

Technical Report 926

# Computer-Mediated Group Processes in Distributed Command and Control Systems: Supervised Shared Work

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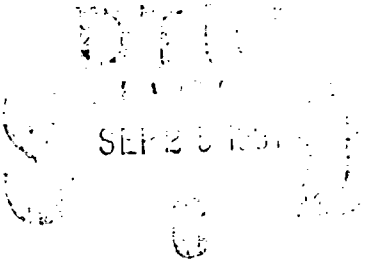

**April 1991**


**United States Army Research Institute for the Behavioral and Social Sciences**

# U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

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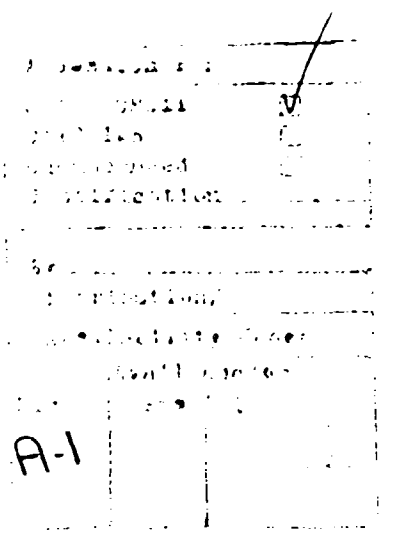


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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

# REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

| | |
|---|---|
| 1a. REPORT SECURITY CLASSIFICATION<br>Unclassified | 1b. RESTRICTIVE MARKINGS<br>-- |
| 2a. SECURITY CLASSIFICATION AUTHORITY<br>-- | 3. DISTRIBUTION/AVAILABILITY OF REPORT<br>Approved for public release; distribution is unlimited. |
| 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE<br>-- | |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S)<br>-- | 5. MONITORING ORGANIZATION REPORT NUMBER(S)<br>ARI Technical Report 926 |
| 6a. NAME OF PERFORMING ORGANIZATION<br>VRC Corporation<br>6b. OFFICE SYMBOL (If applicable)<br>-- | 7a. NAME OF MONITORING ORGANIZATION<br>U.S. Army Research Institute<br>Fort Leavenworth Field Unit |
| 6c. ADDRESS (City, State, and ZIP Code)<br>68 Long Court, Suite E<br>Thousand Oaks, CA 91360 | 7b. ADDRESS (City, State, and ZIP Code)<br>P.O. Box 3407<br>Fort Leavenworth, KS 66027-0347 |
| 8a. NAME OF FUNDING/SPONSORING ORGANIZATION<br>U.S. Army Research Institute for the Behavioral and Social Sciences<br>8b. OFFICE SYMBOL (If applicable)<br>PERI-S | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER<br>MDA903-86-C-0210 |
| 8c. ADDRESS (City, State, and ZIP Code)<br>5001 Eisenhower Avenue<br>Alexandria, VA 22333-5600 | 10. SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO. 62785A; PROJECT NO. 790; TASK NO. 1304; WORK UNIT ACCESSION NO. C02 |

11. TITLE (Include Security Classification)
Computer-Mediated Group Processes in Distributed Command and Control Systems: Supervised Shared Work

12. PERSONAL AUTHOR(S) Linville, James M.; Liebhaber, Michael J.; Obermayer, Andrew H. (VRC Corporation); Fallesen, Jon J. (ARI)

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REPORT (Year, Month, Day) | 15. PAGE COUNT |
|---|---|---|---|
| Final | FROM 88/07 TO 90/08 | 1991, April | |

16. SUPPLEMENTARY NOTATION
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| 17. COSATI CODES | | | 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | Computer dialogue; Group processes; Computer-mediated communications; Human factors; Distributed command and control (C2) (Continued) |
| | | | |
| | | | |

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report describes research on the effects of computer-mediated communications on distributed command and control. The study extends the investigation of computer-mediated communication with shared graphics in distributed C2 to a three-person group (triad) to examine the effects of computer-mediation on the ability of a supervisor to interact with staff members and to exercise control over task accomplishment. An experiment was conducted that required two team members, under the supervision of a third individual, to collaborate on a military tactical movement order task. The three people were also required to perform other work to simulate conditions typical for command staffs. Work was performed face-to-face (FTF) and with the group separated using various modes of computer-mediated communications. The experimental modes evaluated were (1) face-to-face, (2) synchronous with voice communications (SYNCH+V), and (3) voiceless asynchronous electronic-mail communications (ASYNCH). Results indicate that little is lost in performance quality or speed when moving from face-to-face to computer-mediated communications with an auxiliary voice channel. (Continued)

| 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT | 21. ABSTRACT SECURITY CLASSIFICATION |
|---|---|
| ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS | Unclassified |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>Jon J. Fallesen | 22b. TELEPHONE (Include Area Code)<br>(913) 684-4933<br>22c. OFFICE SYMBOL<br>PERI-SL |

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

ARI Technical Report 926

18. SUBJECT TERMS (Continued)

Graphic communications language
Movement planning
Staff operations

19. ABSTRACT (Continued)

There were notable time differences in the ASYNCH mode. The synchronous with voice mode was a more desirable supervisory mode than face-to-face or asynchronous modes.

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Department of the Army

**April 1991**

**Army Project Number**
**2Q162785A790**

**Human Performance Effectiveness and Simulation**

## FOREWORD

Command and control (C2) operations and staff coordination require effective communication among both face-to-face and separated soldiers. Changes from traditional means of communication to computer-mediation must be anticipated in requirements analysis and design when using computers to aid staffs. This is especially true for distributed modes of performance and supervision. The interaction between team members working jointly to solve a problem or to perform a task is affected by the capabilities of the available tools. To date, opportunities for the use of tools to perform analyses and to develop plans have been appropriately identified, but tactical computer design has focused on the transmission and presentation of information and not on information use.

The Fort Leavenworth Field Unit of the U.S. Army Research Institute for Behavioral and Social Sciences has completed an initial phase of research computer mediation in C2 staff operations. This report presents findings characteristics of operations when using various modes of computer communication for a team developing a movement plan. The results have general implications for the design of tactical computers but more importantly for the design of procedures for using computers to support distributed staff performance.

EDGAR M. JOHNSON
Technical Director

COMPUTER-MEDIATED GROUP PROCESSES IN DISTRIBUTED COMMAND AND CONTROL SYSTEMS: SUPERVISED SHARED WORK

## EXECUTIVE SUMMARY

### Requirement:

The military command and control (C2) system is functionally and geographically distributed; future C2 systems will be distributed more to increase survivability and the breadth of command and control. Typically, C2 staffs collaborate and coordinate to solve problems. Voice communications alone may not adequately support distributed staffs cooperating to perform military tasks. Computer networks offer the promise of enhancing group communications. Coordination may be accomplished by two persons or multiperson groups. However, supervision, in some form, is always required and provided for. Previous research has not addressed the role of the supervisor in a distributed, group task.

### Procedure:

This study extends the investigation of computer-mediated communication with shared graphics in distributed C2 to a three-person group (triad). The three person group accomplished supervised, shared work. In particular, this study examines the effects of the mode of computer-mediation on the ability of a supervisor to interact with staff members and to exercise control over task accomplishment. Of interest was the ability of supervisors to maintain cognizance of the task and to affect the activities of the personnel doing the task.

To test the interaction of computer-mediated communication and the role of the supervisor, an experiment was conducted that required two team members, under the supervision of a third individual, to collaborate to perform a task. The task was adapted from a military tactical movement order. Additionally, the three people accomplished other work to simulate a typical environment for command staffs. The supervisors were responsible for the quality of the solution and had very specific guidance that they applied to select movement routes. Besides accomplishing other work, the members of the team responded to priority work requirements generated by the supervisor. Measures were taken on the performance of the primary task and other work and features of the communication transcripts.

Work was performed face-to-face and with the three people separated using various modes of computer-mediated communications. The communication modes evaluated were (1) face-to-face (FTF), (2) separated, with synchronous computer and voice communications (SYNCH+V) with the supervisor receiving a remote screen from one of the staff members, and (3) asynchronous electronic-mail communications (ASYNCH) only.

The design of the overall analysis of the task data was 2 (Experience) X 2 (Trials) X 3 (Communication Modes). Experience was the only between-groups factor. In three triads (experienced), all team members participated in the previous dyad experiment and had experience with the task. The remaining three triads (partial experience) had a previously experienced leader and inexperienced team members. The within-group factors were trials and communication modes.

The goals of this experiment were to study the effects of communication modes on task performance and on the interactions of the supervisor with the rest of the team. To accomplish these goals, a priori comparisons of the modes were performed. The c mparisons were (1) FTF versus SYNCH+V, (2) FTF versus ASYNCH, and (3) SYNCH+V versus ASYNCH.

Findings:

In general the results of this experiment closely paralleled the results of the previous dyad experiment reported in Linville, Liebhaber, Obermayer, and Fallesen (1989). The differences between face-to-face and synchronous with voice conditions were negligible. However, there were notable differences from these two modes to the asynchronous mode. The existence or lack of a voice communication channel appears to be the factor most responsible for performance differences, rather than physical separation or computer-mediation. Additionally, the synchronous mode created a different and, apparently, more desirable supervisory environment than the face-to-face mode, even though performance was not affected. The supervisors indicated that they were most comfortable working in this mode. They said they were able to accomplish their own work without distraction, to monitor the task activities easily, and to make timely supervisory decisions without the pressure of a face-to-face environment.

Utilization of Findings:

Combat developers of C2 systems should consider computer-mediated communications as a viable alternative to face-to-face and voice-only communications. The benefits of computer aiding, shared graphics, shared databases, and two-way graphic communications have the potential to create an environment that accommodates distribution of function and dispersion of assets. Just as important is the possibility of expanding the commander's sphere of influence by allowing supervision to take place from remote or distributed locations.

COMPUTER-MEDIATED GROUP PROCESSES IN DISTRIBUTED COMMAND AND CONTROL SYSTEMS: SUPERVISED SHARED WORK

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# COMPUTER-MEDIATED GROUP PROCESSES IN DISTRIBUTED COMMAND AND CONTROL SYSTEMS: SUPERVISED SHARED WORK

## INTRODUCTION

The military command and control (C2) system is functionally and geographically distributed; however, future C2 systems will be distributed more to increase survivability and the breadth of command and control. Voice communications alone may not adequately support distributed staffs cooperating to perform military tasks, but computer networks offer the promise of enhancing group communications. Typically C2 staffs collaborate and coordinate to solve problems. This coordination may be accomplished by two persons or multiperson groups. However, supervision in some form, is always required and provided. Computer-mediated communication may encompass computer aiding, shared graphics, shared data bases, and two-way graphic communication.

To test the potential of computer-mediated communication, an experiment (Linville, Liebhaber, Obermayer, & Fallesen, 1989) was conducted that required two people to collaborate in the accomplishment of a task based on a military tactical movement order. Besides face-to-face (FTF) work, modes of computer-mediated communications that were used included (1) synchronous communications (SYNCH), in which the computer screens of both remote computers contain the same information at the same time, or asynchronous communications (ASYNCH), in which the individuals share information delayed through electronic mail, and (2) communications with, and without, normal voice conversations (V). Measures of the performance of primary and other work, and features of the communication transcripts were collected. The following experimental modes were evaluated: (1) face-to-face (FTF), (2) synchronous with voice communications (SYNCH+V), (3) synchronous without voice communications, but with the exchange of typed computer messages (SYNCH-V), and (4) asynchronous electronic-mail communications (ASYNCH).

As predicted, the differences between face-to-face and synchronous with voice conditions were negligible. However, there were notable differences from these two modes to synchronous without voice and asynchronous modes. The existence or nonexistence of a voice communication channel appeared to be the factor most responsible for performance differences, rather than physical separation or computer-mediation. As a result, combat developers of C2 systems should have greater confidence in the possibility of computer-mediated communications as an alternative to face-to-face and voice only communications.

