common symbol trials.

Of the 84 Ss trained in the periphery, 20 were randomly selected for further study in naive wheel groups. A random set of ten peripherally trained Ss were placed in the central position of a naive wheel group (P-C) and a second random set of ten peripherally trained Ss were placed in the peripheral position (P-P) of naive wheel groups. Both P-C and P-P groups were then presented with ten successive problem solving trials. A summary of the four types of transfer situations is shown in Figure 2.

| | | Position in Transfer | |
|---|---|---|---|
| | | C | P |
| Position in Training | C | C-C | C-P |
| | P | P-C | P-P |

Fig. 2. Four Transfer Situations: (C = central, P = peripheral).

Due to the fact that two group members (the central and one peripheral member) from each training group also participated in the various experimental transfer groups, it was not possible to conduct all of the transfer groups at one constant interval after training occurred. In order to account for the time variable between training and transfer, a random procedure was established in which one experienced group member performed in a transfer situation (C-C, C-P, P-P, or P-C) approximately ten minutes after receiving training, and the remaining experienced group member performed in the transfer group situation 48 hours after receiving training. The random procedure assured that half (five) of the groups of C-C, P-C, P-P, and C-P performed ten minutes after training and the remaining five groups of each transfer situation performed 48 hours [illegible] had been completed. This procedure assured that all experimental groups were treated equally with regard to the time interval between training and transfer.

In addition to the 21 training groups and the four experimental transfer groups, C-C, C-P, P-P, and P-C, ten five-man wheel groups served as controls. Each of the ten control groups consisted of five inexperienced members and received ten successive problem solving trials in the same manner as the training and transfer (experimental) groups. Every group participating in the study received the same set of instructions (See Appendix A) and worked to the same criterion of ten successive trials.

Four measurements were taken on each group in the experiment: time, number of messages sent, number of errors, and ratings of a post-communication questionnaire. Time, message and error measurements were taken on each of the ten trials while the questionnaire was administered after the tenth trial. To take into account individual performance differences such as reading speed and manual dexterity, time was recorded in time units (one time unit equals 15 seconds).

The time measurement started with the signal given to the groups to begin a trial and terminated after all five group members had indicated answers. The number of errors was also recorded on each trial. An error was defined as an incorrect answer by any member at the termination of any one trial. The third measurement taken on each trial was the number of message slips sent during that trial and was simply recorded as the total number of message slips passed between all group members during any one trial. After each group had completed the tenth trial, each group member was asked to fill out a six item rating scale (See Appendix B). The rating form given to each S after the completion of the tenth trial required that each S rate the first five items on a ten-point scale where zero was low and ten was high. The sixth item on the questionnaire asked each S which position had the most influence on the group's performance and was included to ascertain if the Ss perceived the center position as the most influential.

# RESULTS AND DISCUSSION

The means of the dependent variables time and messages for the control and transfer groups are shown in Table 1. Results of analyses will be discussed for each dependent variable separately.

## Time to Solution

Time unit measurements were collected on each trial for all groups--training, transfer, and control. Because the results of an analysis of variance indicated that the training groups were significantly different ($p < .01$) from each other on the time variable (See Appendix C), the data from transfer groups C-C, C-P, P-P, and P-C were compared using an analysis of covariance with a 4 x 10 factorial, repeated measures design. Statistical control was achieved by taking into consideration the concomitant variate (training score) in addition to the variate of primary interest (transfer score). The transfer scores were termed the criterion or variate, and the mean training scores were labeled as the covariate. Time unit measurements on the covariate were made for the purpose of adjusting the measures on the variate (Winer, 1963). The results of the analysis of covariance are shown in Table 2. These results must be interpreted in light of the significant interaction between treatments and trials ($p < .01$). The simple effects for treatments were examined

Table 1

MEANS OF DEPENDENT VARIABLES TIME AND MESSAGES

FOR CONTROL AND TRANSFER GROUPS

| Group | N | Time Units Mean | Messages Mean |
|---|---|---|---|
| C-C | 10 | 7.91 | 11.79 |
| P-C | 10 | 7.74 | 10.69 |
| P-P | 10 | 11.55 | 14.29 |
| C-P | 10 | 11.36 | 12.64 |
| Control | 10 | 13.21 | 15.19 |