The present study extended the investigation of computer-mediated communication in distributed C2 to a three-person group (triad): Two team members accomplishing the task and the third acting as the supervisor. The study addressed the ability of the supervisors to interact with the staff members and to exercise control over task accomplishment in different types of communication modes. Of interest was the ability of supervisors to remain aware of the task and to affect the task activities of the personnel performing the task. On the other hand, supervisors should remain aware of the task without becoming totally immersed in task procedures.

### Army Staff, Environment, and Computers

The command and control (C2) system is a distributed system. The system is dispersed throughout the battlefield, and must rely on communication systems for assistance in task accomplishment. Future C2 systems will require even more dispersion to improve survivability and to increase the commander's sphere of influence and breadth of command and control.

Large command posts have very high and predictable electronic and physical signatures, making them vulnerable to detection and targeting. Once detected, the command post may be the target of electronic exploitation, jamming, and disruption or destruction by tactical or special forces or weapons. Dispersing into smaller command posts, distributed across the battlefield, may be feasible with the use of computer-mediated communication.

Distributed command posts also allow an increase in redundancy of function. Survivability of function is supported so that one cell of a command post could take over the functions of another cell, if something should prevent it from operating. The replacement cell would certainly have to understand the task requirements, but may be unfamiliar with the status of the required function. Computer prompts of imbedded task procedures and historical activity can compensate for lack of user familiarity.

C2 computer systems have allowed manually performed functions to be replaced or augmented. Examples include creation and transmission of reports, tabulation of resources on hand, record-keeping, message transmission, and graphical displays. Also, the requirement to address tactical requirements (such as responding to increased lethality, work pace and information load) has constrained combat developers to select computer functions where immediate payoff would be high and development risk low.

Remote staffs must share information, provide supervision, coordinate on tasks, perform analyses, and provide recommendations. To enhance these processes, computer aiding, shared graphics, shared data bases and two way graphic communication can aid the distributed C2 system. Computer networks may improve the ability to share data, resolve conflicts, and provide guidance to yield an accurate, timely and coordinated staff product. Voice communications alone probably will not support the collaboration and coordination required for successful task accomplishment.

The area of shared work has been considered only in a limited sense of transmitting messages and using common data bases. The concepts of remote players working on a task in a collaborative fashion are on the horizon. Research on collaborative performance can supply combat developers with lessons learned to augment design concepts early in the development cycle.

Two previous reports from this project (Weisband, Linville, Liebhaber, Obermayer, & Fallesen, 1988; Linville, et al., 1989) provide such data and lessons. They suggest computer-mediated communication can contribute to the success of the distributed C2 system by allowing effective accomplishment of collaborative work from non co-located sites.

## Supervisors and Computer-Mediated Work

The previous experiment in this series attempted to focus attention to a task requiring consensus achievement in a military command staff setting. That experiment compared communication modes to reflect on point-to-point communication design issues such as synchronous versus asynchronous, and voice versus no voice channel. The current research focus is on issues related to military staff supervision.

Kiesler, Siegel, & McGuire (1984) raise six issues surrounding the introduction of electronic communication technologies:

- Does easy, rapid communication change the distribution or quality or the timing of information exchanged?
- Does communication lacking nonverbal feedback give group members enough information to coordinate communication?
- How will people compensate for the absence of nonverbal cues in electronic media?
- As group members participate more equally on a computer, how will the role of status be perceived? Although in the military, status or rank of officers is not easily ignored, it still raises an important question: How will military leaders be perceived and "spoken to" during electronic communications?
- Is electronic communication impersonal and depersonalizing? Because electronic communicators must imagine their audience, messages are depersonalized, inviting stronger or more uninhibited text and more assertiveness in return.
- Because there are few established rules for computer communication, how do people develop a social communication network structure? Do they import norms from other technologies or do they develop new norms?

On this basis one can argue that the role of the leader in computer-mediated non-military groups is unclear. If status cues are reduced and participation is more equal, leader emergence is hindered in groups communicating via computer. On the other hand, status in the military is rank, position, and at times, task dependent. Not only is this status visible, but it is rarely ignored or circumvented.

The literature tells us very little about what to expect from military leaders communicating via electronic media. Therefore, empirical study is required in which one member of the group is the leader and is responsible for accomplishment of the task. The remainder of this document addresses an exploratory study of military staff supervision in various communication settings. The staff supervisor is responsible for task accomplishment, quality control, conflict resolution, and insuring that the coordination required by the nature of the task takes place. Successful supervision requires that the supervisors have a way of exercising control over, and interacting with the personnel they are supervising. This study investigated such supervision with face-to-face and computer-mediated communication.

## Hypotheses

In general, it is hypothesized that the modes of communication examined will create different environments for supervision. With regard to the performance of the two-person working team, it is expected that the results will be similar to the previous study (e.g., performance differences will be negligible between Face-To-Face and Synchronous + Voice conditions, but large differences will occur when compared to the Asynchronous mode). If the measure is sensitive enough, we anticipate that the presence of a supervisor will improve the quality of the solution for the triads when compared to the solutions reached in previous dyad experiments; however, probably at a cost of increased time.

More detailed hypotheses will be stated in the following paragraphs for communication modes, and other experimental factors, in terms of task quality/speed, other work performed, and transcript measures (sentence, style, content code, and word).

Communication Modes. The Synchronous + Voice mode may offer the most advantages to supervisors. In this mode they will be removed from the pressures of operating in a Face-to-Face environment, will have the opportunity to make decisions somewhat insulated from the interactions of the other participants, and will be able to affect task accomplishment in real time. They also will have the advantage of interacting by voice, thereby retaining additional control and authority.

In the Face-to-Face environment the supervisors run the risk of joining in the moment-to-moment team activities and may possibly have reduced authority by being perceived as another team member.

It is believed that the anticipated slow communication times associated with the Asynchronous mode will negate the ability of the supervisor to affect the task in real time and will be further burdened by the inability to communicate by voice. It is anticipated that the lack of timeliness in the Asynchronous mode coupled with the communication difficulties will nullify the advantages of automatic historical data retention and the separation of the supervisor and the team members.

Although it is anticipated that task time will be progressively longer as the mode becomes more unlike Face-to-Face, previous research indicates that the quality of the solution will not significantly vary, regardless of the mode being examined. As the communication mode becomes less like the Face-to-Face mode in terms of separation, time synchronization, and voice-less communication, there should be more complete sentences, fewer interruptions, fewer questions, and fewer communications.

Other Experimental Factors. The supervisory task should be different if the team members are experienced or have just completed training. Based on the previous study, it is expected that task performance, with regard to quality of product, will not be affected greatly by experience, but experienced triads should accomplish the task more quickly. The partially experienced team performance should improve more over experimental trials than that for experienced triads. The experienced triads should have more non-task oriented sentences and less task-specific words. It is expected that supervisors of inexperienced team members will ask more questions, provide more guidance, and seek more information than supervisors of experienced teams.

The rate at which the teams complete the "other work" tasks is not expected to be affected by computer-mediation, separation, or by voice or voiceless conditions. Previous research indicates this work rate will remain constant regardless of the communication mode being examined.

# METHOD

## Experimental Tasks

The specialized laboratory task developed for the dyad shared work experiment (Linville, et al., 1989) was used to test the specific hypotheses. The essence of the task generally relates to the development of a movement plan (Department of the Army, 1984, 1986, 1987), performed by the operations planning cell of a division command post. The plan requires coordination among major functional staff groups, and collaboration within a single functional group. The sub-tasks included in the laboratory manifestation require: (1) route selection, and, (2) completion of other, routine work. A description of the task and the requirements is contained in Linville, et al.(1989).

The basis for selecting this particular task for the laboratory was a belief that the task must be challenging for the military audience and at the same time be attainable, with minimum training, by non-military laboratory subjects. Additionally, this task must retain enough of a military tenor to allow acceptance when subjected to scrutiny by the Army. Additionally, it was deemed necessary that the task be map based, should rely upon graphic communications for information flow and presentation of decision alternatives, should have an element of risk in the various decision alternatives, should provide a motivation for doing well, and should have clearly defined and measurable task measures.

To test the effect of computer-mediated communication on the role of the supervisor, two team members under the supervision of a third individual, collaborated to perform the tactical movement planning task. Each staff individual possessed part of the information to do the task which was primarily graphical. Additionally, the three people were required to perform other work (work of a routine nature performed at a constant pace) to simulate an environment typical for command staffs. The laboratory task allowed participants to be placed in different settings, depending on the mode of communication under investigation. A detailed description of the laboratory layout is presented in Appendix A.

"Priority work" was integral to the task design. Priority questions were asked by the supervisor on a time schedule, emulating the distracting environment in which the staff officer must work. Priority questions dealt with general military information and task specific queries. These questions were answered by the participants by referring to Field Manual 100-5, Operations, or to the task information handouts. (Examples of priority work questions are "How many bridges of greater than 24 tons are located on highway 101", and "Where can I find information on forces for rear area combat?") Measurement and data collection were not performed for this aspect of the task.

"Other work" was a secondary task. Typically other work demands came in the form of fact-based questions to emulate the necessity for accomplishing routine, common tasks in the tactical staff group setting. Other work consisted of responding to general questions by referring to Field Manual 100-5, Operations for the answer. (An example of another work question is, "According to the Allied Command Europe organization chart, who directly commands all of the air defense forces?")

The supervisor was responsible for the quality of the solution and had very specific guidance that he applied to select a course of action.

Supervisor's Role

The supervisor had four primary responsibilities during the accomplishment of the task:

- Responsible for task accomplishment. The supervisor was responsible for the quality of the solution. He was responsible for insuring that the "OPTIMUM" solution was found.
- Responsible for conflict resolution. Regardless of the conflict, the supervisor was responsible for resolving the point of contention. The conflict may have had to do with primary task accomplishment, allocation of resources or tasks, or it may have had to do with process.
- Responsible for accomplishment of "PRIORITY WORK". The supervisor had to assign the priority work to one of the participants, and at times had to redirect the efforts of the staff participant back to the primary task.
- Responsible for own "OTHER WORK". The supervisor had other work to accomplish, and could not afford to get involved in directly solving the primary task. This was the responsibility of the two staff participants.

Value Comparisons

To assist the supervisor in determining a satisfactory (experimenter-defined) solution, the following criteria and penalties were established:

Satisfactory Route criteria (no penalties)

1. Task accomplished in 25 minutes or less.
2. Route length 399 miles or less.
3. Driving through no more than one low value obstacle.
4. Removing no medium or high value obstacles.
5. Upgrading no bridges.

Penalties (for other than satisfactory route)

- Driving through two low value obstacles was equivalent to removing one medium value obstacle, and was equivalent to the upgrade of one 45 ton or larger bridge, and was equivalent to accomplishing task in 26-35 minutes, and was equivalent to a route length of 400-420 miles: one penalty.
- Removal of one high value obstacle was equivalent to removing two medium value obstacles, and was equivalent to the upgrade of one 8 ton-44 ton bridge, and was equivalent to accomplishing the task in 36-45 minutes, and was equivalent to a route length of 421-450 miles: two penalties.
- One additional penalty was assessed for route lengths that were 451-470 miles in length, or for task accomplishment time of 46-59 minutes.
- One additional penalty was assessed for route lengths 471 miles or longer or for task accomplishment time of 60-80 minutes.
- One additional penalty was assessed for task accomplishment time of 81-120 minutes.
- One additional penalty was assessed for task accomplishment time of 121 minutes or greater.

Experimental Factors

Two different levels of experience were used for the triad teams in order to create two different levels of supervisory interaction.

> Experienced (Triad Type A). Individuals who had previous experience in the dyad dyad experiment were formed into three Type A triads to perform the three person experiment. These triads did not utilize the previously used dyads as an imbedded dyad (participant A and B). Rather the available personnel were formed into a new team with one of the personnel being randomly designated as the supervisor.
>
> Partial Experience (Triad Type B). Two inexperienced individuals for each of three triads performed the duties of the imbedded dyad (participant A and B). A previously experienced individual, one who had participated with a Type A triad, was used as the supervisor for these Type B triads.

Three modes of communications were examined in the investigation.

> Face-to face. The team was co-located and used a single computer to complete the task. In this mode the supervisor was in the same room as the two staff participants, but at a different work table. He was able to observe at a distance, walk over to the staff work table and was able to communicate and interact by voice.
>
> Synchronous computer-mediation. Two separate team members (participant A and B) were linked through personal computers, connected by cable between RS-232 serial ports. INSYNCH software (see Appendix B) provided synchronized functions for file and screen transfer, simultaneous movement of a cursor on both screens, and annotation with typed text or free-hand drawing. Additionally, a push-to-talk intercommunication device was provided the team members. The supervisor was placed remote to the two primary staff members. He was furnished with a repeat monitor, so that he could monitor the inter-action between the staff participants and was also provided a push-to-talk intercommunication device to communicate with, and to monitor the communications between, the staff participants.
>
> Asynchronous computer-mediation. Physically separated team members sent and retrieved messages in the form of computer text or graphic files. Files were transmitted to a location where they were stored for access. This equated to a time-delayed mail capability with information retained indefinitely for multiple subsequent access. No voice communication was provided. The supervisor was also located remotely, with access to the mailbox computer terminal. This allowed him to participate on the electronic mail network. All interactions between staff menbers and the supervisor were done through electronic mail.

In the face-to-face mode the computer was used as a medium for task presentation. In the distributed mode of operation team members had computers with common task information. The tasks required information sharing, problem solving and consensus.

Subjects were teamed into triads. Each triad completed the task under each of the three modes of communication. For each mode of communication, three trials of the tasks were performed. Each trial on each mode of communication used different versions of the problem. Seven versions had been prepared in advance by varying the start and stop points, the movement objectives, and the obstacles to movement. The presentation order of the modes of communication was counterbalanced, as was the order of problem versions. The first trial for each mode was a familiarization and training event and not included in data analysis. All familiarization trials used one of the seven versions of the problem.

## Training

Training was conducted for the supervisor, for the new participants, and for the triad teams. Training was conducted separately for the supervisor, and for the two new members of the triad.

Supervisor training. The supervisor attended a one hour training session separate from any triad training. At this session, the guidance for task accomplishment was reviewed in detail. The supervisor was required to work with the guidance for an "optimum" solution. This aided the supervisor in determining an optimum choice, and served as the basis for making choices between alternative solutions. The supervisor also had training in the process of accomplishing the task. This training delineated each of the two staff participants' task responsibilities, outlined the interaction protocols, and highlighted the most common process errors. Also, supervisor and participant communications were covered, so that the supervisor could interact more readily with the participants.

New personnel training. New personnel underwent training in the areas of task accomplishment, process, and communication protocol. This training was the same as that received by previously trained dyads. This training required approximately 7 hours.

Triad team training. Triads were trained in process, task accomplishment, and interaction protocol during the first trial of each mode. This training was primarily a review of previously learned behavior.

The team training sequence was the same for all triads. Each triad was introduced to the requirements, provided with an explanation of the goals of the experiment, and conducted hands-on-training with lab supervisor assistance and demonstration. The objectives of the training were to reinforce the behavior learned during new personnel training, or during previous dyad experience and to allow the triad to perform as a team. The same version of the task was used for all training sessions. At the end of the training sessions, the triads were confident that they could accomplish the task, using any of the three modes of communication.

## Test Participants

A pool of 15 subjects was formed into six triads (three of them filled roles in two triads). Nine of the subjects performed in the 12 previously experienced slots (3 Type A Triads and 3 supervisors for Type B triads) and 6 of the subjects performed in the non-experienced slots. All of the subjects were male college undergraduates. Their participation in the experiment was voluntary; however, they were paid a nominal amount for participating.

## Data Sources

The experimental task provided a rich source of data. Data sources included event times, route score, voice transcripts, number of units of "other work" completed, participant ratings on supervisor, and observations by the experimenter.

## Task Measures

The measures examined dealt with the recording of events and time that were available for measurement and with the coding applied to the transcripts of the communications. Figure 1 shows the relationship of the time measures collected during the laboratory sessions.

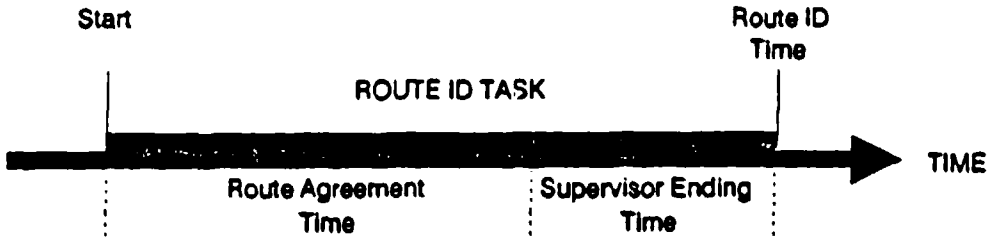



**Figure 1. Relationship of task measures.**

Route Agreement Time. This was computed as the elapsed time until participants A and B came to an agreement on the selected route and annotated the computer map sheet with the route, bridges upgraded or driven through, and with the obstacles driven through or removed. Once the preceding steps were accomplished the map was saved as a final map. This data point measure was affected by the amount and mode of communication.

Route ID Time. This measure portrays the total time necessary for the completion of the graphical task.

Supervisor Ending Time. This time was the amount of time used by the supervisor to verify the solution, provide approval, complete administrative requirements, and end the task.

Route Score. A set of penalties was developed to score the value or merit of a route determined by the team. This route score allowed comparison of solutions across modes.

Other Work. The accomplishment of other work was computed as the number of other work items that can be completed per unit time (1 hour).

Transcript Analysis Measures

Transcripts for the voiceless mode, Asynch, were obtained from typed messages sent between team members over the computer network. Transcripts from the two voice modes were taken from audio tape recordings of team members while they performed the experimental tasks. One transcript consisted of all communication that occurred during Route ID Time for a given mode and trial. Each triad participated in three modes of two trials each; resulting in a total of 36 transcripts (3 modes * 2 trials * 6 triads).

The same dependent variables were used here as in Linville, et al., (1989). The variables were grouped into four categories for descriptive purposes. Transcript data were taken from the output of the transcript analysis program, SALT (Miller & Chapman, 1985). Content codes were added to each message by the experimenter. This coding allowed several language characteristics to be examined and analyzed. The codes are described below.

Sentence. These variables identified the basic structure of each message or sentence. The two sentence variables are:

[COMPLT] percentage of complete sentences
[FLSTRT] percentage of false starts: "I think, I think ..."

Style. The four variables in this category indicated the type of message. They are:

[DECLAR] percentage of declarative sentences
[QUEST] percentage of questions
[UNFIN] percentage of unfinished sentences
[INTRPT] percentage of interrupted sentences

Content. Fourteen variables were used to describe the content of each message. Some refer to an entire message and others refer to particular words. The analysis was based on the percentage of occurence of a variable when compared to all other content variables. They are:

| | |
|---|---|
| [A] | abbreviation understandable in context: obs for obstacles |
| [C] | message indicated confusion on part of sender |
| [CR] | computer-related message: "Hit return key." |
| [F] | feedback from message receiver to sender: "okay." |
| [FA] | message providing formal approval (supervisor only) |
| [G] | guidance message (supervisor only) |
| [GI] | general information |
| [I] | information seeking (supervisor only) |
| [NTO] | non-task oriented message: "It's hot today." |
| [P] | processing: "I'll measure the route now." |
| [PO] | polite: "Thank you." |
| [TO] | task oriented message: "Take hwy 12 South." |
| [TS] | task specific word: "bridge" |
| [U] | uninhibited language: "That was stupid." |

Word. These variables captured the usage of words alone and within messages. The variables are:

[DIFFW] number of different words used
[TOTW] total number of words used

# RESULTS

The results are presented in three sections. The results of an analysis of the task variables are reported first. This is followed by the results from an analysis of the transcript data, and lastly, the results from the post-experiment questionnaire are presented.

## Analysis of Task Measures

The dependent task measures were:

(1) Route ID Time,
(2) Route Agreement Time,
(3) Supervisor Ending Time,
(4) Route Score,
(5) Other Work.

The results of the task analysis are divided into three parts. First is an analysis of all the factors in the design. Second are specific comparisons among the communication modes. Third are the results from a comparison of dyad and triad performance on selected task measures.

## Task Analysis

A 2 (Experience) X 2 (Trials) X 3 (Communication Modes) ANOVA was performed on each task measure. The primary hypotheses are:

- Experienced triads will accomplish the task more quickly than the partially experienced triads.
- Partially experienced triads will accomplish the task as well as experienced triads.
- Partially experienced triads will improve more than experienced triads, during the second trial of the task.
- Task times will take longer as the Communication Mode becomes less like FTF.

Experience was the only between-groups factor. Recall, that in three triads (experienced, Type A), all team members participated in the previous dyad experiment and were experienced at performing the task. The remaining three triads (partial experience, Type B) had an experienced leader and inexperienced team members. The within-group factors were Trials and Communication Modes. Each triad underwent two trials. The Modes, described earlier, were Face-To-Face (FTF) communication, Synchronous computer + Voice (Synch+V) communication, and Asynchronous (Asynch) computer communication.

A complete breakdown of means and standard deviations by Experience, Trials, and Communication Modes for each task measure is in Table C-1. Triad statistics are summarized by Experience and Communication Modes in Table C-2, by Trials and Communication Modes in Table C-3, by Communication Modes only in Table C-4, and by Trials and Experience in Table C-5. Tables C-1 through C-5 are in Appendix C. Box plots of the task measures are also in Appendix C. The results of the analysis are summarized below; complete source tables are in Appendix C.

There were not any overall differences that could be attributed to Experience, i.e., between triads with experienced team members (Type A) compared to triads with partially experienced team members (Type B). However, there was an interaction between Experience and Trials for Route ID Time, $F(1,4)=14.1, p=.02$; Route Agreement Time, $F(1,4)=14.6$, $p=.019$; and Route Score, $F(1,4)=60.1, p=.001$. See Figures 2, 3, and 4. The Standard Error of the Measure is also shown in Figures 2, 3, and 4. Times and scores improved from Trial 1 to Trial 2, for Type B triads, as Figures 2 through 4 show, and interestingly a decrease in performance was noted for the Type A triads. However, this decrease in performance was not statistically significant. A significant main effect for Trials was also shown for Route ID Time, $F(1,4)=13.0, p=.023$, and Route Agreement Time, $F(1,4)=8.4, p=.044$. Although Type A triads tended to perform better than Type B triads, the presence of an experienced leader in triads with inexperienced team members (Type B) appeared to speed the task learning process as indicated by the improved performance times for the second trial.

Overall differences among Communication Modes were significant for Route ID Time, $F(2,8)=159.2, p < .001$; Route Agreement Time, $F(2,8)=56.4, p< .001$; and Supervisor Ending Time, $F(2,8)=51.9, p< .001$. In general, the times increased from the FTF mode to the Synch+V mode to the Asynch mode, as can be seen in Figures 5 through 7. Most of the differences among the modes appear to be due to the Asynch condition. Communication Modes are analyzed in detail below. There were not any significant interactions between Communication Modes and Experience or between Communication Modes and Trials (except for Other Work, $F(2,8)=4.5, p=.05$).