## Table 2

## ANALYSIS OF COVARIANCE FOR TRANSFER GROUPS
## ON TIME UNIT VARIABLE

| Source of Variation | SS | df | MS | F | *p* |
|---|---|---|---|---|---|
| A (transfer groups) | 1324.63 | 3 | 441.54 | 8.28 | <.01 |
| Subj w. A | 1919.55 | 36 | 53.32 | | |
| B (trials) | 16010.18 | 9 | 1778.90 | 86.19 | <.01 |
| AB | 1449.60 | 27 | 53.69 | 2.60 | <.01 |
| Residual | 6668.32 | 323 | 20.64 | | |
| A (adj) | 1267.56 | 3 | 422.52 | 9.53 | <.01 |
| Subj w. A (adj) | 1550.67 | 35 | 44.30 | | |

to indicate, by trial, which treatment groups were significantly different. As shown in Table 3, the interaction seemed to involve significant treatment differences existing on the first two trials, but not on the last eight.

The Duncan Multiple-Range test was used to examine group differences on each of the first two trials. Results of these analyses appear in Tables 4 and 5. On trial one the groups with an experienced member in the central position (C-C and P-C) were significantly faster ($\underline{p} < .01$) than transfer groups with an experienced member in the periphery (C-P and P-P). On trial two the groups with an experienced person in the center (C-C and P-C) differed significantly only from the P-P groups. There were no group differences on other trials. On both trial one and trial two the experienced person's position during training did not make an appreciable difference in the transfer situation. This is shown on both trials by the lack of significant difference between C-C and P-C and between P-P and C-P.

In order to establish the relative effect of transferring one trained person to a naive network, mean times for all 10 trials by the four transfer groups were compared against a control group using Dunnett's t statistic. The results of this analysis are shown in Table 6. The findings of Dunnett's t statistic, supported by the means shown in Table 1 reveal the following: (1) only the C-C and P-C

Table 3

SIMPLE EFFECTS FOR TRANSFER GROUPS

ON TIME VARIABLE

| Source of Variation | SS | df | MS | F | p |
|---|---|---|---|---|---|
| A at $B_1$ (at Trial 1) | 1833.92 | 3 | 611.31 | 13.80 | $< .01$ |
| A at $B_2$ (at Trial 2) | 430.53 | 3 | 143.51 | 3.24 | $< .05$ |
| A at $B_3$ (at Trial 3) | 29.59 | 3 | 9.83 | .222 | NS |
| A at $B_4$ (at Trial 4) | 161.50 | 3 | 53.83 | 1.22 | NS |
| A at $B_5$ (at Trial 5) | 123.81 | 3 | 41.27 | .93 | NS |
| A at $B_6$ (at Trial 6) | 54.64 | 3 | 18.21 | .41 | NS |
| A at $B_7$ (at Trial 7) | 36.85 | 3 | 12.28 | .28 | NS |
| A at $B_8$ (at Trial 8) | 26.84 | 3 | 8.95 | .20 | NS |
| A at $B_9$ (at Trial 9) | 6.72 | 3 | 2.24 | .05 | NS |
| A at $B_{10}$ (at Trial 10) | 15.21 | 3 | 5.07 | .11 | NS |
| Subj w. A (adj) | 1550.67 | 35 | 44.30 | | |

Table 4

DUNCAN MULTIPLE-RANGE FOR TRANSFER GROUPS AT TRIAL 1

| Treatment | Mean | P-C | C-C | C-P | P-P | Shortest Significant Ranges at $p < .01$ |
|---|---|---|---|---|---|---|
| P-C | 19.21 | -- | 2.35 | 12.45* | 16.24* | $R_2 = 8.17$ |
| C-C | 21.56 | | | 10.10* | 13.89* | $R_3 = 8.52$ |
| C-P | 31.66 | | | -- | 3.79 | $R_4 = 8.75$ |
| P-P | 35.45 | | | | -- | *Sig at $p < .01$ |

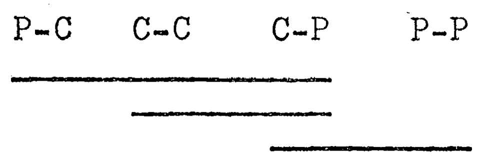
$\underline{\text{P-C}\quad\text{C-C}}\qquad\underline{\text{C-P}\quad\text{P-P}}$

Any two treatments not underscored by the same line are significantly different ($p < .01$).
Any two treatments underscored by the same line are not significantly different.