## Communication Mode Comparisons

Three comparisons to test the hypothesis regarding Communication Mode differences were performed for each task measure. The hypothesis was that increased performance dif-

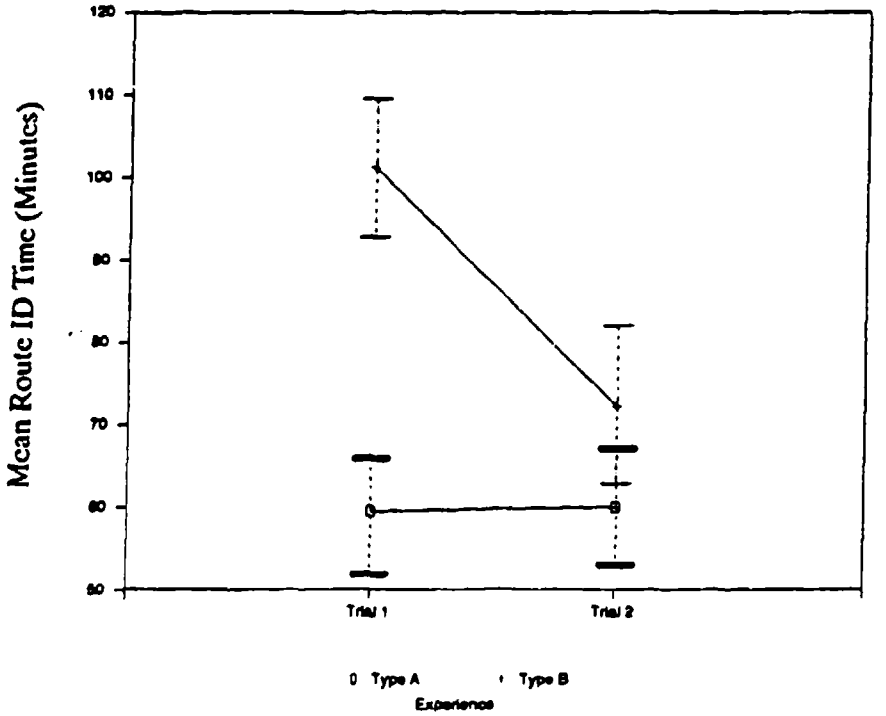



Figure 2. Mean route ID time by experience and trial (short horitzontal base represent standard error).

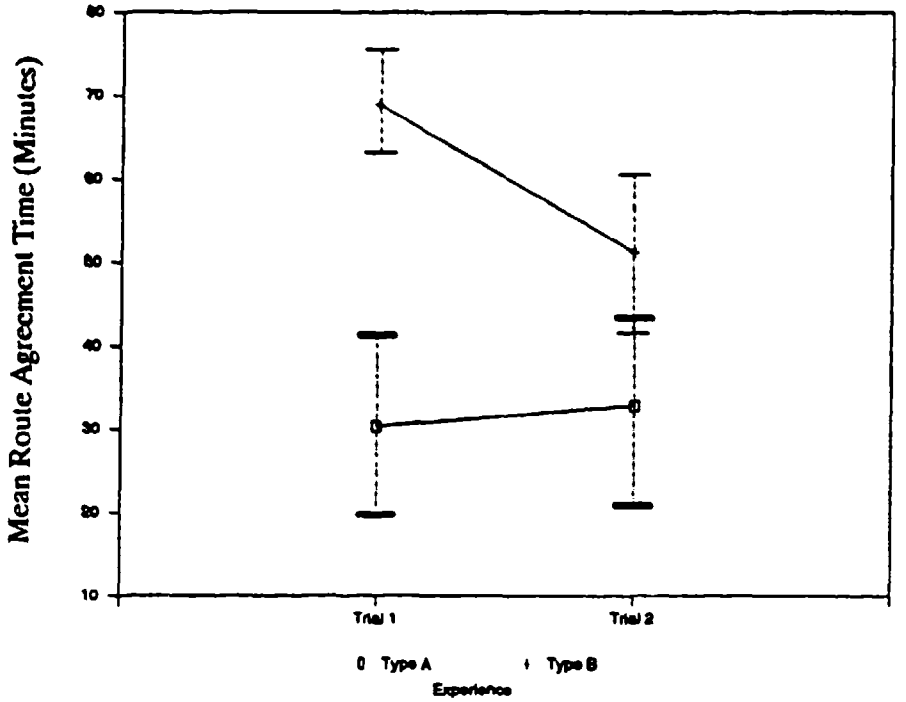



Figure 3. Mean route agreement time by experience and trial.

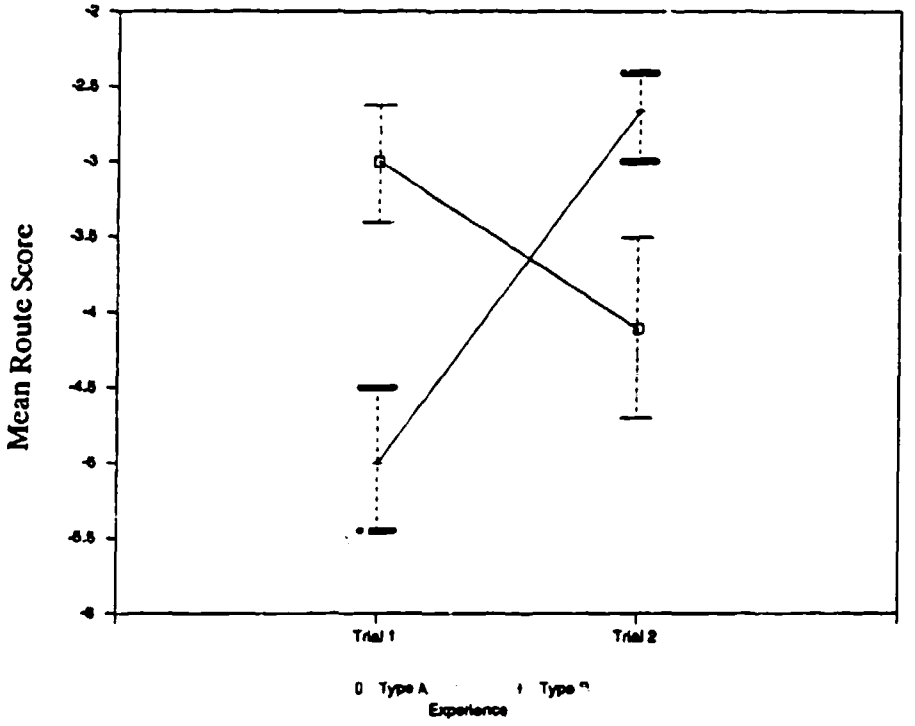



Figure 4. Mean route score by experience and trial.

ferences between Communication Modes should be seen as the modes become more unlike FTF communication. Synch+V and Asynch communication styles are increasingly altered from FTF. Therefore, performance under the FTF and Synch+V conditions should be similar, and both are expected to be different from the Asynch condition. Three *a priori* contrasts comparing the Communication Modes were analyzed. The source tables for the results are in Appendix D and are summarized here.

FTF to Synch+V comparison. There were not any significant differences between these two modes on any dependent variable. Nor were there any significant interactions between this comparison and Experience. It appears that FTF and Synch+V communication are sufficiently similar so as not to produce any significant time or performance differences on the variables measured here.

FTF to Asynch comparison. Performance times were much slower in the Asynch mode compared to the FTF mode for Route ID Time, $F(1,4)=177.2, p < .001$; Route Agreement Time, $F(1,4)=52.3, p=.002$; and Supervisor Ending Time, $F(1,4)=57.4, p=.002$. This comparison did not interact with Experience. The performance differences can be seen in Figures 5, 6, and 7. Asynchronous communication seems to be sufficiently different from FTF to increase the time required to perform the task. However, performance differences between FTF and Asynch were not significant for Route Score or Other Work.

Synch+V to Asynch comparison. Performance in the Asynch condition was slower than performance in the Synch+V condition for Route ID Time, $F(1,4) = 233.1, p < .001$, Route Agreement Time, $F(1,4) = 77.0. p = .001$, and Supervisor Ending Time, $F(1,4) = 49.8, p = .002$. (See Figures 5, 6, and 7.) There were not any significant differences for Route Score or Other Work. As expected, the FTF and Synch+V conditions were similar, and both were considerably faster than the Asynch condition. Therefore, Communication Mode affects task time but not necessarily task quality.

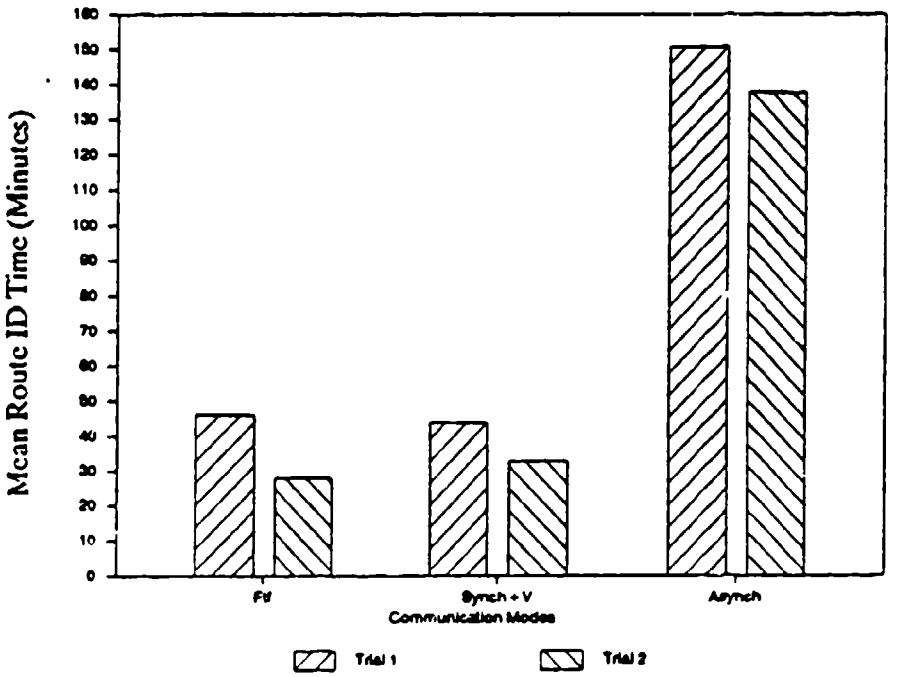



Figure 5. Mean route ID time by communication modes and trial.

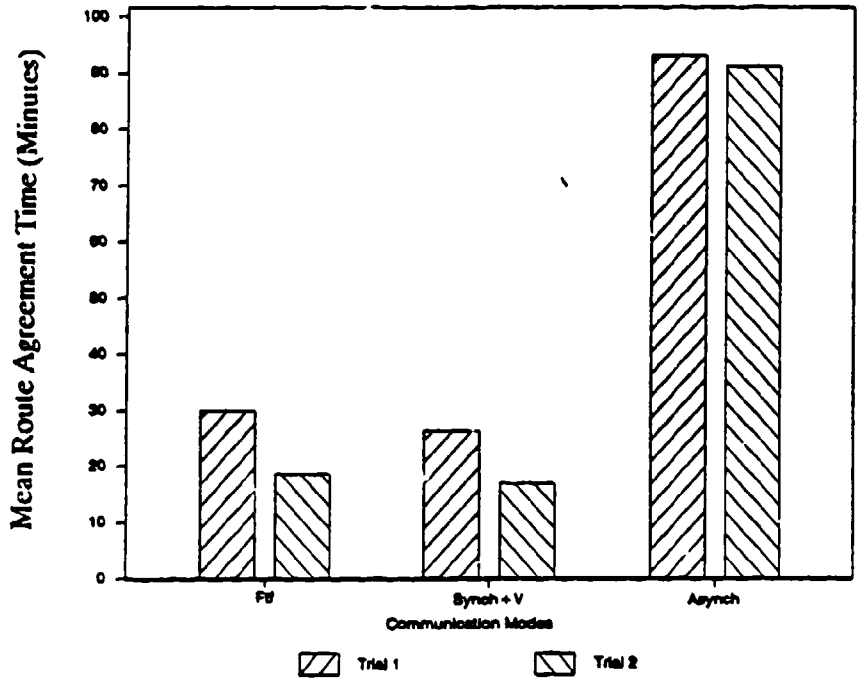



Figure 6. Mean route agreement time by communication modes and trial.

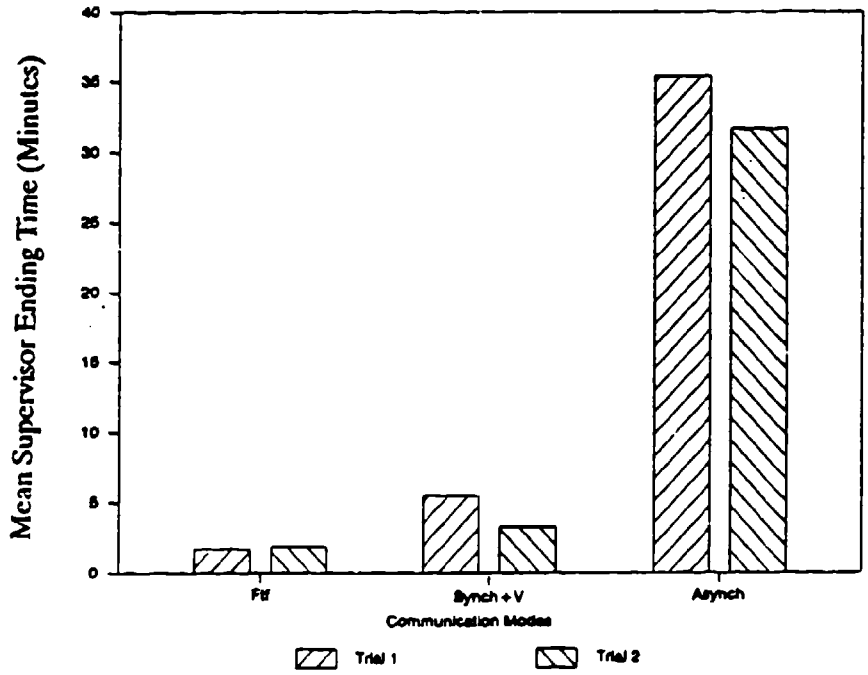



Figure 7. Mean supervisor ending time by communication modes and trial.

## Previous Dyad Performance Compared to Triad Performance

Using data collected in the previous dyad experiment (Linville et al., 1989), a comparison between performance of the triad teams and dyad teams was performed. It was hypothesized that the time to complete the task would be longer for the triads and that the performance, based on route scores, would be better for the triads.

Priority Work was not used in the dyad study. Therefore, in order to compare the dyads and triads, it was necessary to remove the time spent on priority work from the triad data. Only the FTF and Synch+V conditions were comparable because it was not possible to identify the priority work times for the Asynch condition. Means and Standard Deviations and the source tables for the analysis are in Appendix E.

Dyads had shorter Route ID Times, $F(1,24) = 16.1, p = .001$, and Route Agreement Times, $F(1,24) = 8.9, p = .006$, than did triads. There were no differences for Route Scores. Means of Route ID Time and Route Agreement Time, and the Standard Error of the Measure, are plotted in Figures 8 and 9. Apparently a smaller team size allowed the dyads to reach a quicker, but not necessarily better, solution.

## Communication Mode Analysis of Triad Transcripts

Transcripts of communication from th ids were analyzed. The results are presented by each class (Sentence, Style, C nt Code, & Word) of dependent measure. Within each class, separate analyses were done on the entire transcript (Total Transcript) and on a transcript of only the supervisor's communication (Supervisor-Only Transcript). The supervisor's communications were contained in the Total Transcript also. The general hypotheses were:

Total Transcript-

- As the Communication Mode became less like FTF there would be more complete sentences, fewer interruptions, fewer questions, and fewer communications.
- That Type A triads would have more non-task oriented sentences, more general information conversations, and would have less task oriented sentences and less task specific words than the Type B triads.

Supervisor-only Transcript-

- That Communication Modes would affect the supervisor communications in the same way that they affected the total transcripts.
- That supervisors of Type B triads would ask more questions, provide more guidance, and seek more information than the supervisors of Type A triads.

A Chi-square test of Association (Glass & Hopkins, 1984) was performed on the Sentence, Style, and Code measures since the data were a proportion of occurrence within a transcript. Communication Modes and Trials were within group design factors and Experience was a between-group design factor. The Supervisor-Only data were collapsed over Trials because of its low occurrence relative to a total transcript. Hence, Trials was not a factor in the Supervisor-Only analysis. The Means and Standard Deviations, along with the complete results of the analysis, are in Appendix F. The results are summarized below.

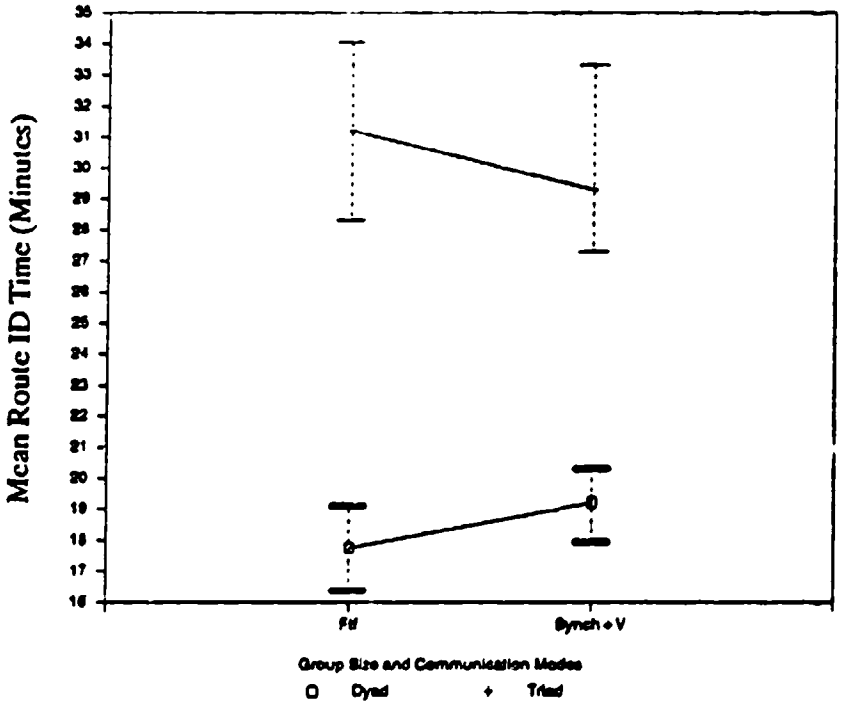



Figure 8. Mean route ID time by communication modes and team size.

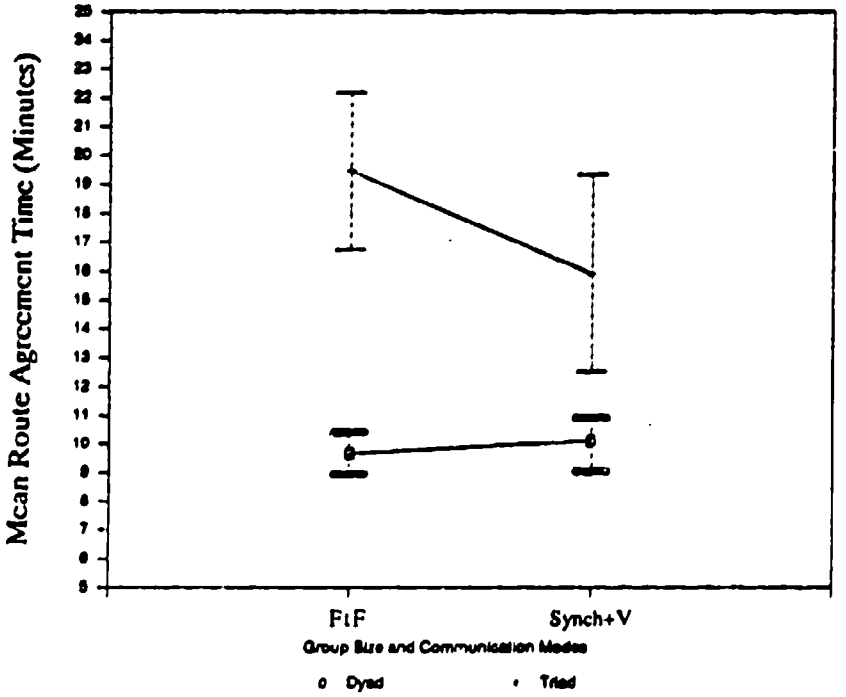



Figure 9. Mean route agreement time by communication modes and team size.

Sentence Variables

The Sentence dependent variables were the total proportion of Complete and False Start sentences.

Total Transcript. There was an interaction between Communication Mode and Sentence Type, $X^2(4) = 77.8, p < .05$. Most sentences were Complete, with only a small proportion of False Start sentences. This can be seen in Figure 10. False Starts only occur in the voice modes and did not occur in the Asynch mode. There were no interactions with Trials or Experience.

Supervisor-only Transcript. A similar interaction between Communication Mode and Sentence Type, $X^2(4) = 37.8, p < .05$ was found in the Supervisor-only transcripts. Again, most Supervisor-only sentences were Complete, as Figure 11 shows.

Style Variables

Style dependent variables were the proportion of Declarative, Question, Unfinished, and Interrupted sentences.

Total Transcript. The proportion of each Style depended on the Communication Mode, $X^2(6) = 128.2, p < .05$, as Figure 12 shows. As expected, the proportions for FTF and Synch+V were similar, and both were different from Asynch. There were no interactions with Trials or Experience on any of the measures.

Supervisor-only Transcript. For the Supervisor, Experience interacted with Style, $X^2(3) = 11.7, p = .009$. Supervisors of Type A triads made more statements and asked fewer questions than did Supervisors of Type B triads. See Figure 13. The proportions of any given Style also depended on Communication Mode, $X^2(6) = 107.9, p < .001$. See Figure 14. As predicted, the Asynch mode was least like the other two modes.

Content Code Variables

The Total Transcript codes were A, C, CR, F, GI, NTO, P, PO, TO, TS, and U (see page 10 for definitions). The Supervisor-only codes were FA, G, and I.

Total Transcript. There tended to be more codes associated with Trial 1 than with Trial 2, but the amount depended on a given code, $X^2(10) = 25.2, p = 0.005$. See Table 1. The amount of codes for Experienced triads remained constant across trials while the partially experienced triads had fewer codes in Trial 2 than in Trial 1, $X^2(1) = 43.6, p < 0.05$. The amount of codes in each trial also depended on Communication Mode, $X^2(2) = 65.2$, $p < 0.05$. There were fewer codes in FTF, Trial 2 than in FTF, Trial 1. The number of codes in Trials 1 and 2 in Synch+V and in Asynch were approximately equal. The transcripts of Experienced triads differed from partially experienced triads in the types of different codes that were seen in the transcript, $X^2(10) = 49.8, p < 0.05$. See Table 1. The largest difference in code usage, for both triads, was in the FTF mode, $X^2(2) = 13.3, p = 0.001$. Finally, the presence of a particular code depended on Communication Mode, $X^2(20) = 290.5, p < 0.05$, as shown in Table 1. See Appendix F for exact values.

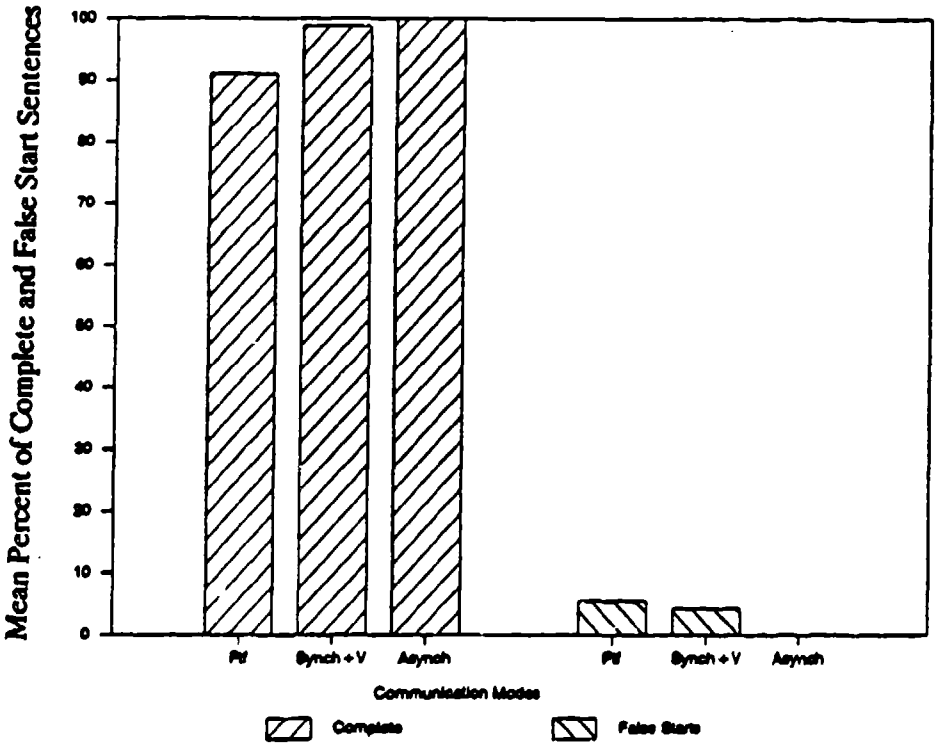



Figure 10. Mean percent of complete and false start sentences by communication modes.