Table 5

DUNCAN MULTIPLE-RANGE FOR TRANSFER GROUPS AT TRIAL 2

| Treatment | Mean | P-C | C-C | C-P | P-P | Shortest Significant Ranges at $p < .05$ |
|---|---|---|---|---|---|---|
| P-C | 10.59 | -- | .10 | 5.27 | 7.55* | $R_2 = 6.06$ |
| C-C | 10.69 | | -- | 5.17 | 7.45* | $R_3 = 6.37$ |
| C-P | 15.86 | | | -- | 2.28 | $R_4 = 6.58$ |
| P-P | 18.14 | | | | -- | *Sig at $p$ .05 |



Any two treatments not underscored by the same line are significantly different ($p < .05$).
Any two treatments underscored by the same line are not significantly different.

Table 6

DUNNETT'S T STATISTIC COMPARING TRANSFER GROUPS VS. CONTROL

ON TIME VARIABLE

| Groups Compared | Differences Between Means | df | t statistic | p |
|---|---|---|---|---|
| C-C vs. Control | -5.30 | 1 | 5.63 | $< .01$ |
| P-C vs. Control | -5.47 | 1 | 5.81 | $< .01$ |
| P-P vs. Control | -1.66 | 1 | 1.76 | NS |
| C-P vs. Control | -1.85 | 1 | 1.97 | NS |

groups had significantly faster time scores than the control group ($\underline{p} < .01$); (2) the fastost group was P-C followed in order by C-C, C-P, P-P, and the control group.

The results of the analysis of covariance and the various individual and general comparisons point to several interesting aspects of wheel network behavior in a transfer situation. The findings of the study indicate the type of training which experienced $\underline{S}$s received, central or peripheral, had no apparent effect on their ability to reduce the time scores of their transfer groups. The factor that clearly played the major role in the four transfer group situations was the location of the experienced member in the wheel network. Experienced group members in central positions of the transfer groups, regardless of their position during training, were able to significantly decrease the time unit scores compared to those transfer groups whose experienced member was in a peripheral position. It appears that both centrally and peripherally trained individuals were equally able to learn the techniques necessary for problem solving during the ten training trials, but their ability to influence the performance times of their transfer group depended on the position to which they were assigned in the new group.

The significant interaction between transfer group and trials proved interesting. With group differences significant only on the first two trials, it appears the C-C and P-C groups were decreasing total time unit scores by faster problem solving behavior on the initial two trials. This finding implies the experienced Ss in the central position during transfer were able to influence their group score early in the transfer situation and thus provide them with fast starts. The early influence provided by the experienced C-C and P-C group members proved to be important because the first several trials were generally the most difficult for the majority of the groups.

Although the time scores of the C-C and P-C groups were the only scores which differed significantly from the control group, it is interesting to note that the P-P and C-P scores, although not significantly different, were generally lower than the control group time scores (See Table 1). This trend suggests experienced peripheral members, to some degree, do influence their transfer groups. To possibly account for this trend, it was hypothesized that the experienced members of the P-P and C-P groups were perhaps able to decrease group time scores by sending organizational type messages to the central member.

To investigate this possibility, ten individuals familiar with the wheel network structure were given 375 message slips and were asked to separate them into organizational type messages and non-organizational type messages. The 375 message slips were messages which had been written by the experienced members in the four transfer situations during the first and second trials. After the messages had been sorted by the ten Ss, the frequency of organizational type messages was recorded for each transfer group and analyzed by use of analysis of variance technique (See Table 7). The results indicate that the experienced members of the four transfer groups differed in regard to the number or organizational type messages they sent. The experienced C-P group members issued the most organizational type messages, followed in decreasing order by the experienced members of the C-C, P-P, and P-C groups.

Duncan's multiple-range test was used to determine which transfer groups differed from each other on the organizational message variable (See Table 8). Results of Duncan's test indicate that experienced C-P group members sent significantly more organizational messages than did experienced members of the other three transfer groups ($p < .01$). The results also indicate that experienced C-C and P-P group members sent significantly more organizational messages than did experienced P-C individuals ($p < .05$). Apparently, the experienced Ss transferred to a central position had less cause to send messages to facilitate organization since they themselves occupied the most influential position and could impose organization directly. The attempts by the experienced P-P and C-P group members to increase problem solving efficiency

Table 7

ANALYSIS OF VARIANCE OF ORGANIZATIONAL MESSAGES SENT BY EXPERIENCED MEMBERS OF THE FOUR TRANSFER GROUPS

| Source of Variation | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Subjects | 224.03 | 9 | 24.89 | 3.08 | $<.05$ |
| Treatments | 351.48 | 3 | 117.16 | 14.50 | $<.01$ |
| Error | 218.27 | 27 | 8.08 | | |
| Total | 793.78 | 39 | | | |