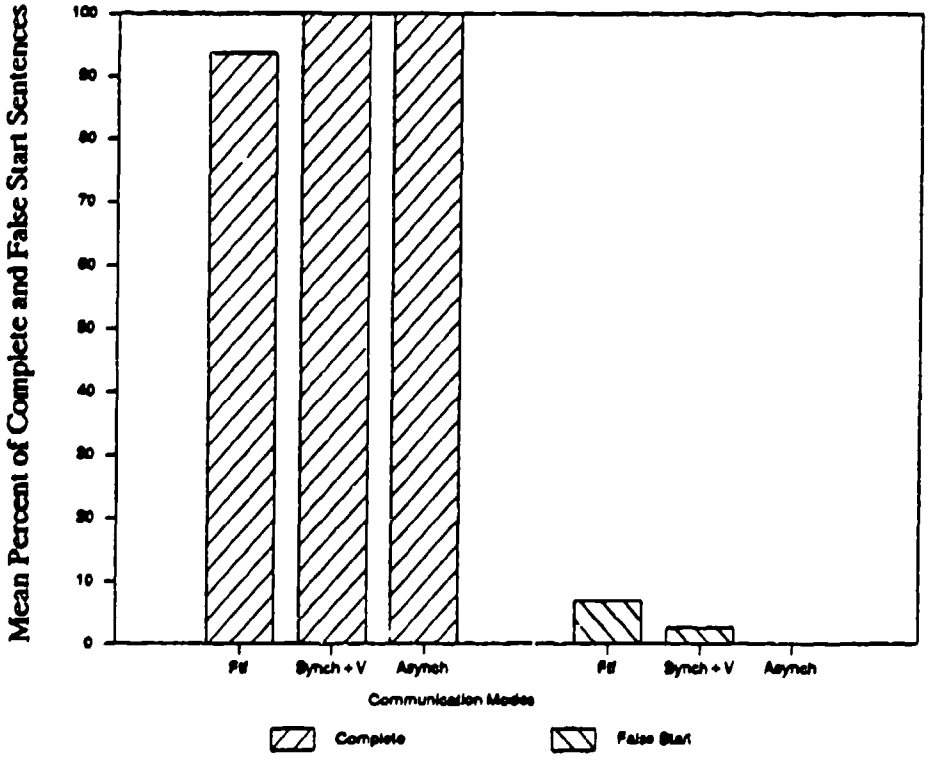



Figure 11. Mean percent of complete and false start sentences for supervisor-only transcripts, by communication modes.

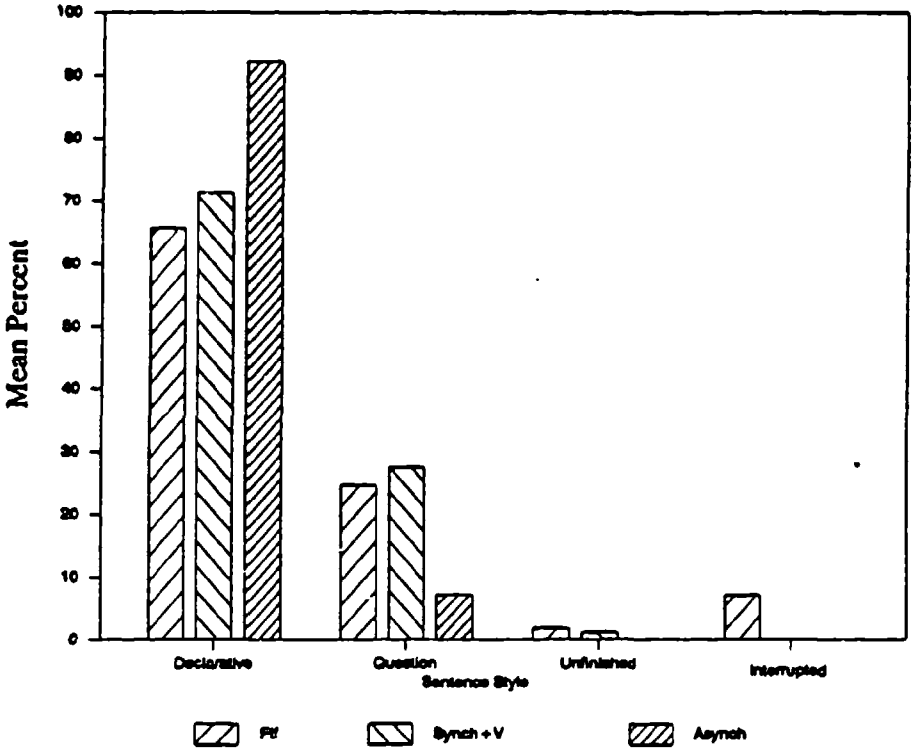



Figure 12. Mean percent of declarative, question, unfinished, and interrupted sentences, by communication modes.

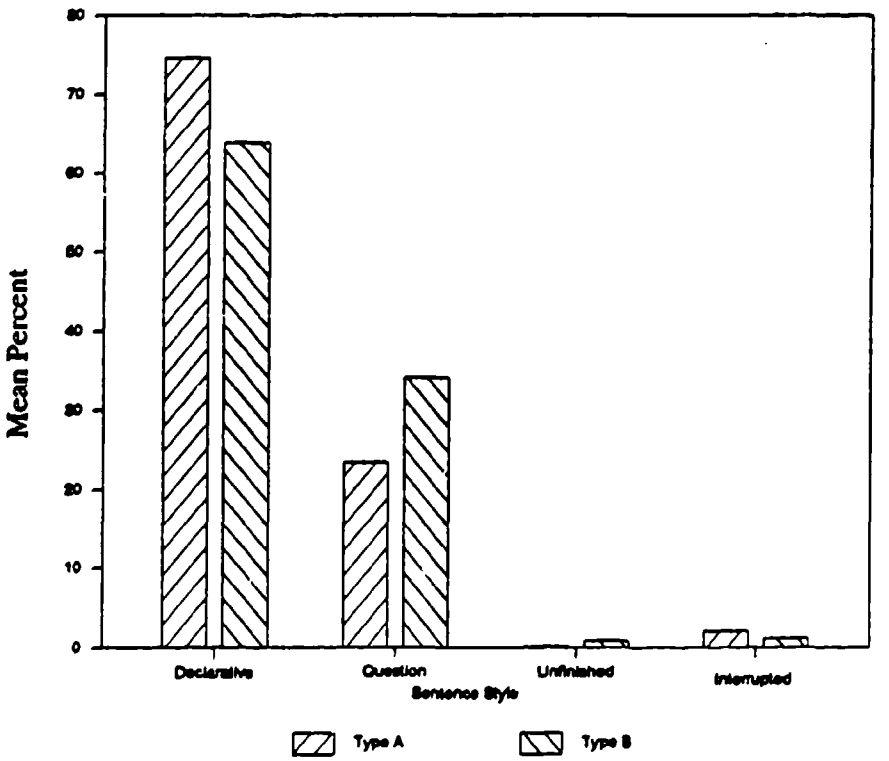



Figure 13. Mean percent of declarative, question, unfinished, and interrupted sentences, by experience, for supervisor-only transcripts.

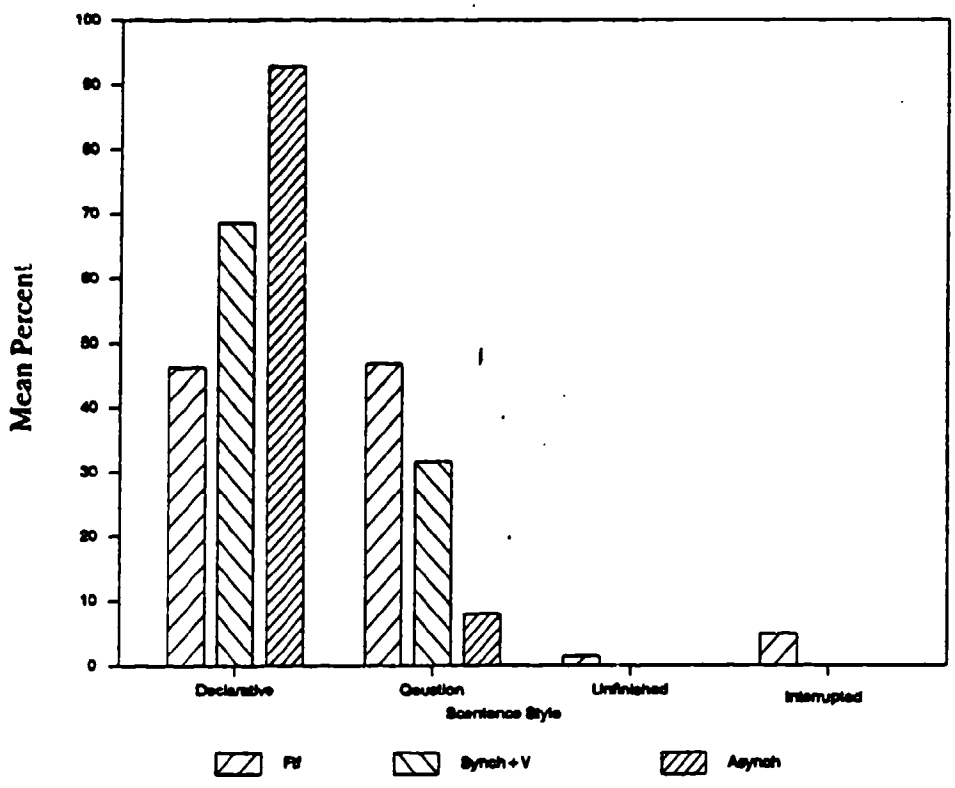



Figure14. Mean percent of declarative, question, unfinished, and interrupted sentences, by communication modes, for supervisor-only transcripts.

Table 1
Total Transcript Content Codes by Trial, Experience, and Communication Modes (Percentage of Occurrence)

| | Content Code | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | C | CR | F | GI | NTO | P | PO | TO | TS | U |
| Trials | | | | | | | | | | | |
| 1 | 1.49 | 1.04 | 1.08 | 3.17 | 6.17 | .57 | 4.05 | .32 | 18.27 | 21.37 | .85 |
| 2 | 1.90 | 1.17 | .95 | 1.99 | 3.48 | .09 | 3.13 | .28 | 12.95 | 15.10 | .57 |
| Experience Type | | | | | | | | | | | |
| A | 1.65 | 1.36 | .89 | 1.99 | 5.41 | .57 | 3.07 | .38 | 13.01 | 17.06 | .82 |
| B | 1.74 | .85 | 1.14 | 3.17 | 4.24 | .09 | 4.12 | .22 | 18.20 | 19.40 | .60 |
| Communication Modes | | | | | | | | | | | |
| FTF | .66 | 1.11 | .85 | 4.02 | 6.55 | .63 | 2.28 | .09 | 19.56 | 18.42 | 1.11 |
| S+V | 1.77 | 1.08 | 1.04 | 1.14 | 2.91 | .03 | 3.45 | .28 | 8.99 | 12.88 | .22 |
| Asy | .95 | .03 | .13 | .00 | .19 | .00 | 1.46 | .22 | 2.66 | 5.16 | .09 |

A = abbreviation, C = confusion, CR = computer related, F = feedback, GI = general information, NTO = non-task oriented, P = processing, PO = polite, TO = task oriented, TS = task specific, U = uninhibited.

The trend during the second trials, as shown by content codes, was a sharpened focus on the task at hand, and less discussion by the participants. The codes showing decreasing usage: CR, F, GI, NTO, P, TO, TS, and U; indicate that there was less general and non-task oriented discussion, less discussion and instruction on the task and the process, and a decrease in automatic responses (feedback) to the partner or supervisor. The use of more abbreviations (A) indicates an attempt to speed communications. Likewise the increase in confusion (C) may be attributable to shortened communications and less discussion. However, comparison of codes of interest were not statistically significant.

Comparing experienced triads (Type A) to partially experienced triads (Type B), most of the indicators are as expected. More discussion of the task and the process by Type B triads is shown by the increased number of computer related (CR), feedback (F), process (P), task oriented (TO), and task specific (TS) codes. The greater familiarity with the task by the Type A triads is indicated by the increase in general information (GI) and non-task oriented (NTO) codes. The above differences, when testing individual codes, were not statistically significant.

Comparison of the modes indicates the difficulty of communicating in the Asynch mode. Fewer codes of all types, except polite (PO), indicate that the communication difficulty reduces the attempts at communication and that most communications are focused to the task at hand. Specific mode comparisons, based on the individual codes are shown below:

| Mode Comparison | Code | Statistics | Preponderance |
|---|---|---|---|
| FTF vs. Synch+V | A | $F(1,9)=28.1, p < 0.001$ | Synch+V |
| | F | $F(1,9)=14.7, p = 0.004$ | FTF |
| | GI | $F(1,9)= 7.6, p = 0.022$ | FTF |
| | U | $F(1,9)=14.7, p = 0.004$ | FTF |
| FTF vs. Asynch | CR | $F(1,9)=10.8, p = 0.009$ | FTF |
| | F | $F(1,9)=28.9, p < 0.001$ | FTF |
| | GI | $F(1,9)=22.9, p = 0.001$ | FTF |
| | TO | $F(1,9)=18.3, p = 0.002$ | FTF |
| | U | $F(1,9)=19.3, p = 0.002$ | FTF |
| Synch+V vs. Asynch | A | $F(1,9)=16.9, p = 0.003$ | Synch+V |
| | CR | $F(1,9)=16.0, p = 0.003$ | Synch+V |
| | P | $F(1,9)=11.2, p = 0.009$ | Synch+V |
| | TS | $F(1,9)= 5.4, p = 0.046$ | Synch+V |

A=abbreviation, F=feedback, GI=general information, U=uninhibited language, CR=computer related, TO=task oriented, P=processing, TS=task specific

Supervisor-only Transcript. The types of codes used by the supervisors depended on the Communication Mode, $X^2(4) = 40.2, p < .05$. As expected, the FTF and Synch+V modes were similar, and were distinct from the Asynch mode. See Table 2 and Figure 15. The Experience by Content Code and the Experience by Communication Modes interactions were not significant. See Appendix F for exact values.

Table 2
Supervisor-only Content Codes by Experience and Communication Modes
(Percentage of occurrence)

| | Content Code | | |
|---|---|---|---|
| | FA | G | I |
| Experience Type | | | |
| A | 2.75 | 21.98 | 15.93 |
| B | 1.10 | 27.47 | 30.77 |
| Communication Modes | | | |
| FTF | .55 | 30.22 | 32.42 |
| S+V | .55 | 15.38 | 12.64 |
| Asy | 2.75 | 3.85 | 1.65 |

The supervisors interacted with the triad types as expected. More guidance (G) was provided to the Type B triads, and more attempts at gleaning information (I) from the Type B triads was observed. Since the supervisor had a tendency to work with the Type B triad as opposed to waiting on a solution to be proposed, as with the Type A triads, more instances of formal approval (FA) were observed for the Type A triads. These comparisons were not statistically significant.

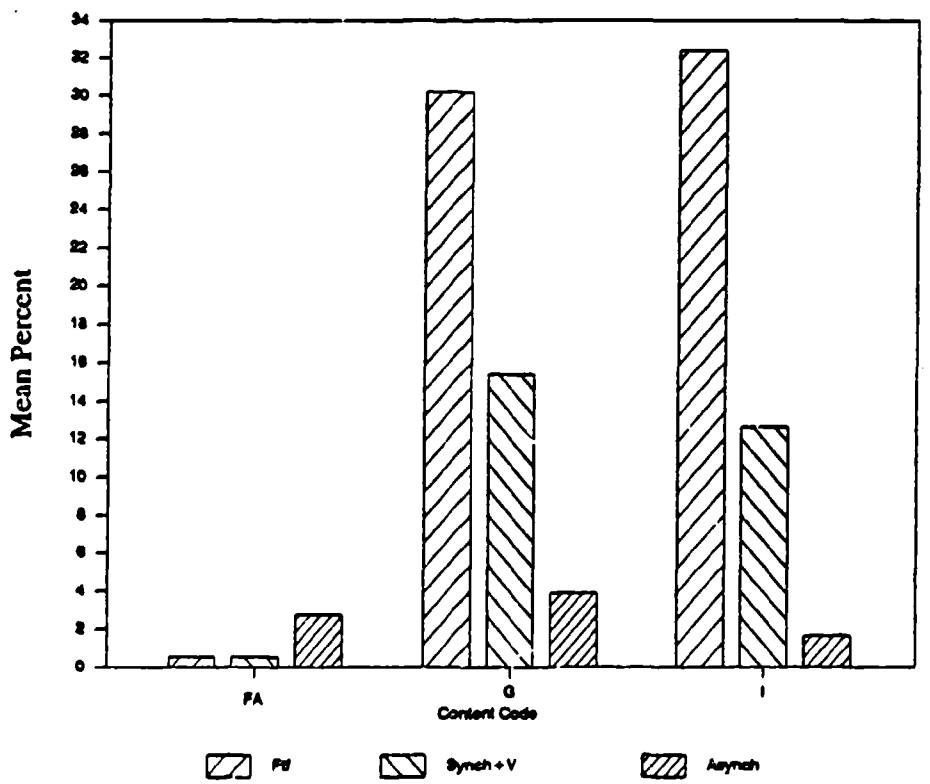



Figure 15. Mean percent of formal approval, guidance, and information seeking codes, by communication modes.

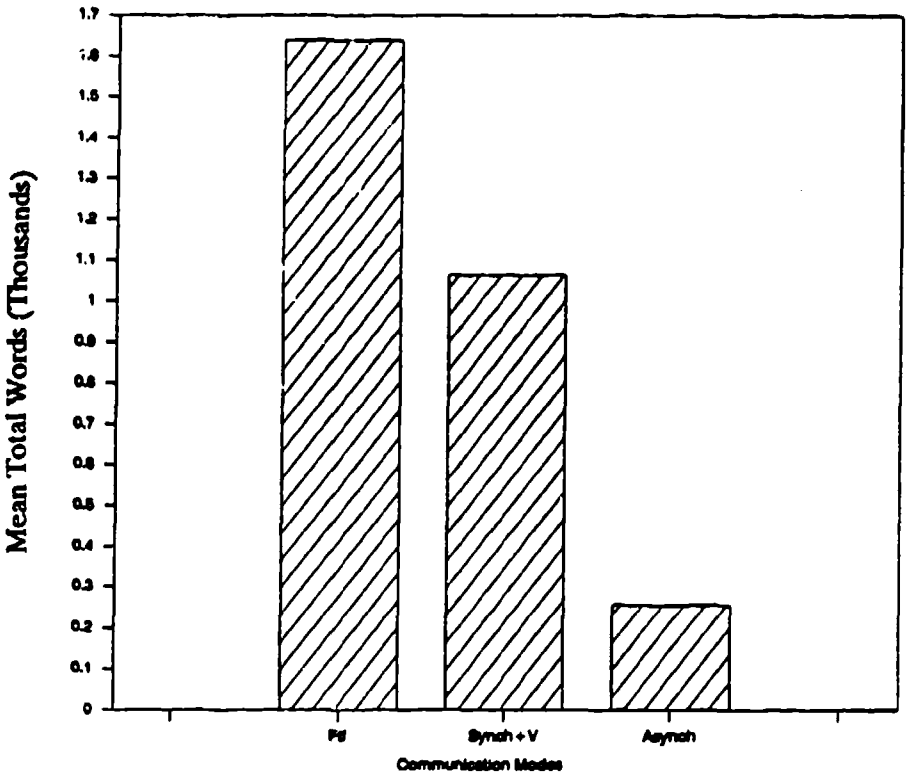



Figure 16. Mean number of total words by communication modes.

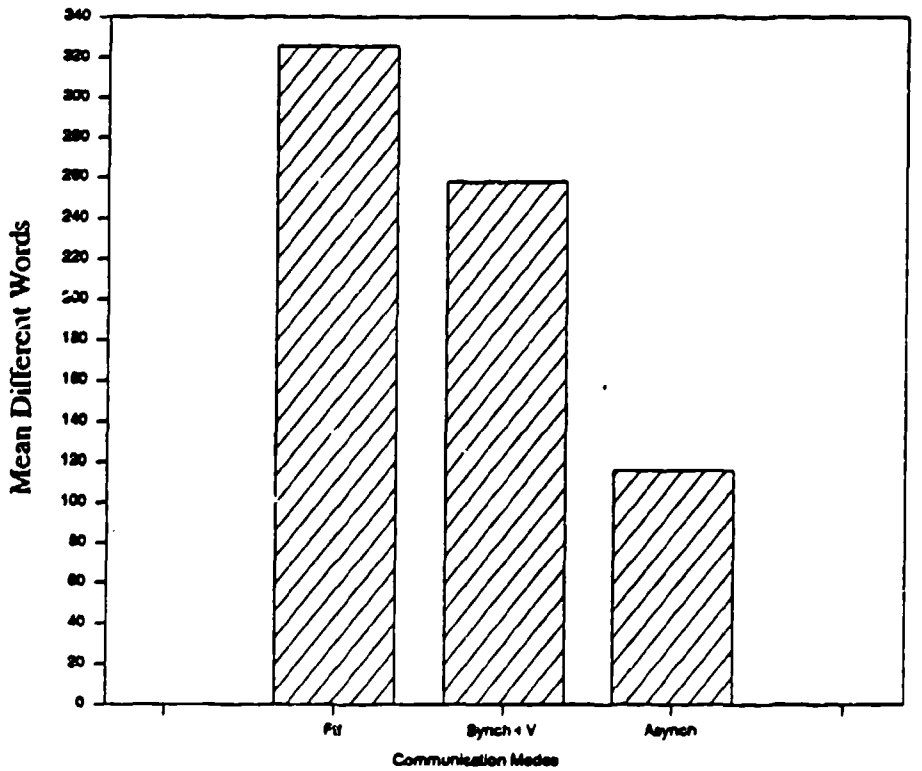



Figure 17. Mean number of different words by communication modes.

With the exception of formal approval (FA), the Asynch mode had less codes of all types. This is an indication of fewer communications. Formal approval (FA) was a convenient way for the supervisor to end the task in the Asynch mode. Specific mode comparisons, based on the individual codes are shown below:

| Mode Comparison | Code | Statistics | Preponderance |
|---|---|---|---|
| FTF vs. Synch+V | G | $F(1,9) = 34.2, p = 0.010$ | FTF |
| FTF vs. Asynch | FA | $F(1,9) = 11.5, p = 0.043$ | Asynch |
| | G | $F(1,9) = 110.4, p = 0.002$ | FTF |
| Synch+V vs. Asynch | G | $F(1,9) = 21.7, p = 0.019$ | Synch+V |

Word Variables

As expected, the total number of words was much higher in the FTF mode than in the Asynch mode, $F(2,4) = 8.5, p = .037$, and there were more different words used in the FTF mode than in the Asynch mode, $F(2,4) = 8.6, p = .036$, see Figures 16 and 17, respectively. No differences were attributed to the Trials or Experience factor.