## Table 8

## DUNCAN MULTIPLE-RANGE TEST FOR MEAN NUMBER OF ORGANIZATIONAL MESSAGES SENT BY EXPERIENCED MEMBERS OF THE FOUR TRANSFER GROUPS

| Treatment Group | Mean | P-C | P-P | C-C | C-P | Shortest Significant Ranges at $p < .05$ | $p < .01$ |
|---|---|---|---|---|---|---|---|
| P-C | 3.5 | -- | 3.20* | 4.20** | 8.30** | $R_2$ = 2.596 | 3.496 |
| P-P | 6.7 | | -- | 1.00 | 5.10** | $R_3$ = 2.728 | 3.646 |
| C-C | 7.7 | | | -- | 4.10** | $R_4$ = 2.815 | 3.747 |
| C-P | 11.8 | | | | -- | | |

*Sig at $p < .05$

**Sig at $p < .01$

$$\text{P-C} \quad \underline{\text{P-P} \quad \text{C-C}} \quad \text{C-P}$$

Any two treatments not underscored by the same line are significantly different.

Any two treatments underscored by the same line are not significantly different.

through organizational type messages may well explain the finding that even these groups were somewhat faster than the control group. It is interesting to note that the C-P experienced members tended to send significantly more organizational messages than did the P-P experienced members, and also that the C-C experienced members sent significantly more organizational messages than did P-C experienced members. This finding indicates possible differences due to prior training or experience. The centrally trained Ss apparently took more initiative in attempting to increase problem solving efficiency than did peripherally trained individuals.

## Messages

The analysis of the number of messages sent by each experimental group was handled in the same manner as the time unit variable. The number of messages sent by each of the 21 training groups differed at a significant level (See Appendix D) and as a result, the analysis of covariance with a 4 x 10 factorial repeated measure design was again utilized. The mean number of messages of the training groups served as covariates and were used to adjust the transfer score or variate. The results of the analysis of covariance on number of messages sent can be found in Table 9. The mean number of messages are shown in Table 1.

The results of the analysis, using the adjusted scores, indicated significant differences ($p < .01$) between transfer

Table 9

ANALYSIS OF COVARIANCE FOR TRANSFER GROUPS ON MESSAGE VARIABLE

| Source of Variation | SS | df | MS | F | p |
|---|---|---|---|---|---|
| A (transfer groups) | 691.69 | 3 | 230.56 | 2.62 | NS |
| Subj w. A | 3167.61 | 36 | 87.99 | | |
| B (trials) | 7153.38 | 9 | 794.82 | 41.53 | .01 |
| AB | 708.33 | 27 | 26.23 | 1.37 | NS |
| Residual | 6182.29 | 323 | 19.14 | | |
| A (adj) | 1000.66 | 3 | 333.55 | 5.07 | .01 |
| Subj w. A (adj) | 2303.76 | 35 | 65.82 | | |

groups on the message variable. As expected, significant differences between trials were also noted ($\underline{p} < .01$), suggesting that fewer messages were required to solve the problem as naive Ss gained experience in the network. The result of the group-by-trial interaction on the message variable was not found to be significant.

Because of the significant transfer group differences, general comparisons were utilized to make the specific group comparisons shown in Table 10. The individual comparisons were made with the use of the adjusted error term. The results suggest that the C-C, P-C, and C-P transfer groups sent significantly fewer messages than did the control group. The fewest messages were sent by the P-C group, followed in order of increasing numbers of messages by C-C, C-P, P-P, and the control group. The findings also indicate that the P-P transfer group sent significantly more messages than either the C-C group ($\underline{p} < .05$) or the P-C group ($\underline{p} < .01$). Consistent with the above results, the comparisons indicate marked differences ($\underline{p} < .05$) when the groups with an experienced S in the center (C-C and P-C) were compared with the groups whose experienced member was in the periphery (P-P and C-P). Other possible comparisons between transfer groups were not significant.

As was the case with the time variable, results of the message analysis indicate that the type of prior training of

### Table 10

### GENERAL COMPARISONS BETWEEN ALL GROUPS ON MESSAGE VARIABLE

| Source of Variance | SS | df | MS | F | *p* |
|---|---|---|---|---|---|
| C-C vs. Control | 578.00 | 1 | 578.00 | 8.78 | $< .01$ |
| P-C vs. Control | 1012.50 | 1 | 1012.50 | 15.38 | $< .01$ |
| P-P vs. Control | 40.50 | 1 | 40.50 | .62 | NS |
| C-P vs. Control | 325.12 | 1 | 325.12 | 4.94 | $< .05$ |
| C-C vs. P-C | 120.52 | 1 | 120.52 | 1.83 | NS |
| C-C vs. P-P | 426.08 | 1 | 426.08 | 6.47 | $< .05$ |
| C-C vs. C-P | 36.12 | 1 | 36.12 | .54 | NS |
| P-C vs. P-P | 999.74 | 1 | 999.74 | 15.18 | $< .01$ |
| P-C vs. C-P | 288.61 | 1 | 288.61 | 4.38 | $< .05$ |
| P-P vs. C-P | 214.04 | 1 | 214.04 | 3.25 | NS |
| C-C & P-C vs. P-P & C-P | 350.00 | 1 | 350.00 | 5.31 | $< .05$ |
| C-C & C-P vs. P-C & P-P | 3.33 | 1 | 3.33 | .05 | NS |
| Subj w. A (adj) | 2303.76 | 35 | 65.82 | | |

the experienced group member (central or peripheral) had no apparent effect on the efficiency of the transfer group. The analysis further suggests that the position which experienced group members occupied in the transfer groups affected group message sending behavior. This result is also consistent with the findings of the time unit analysis.

The noted differences between the four transfer groups and the control group again proved interesting. The findings suggest that fewer messages were required to solve the problem when an experienced S was a member of the group regardless of his position. Perhaps the ability of experienced Ss to decrease the number of messages sent by their group could be explained by their tendency to send organizational type messages as mentioned earlier. This would be especially important in the case of the P-P and C-P transfer groups since the experienced member does not occupy the most influential (central) position. If the central members of the P-P and C-P groups gained useful information from messages sent by experienced peripheral members, decreased time and number of messages per trial could easily result.

## Errors

Even though the number of errors was recorded on each trial, there were not enough errors to permit meaningful analysis. Prior research has indicated low error scores with networks high in centrality, thus accounting for the minimal error data found with the wheel networks (Leavitt, 1951; Cohen et al, 1962a).

## Post-Communication Questionnaire

Traditionally, research on communication networks has included an examination of the attitudes of group members. Attitude data collected from the control and transfer groups were analyzed in two steps. First, Spearman Rank correlations were computed, for each treatment and control condition, between the responses to the first five items of the attitude questionnaire in Appendix B. These inter-item correlations were computed to ascertain if items a and b, concerning efficiency or if items c, d, and e, dealing with satisfaction were really measuring the same aspects (See Appendixes E, F, G, H, and I). Although the magnitude of the relationships vary across treatment groups, moderate to high correlations were found between questions dealing with efficiency. These correlations were not high enough to indicate that the Ss saw ratings of leader efficiency and group efficiency as identical. Except for item c dealing with satisfaction with position in the group, moderate to high correlations were also obtained between the satisfaction items. Ratings of satisfaction with group performance and leader performance, while moderately correlated, were only slightly related to satisfaction with position in the group. This finding suggests that individuals satisfied with the performance of the group and the leader were not necessarily satisfied with their own position in the group. In general, even though some of the satisfaction variables are definitely correlated, they are not correlated to the extent that they are measuring identical dimensions.

In order to look at the differences in ratings between the various experimental and control groups, the nonparametric, Friedman two-way analysis of variance by ranks was utilized. To control for possible confounding, only the data provided by three inexperienced, peripheral members from each group were analyzed. Thus, ratings by central position members and by group members having previous experience were not included in the analyses. The results of the Friedman analysis are shown in Table 11. The ratings of the five groups (four experimental and one control) on each of the five questionnaire items were not found to be significantly different. The lack of significant results may be due to several factors. Since the rating questionnaire was filled out after the completion of the tenth trial, a large majority of the groups were rating each item after having reached nearly maximum efficiency in the communication network. This fact may account for the generally high ratings on all items and thus explain the lack of difference between groups on the rating questionnaire.

Turning now to ratings made by the experienced members of the transfer groups, the Friedman two-way analysis was

Table 11

FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE

OF GROUP RATINGS ON QUESTIONNAIRE ITEMS

| Questionnaire Item | N | K | df | $\chi_r^2$ | p |
|---|---|---|---|---|---|
| a | 30 | 5 | 4 | 4.03 | NS |
| b | 30 | 5 | 4 | 6.08 | NS |
| c | 30 | 5 | 4 | 6.12 | NS |
| d | 30 | 5 | 4 | 3.09 | NS |
| e | 30 | 5 | 4 | 8.77 | NS |

again used to look for differences in ratings on items a, c, and d. Results of this analysis (See Table 12) indicate no significant differences between the treatment groups on the items dealing with group efficiency (a) and satisfaction with the performance of the group (d). Ratings on item c, satisfaction with position in the group, were significantly different ($\underline{p} < .02$). To determine which treatment groups differed on this item, a Mann-Whitney U test was used to make all possible comparisons. Table 13 shows that the experienced members in the P-P groups rated satisfaction with their position in the group significantly lower than the experienced members in the C-C and P-C groups ($\underline{p} < .002$). These results partially support Leavitt's (1951) findings that the peripheral members enjoy their jobs less than members in the central position. The significant difference between P-P and P-C experienced group members is consistent with Leavitt's (1951) finding and lends support to the research of Cohen, Bennis, and Walkon (1962a) in which changes from circle networks to central positions in wheel networks (an increase of two open channels) was found to increase job satisfaction. It is interesting to note that the C-P groups did not differ significantly on their ratings of item c compared to any of the other transfer groups. This result is also consistent with the findings of Cohen and his associates (1962a). Cohen's study found that when a demotion was from a position of

## Table 12

## FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE OF EXPERIENCED GROUP MEMBER'S RATINGS ON QUESTIONNAIRE ITEMS A, C, AND D

| Questionnaire Item | N | K | df | $\chi_r^2$ | *p* |
|---|---|---|---|---|---|
| a | 10 | 4 | 3 | 5.55 | NS |
| c | 10 | 4 | 3 | 11.2 | $< .02$ |
| d | 10 | 4 | 3 | 7.53 | NS |

Table 13

MANN-WHITNEY U-TEST BETWEEN TRANSFER GROUPS

ON QUESTIONNAIRE ITEM C

| Groups Compared | $N_1$ | $N_2$ | U | U' | p |
|---|---|---|---|---|---|
| C-C vs. C-P | 10 | 10 | 35 | 65 | NS |
| C-C vs. P-P | 10 | 10 | 7 | 93 | $<.002$ |
| C-C vs. P-C | 10 | 10 | 58 | 42 | NS |
| C-P vs. P-P | 10 | 10 | 30 | 70 | NS |
| C-P vs. P-C | 10 | 10 | 69.5 | 30.5 | NS |
| P-P vs. P-C | 10 | 10 | 93.5 | 6.5 | $<.002$ |

Lowest value of U or U' used to test for significance.

greater-than-equality to one of equality, the only significant negative effect was on interest in the task. The demotion from a position of greater-than-equality experienced by C-P transfer members apparently did not decrease their satisfaction with their position in the group.

Analysis of ratings on items b and e required exclusion of data from the experienced members in the C-C and P-C groups. This was done because these two items dealt with leader efficiency (b) and satisfaction with the leader (e). It was felt the members of the C-C and P-C groups would be biased in rating themselves. Because data from only two groups of experienced members were being analyzed, the Mann-Whitney U test for differences between independent samples was used. Table 14 shows no significant differences between the treatment groups for the two items b and e. Apparently, the peripheral members, regardless of their initial training, did not differ systematically in their evaluation of the leader or their satisfaction with the leader's performance. It was felt that the centrally trained individuals transferred to the periphery of a new group might be more critical of the naive leader in the central position than persons trained in the periphery would be. That this was not the case could be explained by the previous results showing no differences between experienced members in C-P and P-P groups in terms of their ability to influence group performance.

## Table 14

## MANN-WHITNEY U-TEST BETWEEN P-P AND C-P GROUPS ON QUESTIONNAIRE ITEMS B AND E

| Groups Compared | $N_1$ | $N_2$ | Item b | | | Item e | | |
|---|---|---|---|---|---|---|---|---|
| | | | U | U' | *p* | U | U' | *p* |
| P-P & C-P | 10 | 10 | 49.5 | 50.5 | NS | 50.5 | 49.5 | NS |

Lowest value of U or U' used to test for significance.

## CONCLUSION

Over all, the results of transferring peripheral or centrally trained individuals to peripheral or central positions of the wheel network revealed that (1) the position occupied by the experienced Ss during training had no apparent effect on the time scores or the number of messages sent by the transfer groups; (2) the network position occupied by the experienced S in the transfer situations had a significant impact on the group's time to complete the task and the number of messages they sent; (3) more specifically, transfer groups with experienced members occupying central positions (C-C and P-C) had significantly greater group efficiency, in terms of lower time scores and fewer messages sent, when compared to transfer groups with peripherally-positioned experienced members (P-P and C-P); (4) in terms of time and messages, wheel network groups consisting of one experienced group member in a central position were significantly more efficient in solving simple tasks than were naive control groups; (5) rating scores on the five questionnaire items did not differ significantly across treatment groups; (6) the experienced central members reported greater satisfaction with their position than did the experienced peripheral members who had received prior training in the periphery.

As a result of the apparent ability of one group member to influence total group performance in a wheel network, several suggestions for future research can be made. First, it would be in order to extend these findings to different types of networks. Second, it might be valuable to explore the relationship between this transfer phenomenon and a variety of individual differences such as leadership style, intelligence, race, sex, etc. Third, the problem solving group might be used to examine power processes by transferring more than one trained member into a naive group. Fourth, it might be similarly possible to examine status conflicts by establishing an a priori status structure in a naive problem solving group and then inserting a trained person in a low status position. Pilot work also suggested a fifth area of future research; the distinct possibility of developing a computerized simulation of a wheel network. Such a simulation would allow investigators to focus on the behavior of a single individual in a manipulable problem solving situation without the present problem of having to recruit large numbers of subjects to staff the network. Finally, research is needed to check on the generality of the findings in the present study to other problem solving situations, specifically to situations involving different, more complex problems.

# SUMMARY

Research was conducted to explore the effects of prior experience of one group member on the performance of the wheel network. The performances of four experimental transfer groups and one control group were investigated. The four experimental groups included combinations of centrally or peripherally trained Ss transferred to a central or peripheral position in naive wheel networks. Four dependent variables were measured: time, number of messages, number of errors, and individual ratings on a post communication questionnaire.

The position of the experienced group member in the transfer situation had a significant impact on the variables of time and number of messages sent by the group. The position of the experienced group member during training was not found to significantly influence transfer group behavior.

Differences between group ratings on the questionnaire items did not prove significant. Analysis of experienced group member ratings indicated that Ss transferred to a central position were more satisfied with their position in the group than peripherally transferred individuals who had received prior training in a peripheral position.

Future research possibilities investigating varied aspects of communication networks were discussed.

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# Appendix A

## Instructions

The communication project you are involved in will require the participation of all group members. Each group member will be seated in one of the five booths located around the communication channels or slots. All communication will be written on the message slips provided in the booths, and passed through the open slots. Verbal communication will not be permitted during the experiment.

When you are given the signal to begin, you will turn over your first card marked #1. On the reverse side of the card you will see five different symbols out of a possible set of six. The six symbols include a circle, square, diamond, triangle, plus sign, and asterisk. On any one trial, every group member will have one of the symbols in common. Your task as a group will be to determine the one symbol that all group members have on their card. Since you are working as a group, you will want to share your answer with the group if you obtain the answer first. As soon as you know the common symbol, push the appropriate switch marked with that symbol. Leave your switch on unless you decide to change your answer or until the end of the trial when you will be told to place your switch in the off position. A trial will terminate when everyone has selected an answer. The experimenter will inform you when the trial is over and collect the message slips you used during that trial. You will then be given the signal to begin the next trial.

You will be given ten trials during the project, which you should complete as accurately and swiftly as you can. You must work as a team to efficiently solve each task.

In summary, remember that on each trial you will have five symbols on your card. Every group member has one common symbol. For instance, perhaps on Trial 1, everyone has a diamond or a square or one of the other symbols. Be sure to use only the colored pen provided for you and to send only message slips that you have written. Do not send message slips that someone else has sent to you. You may write as much information as you feel necessary on any message slip and send as many messages as you like. Please do not mark on the trial cards as they will be used again.

# Appendix B

## RATING FORM

## POST COMMUNICATION QUESTIONNAIRE

CIRCLE ONE NUMBER EACH NAME____________________

On a ten point scale where 0 means very low and 10 means very high, rate:

a. the efficiency of your group 0 1 2 3 4 5 6 7 8 9 10

b. the efficiency of your leader 0 1 2 3 4 5 6 7 8 9 10

c. your satisfaction with your position in the group 0 1 2 3 4 5 6 7 8 9 10

d. your satisfaction with the group's performance 0 1 2 3 4 5 6 7 8 9 10

e. your satisfaction with your leader's performance 0 1 2 3 4 5 6 7 8 9 10

f. Which position (color) had the most influence on the group's performance?

## Appendix C

## ANALYSIS OF VARIANCE FOR TRAINING GROUPS ON TIME UNIT VARIABLE

| Source of Variation | | SS | df | MS | F | p |
|---|---|---|---|---|---|---|
| Between trials | | 24345.12 | 9 | 2705.01 | 60.26 | $< .01$ |
| Within trials | | 10550.90 | 200 | | | |
| Training groups | 2470.59 | | 20 | 123.53 | 2.75 | $< .01$ |
| Residual | 8080.31 | | 180 | 44.84 | | |
| Total | | 34896.12 | 209 | | | |

## Appendix D

## ANALYSIS OF VARIANCE FOR TRAINING GROUPS
## ON MESSAGE VARIABLE

| Source of Variation | | SS | df | MS | F | p |
|---|---|---|---|---|---|---|
| Between trials | | 9843.54 | 9 | 1093.73 | 42.26 | $< .01$ |
| Within trials | | 5250.13 | 200 | | | |
| Training groups | 2570.10 | | 20 | 128.50 | 4.96 | $< .01$ |
| Residual | 4658.86 | | 180 | 25.88 | | |
| Total | | 15093.67 | 209 | | | |

## Appendix E

## CORRELATIONS BETWEEN RATING ITEMS FOR C-C GROUP MEMBERS

## EXCLUDING CENTRAL MEMBER

| | | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| Efficiency of Group . . . . . . . . . | 1. | 1.000 | | | | |
| Efficiency of Leader . . . . . . . . . | 2. | .912 | 1.000 | | | |
| Satisfaction with Position . . . . . . | 3. | .498 | .504 | 1.000 | | |
| Satisfaction with Group Performance. | 4. | .610 | .610 | .347 | 1.000 | |
| Satisfaction with Leader Performance | 5. | .882 | .912 | .483 | .618 | 1.000 |

r = .306 significant at $p < .05$

## Appendix F

## CORRELATIONS BETWEEN RATING ITEMS FOR P-C GROUP MEMBERS

## EXCLUDING CENTRAL MEMBER

| | | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| Efficiency of Group . . . . . . . . . | 1. | 1.000 | | | | |
| Efficiency of Leader . . . . . . . . | 2. | .408 | 1.000 | | | |
| Satisfaction with Position . . . . . | 3. | -.002 | .207 | 1.000 | | |
| Satisfaction with Group Performance. | 4. | .826 | .552 | .041 | 1.000 | |
| Satisfaction with Leader Performance | 5. | .413 | .727 | .262 | .618 | 1.000 |

$r$ = .306 significant at $\underline{p} < .05$

## Appendix G

## CORRELATIONS BETWEEN RATING ITEMS FOR P-P GROUP MEMBERS
## EXCLUDING EXPERIENCED AND CENTRAL MEMBERS

| | | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| Efficiency of Group . . . . . . . . . | 1. | 1.000 | | | | |
| Efficiency of Leader . . . . . . . . . | 2. | .886 | 1.000 | | | |
| Satisfaction with Position . . . . . . | 3. | .211 | .271 | 1.000 | | |
| Satisfaction with Group Performance. | 4. | .784 | .745 | .277 | 1.000 | |
| Satisfaction with Leader Performance | 5. | .858 | .887 | .258 | .894 | 1.000 |

$r$ = .306 significant at $\underline{p} < .05$

# Appendix H

## CORRELATIONS BETWEEN RATING ITEMS FOR C-P GROUP MEMBERS EXCLUDING EXPERIENCED AND CENTRAL MEMBERS

| | | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| Efficiency of Group . . . . . . . . . | 1. | 1.000 | | | | |
| Efficiency of Leader . . . . . . . . . | 2. | .464 | 1.000 | | | |
| Satisfaction with Position . . . . . . | 3. | -.194 | .286 | 1.000 | | |
| Satisfaction with Group Performance. | 4. | .438 | .702 | .277 | 1.000 | |
| Satisfaction with Leader Performance | 5. | .424 | .865 | .351 | .828 | 1.000 |

$r$ = .306 significant at $\underline{p} < .05$

## Appendix I

## CORRELATIONS BETWEEN RATING ITEMS FOR CONTROL GROUP MEMBERS

## EXCLUDING CENTRAL MEMBER

| | | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|---|
| Efficiency of Group . . . . . . . . . | 1. | 1.000 | | | | |
| Efficiency of Leader . . . . . . . . . | 2. | .463 | 1.000 | | | |
| Satisfaction with Position . . . . . | 3. | .258 | .213 | 1.000 | | |
| Satisfaction with Group Performance. | 4. | .584 | .565 | .156 | 1.000 | |
| Satisfaction with Leader Performance | 5. | .492 | .899 | .299 | .678 | 1.000 |

$r = .306$ significant at $\underline{p} < .05$