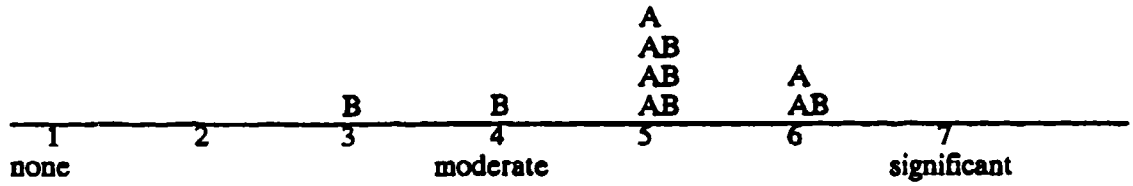
Post-Experiment Questionnaire Analysis

Data were also collected in the form of a questionnaire completed by the participants after completing the last laboratory session. This information is presented below. The participants provided a subjective evaluation of the supervisor's performance and the supervisor's effect on the team performance. They also rated the supervisor's effectiveness in each mode of communication. There were three response categories: Supervisor performance and effectiveness, Supervisor interaction, and Supervisor style. These are shown in Tables 3, 4, and 5 respectively.

Table 3

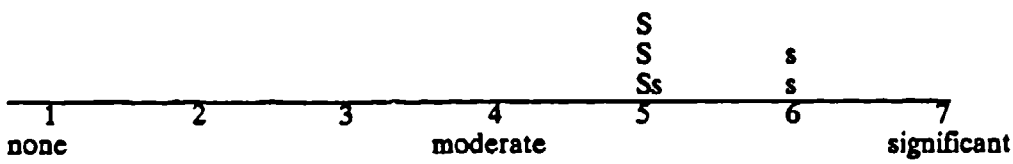
Questionnaire Responses Relating to Supervisor Performance and Effectiveness

"Supervisor effect on solution quality"




N = 12
A = Team member of experienced team; distribution statistic mode = 5
B = Team member of partially experienced team; distribution statistic mode = 5

"Supervisor effect on solution quality"




N = 6
S = Supervisor of experienced team; distribution statistic mode = 5
s = Supervisor of partially-experienced team; distribution statistic mode = 6

"Attempted to reach a better solution because of the supervisor"

| | |
|---|---|
| Ba | |
| Ba | |
| Ba Bb | Bb |
| Aa Bb | Ab |
| Aa Ab | Aa Ab |
| YES | NO |

N = 12 (supervisors did not answer)
Aa = Type A, team member a
Ba = Type B, team member a
Ab = Type A, team member b
Bb = Type B, team member b

"Perceived Supervisor effectiveness in each Communication Mode"

| | | | |
|---|---|---|---|
| | Mt | | |
| Lt | Mt | | |
| Lt | Mt | | |
| Lt | Mt | | |
| Lt | Mt | | N = 24 |
| Lt | Mt | | |
| Lt | Mt | | L = least effective, |
| Lt | Mt | Lt | M = most effective, |
| Lt | Mt | Lt Mt | t = rated by team member |
| Lt | Mt | Lt Mt | |
| Asynch | Synch+V | FTF | |
| L=9 | M=10 | L=3 M=2 | |

Table 3 - (Cont'd)

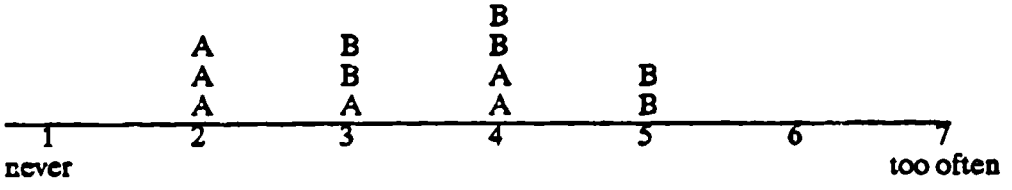
"Perceived Supervisor effectiveness in each Communication Mode"

| | | | |
|---|---|---|---|
| Ls | | | N = 12 |
| Ls | Ms | | L = least effective, |
| Ls | Ms | Ms | M = most effective, |
| Ls | Ms | Ms | s = rated by supervisor |
| Ls | Ms | Ls | |
| Asynch | Synch+V | FTF | |
| L=5 | M=4 | L=1 M=2 | |

Table 4

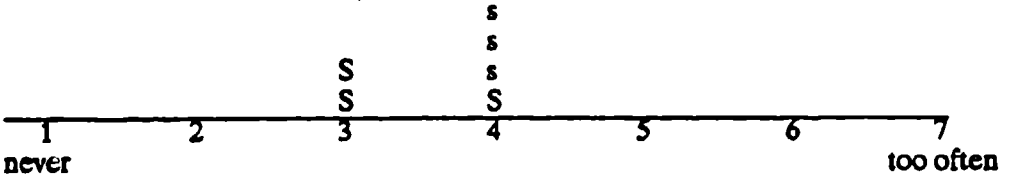
Questionnaire Responses Relating to Supervisor Interaction

"Supervisor interrupted"




N = 12
A = Team member of experienced team; distribution statistic mode = 2
B = Team member of partially experienced team; distribution statistic mode = 3, 4, 5

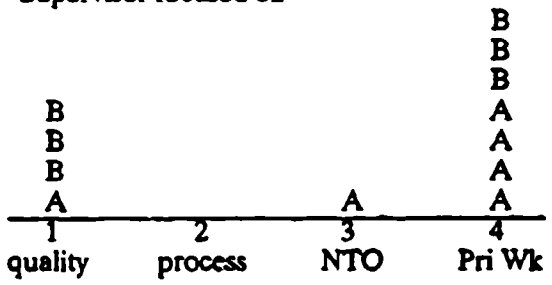
"Supervisor interrupted"




N = 6
S = Supervisor of experienced team; distribution statistic mode = 3
s = Supervisor of partially-experienced team; distribution statistic mode = 4

Table 4 - (Cont'd)

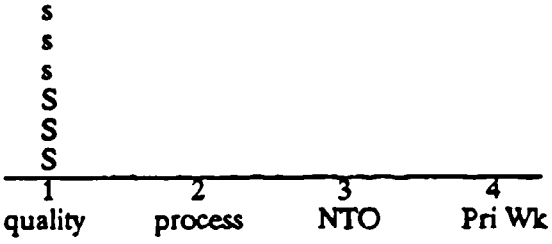
"Supervisor focused on"




NTO = non-task items, Pri Wk = priority work

N = 12
A = Team member of experienced team; distribution statistic mode = 4
B = Team member of partially experienced team; distribution statistic mode = 1, 4

"Supervisor focused on"



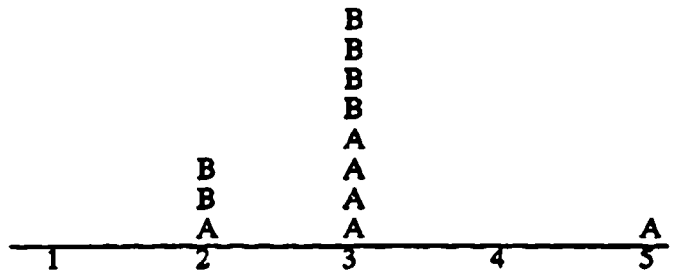

NTO = non-task items, Pri Wk = priority work

N = 6
S = Supervisor of experienced team; distribution statistic mode = 1
s = Supervisor of partially-experienced team; distribution statistic mode = 1

Table 5

Questionnaire Responses Relating to Supervisor Style

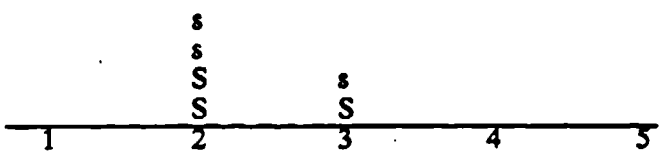
"Style of Supervisor Interaction"




N = 12
A = Team member of experienced team; distribution statistic mode = 3
B = Team member of partially experienced team; distribution statistic mode = 3

Scale:
1 = Supervisor always told members what to do, even if not asked.
2 = Supervisor told members what to do, but did not interrupt unnecessarily.
3 = Supervisor responded to team's questions and offered guidance as necessary.
4 = Supervisor provided direction only when asked by a team member.
5 = Supervisor hardly ever offered guidance/direction other than Priority Work.

"Style of Supervisor Interaction"




N = 6
S = Supervisor of experienced team; distribution statistic mode = 2
s = Supervisor of partially-experienced team; distribution statistic mode = 2

Scale:
1 = Supervisor always told members what to do, even if not asked.
2 = Supervisor told members what to do, but did not interrupt unnecessarily.
3 = Supervisor responded to team's questions and offered guidance as necessary.
4 = Supervisor provided direction only when asked by a team member.
5 = Supervisor hardly ever offered guidance/direction other than Priority Work.

Experienced triads indicated that the supervisor had an effect on the quality of the solution, but triads were divided as to the efficacy of the supervisor. Not surprisingly the supervisor was thought to be the least effective in the Asynch mode. It is interesting that the supervisor was rated less effective in FTF than in Synch+V (where transcripts indicated a greater interaction with the team members in FTF), yet was rated most effective in Synch+V which doesn't appear to differ from FTF in quality of solution or performance times. There is an appreciable difference in the perceived focus of the supervisor's interaction when comparing supervisor's versus team member's perceptions in the graph on Supervisor Focus in Table 3. It appears that the team members and the supervisors were not overly critical of the supervisor's style in interacting with the teams.

## DISCUSSION

This section highlights the performance of the teams based on the communication mode and details the supervisory function based on communication mode and team experience.

Communication Mode

Face-to-Face (FTF). As in the dyad experiment (Linville, et al., 1989), the face-to-face mode appeared to offer an environment that was conducive to solving the task. The team members had immediate access to each other and to the supervisor, and immediate feedback was provided to all queries. Non-verbal cues and responses were observed during task accomplishment. However, the supervisor tended to "join" the team in the face-to-face mode. That is he tended to work the problem along with the imbedded dyad. As time progressed, all three members were involved in primary task accomplishment. Rather than a supervisor-and-team environment, a three member team evolved.

Supervisor ending time is an indication of the amount of interaction the supervisor had with the team during task accomplishment time. The shortest supervisor ending times were observed in the FTF mode. Shorter supervisor ending times indicate that the supervisor worked the problem with the imbedded dyad. Rather than allowing the team members to arrive independently at a solution, and present the supervisor the solution for review, modification, and approval, the supervisors worked directly on the task with the team members. This task did not necessarily suffer because of the supervisors close interaction; however, it does indicate that supervisors may not be able to insulate themselves to the extent necessary to allow work on other tasks and to allow them to remain objective.

Synchronous + Voice (SYNCH+V). There were no significant performance differences between FTF and SYNCH+V. The supervisor and the team members were able to exchange information in real time and the supervisor was able to influence the task in real time. The availability of a voice channel allowed the supervisor to expect immediate responses to any queries or guidance. Responses to the team members and the supervisor were immediate. The imbedded dyads and the supervisors indicated that this mode was most conducive to effective supervision. It was observed that the supervisors allowed the imbedded dyad to solve the task without undue interference. The supervisors could see the task graphic on his monitor and could observe the actions of the team members as well as monitor their conversations. The supervisors did not "join" the team in this mode. They did monitor the status of the task, provide guidance in a succinct manner, question the team members as to alternatives, and provide approval of the final product.

The increased supervisor ending time indicates that many of the interactions by the supervisor occurred after the team had reached an agreed upon route. This mode allowed supervisors to remain aware of the task without being distracted from other duties, and provided an environment that permitted them to deliberate without being pressured by the proximity of the other team members.

Asynchronous (ASYNCH). The time-sensitive measures (Route ID Time, Route Agreement Time, and Supervisor Ending Time) increased significantly for this mode. The other measures, Route Score and Other Work, were not significantly different. Time increased due to the relative slow communications provided to the team members. It was indicated that the supervisor was the least effective in this mode. The team members and the super-

visors reported that this was because the supervisors did not feel that they could affect the solution in a timely manner and that any improvements that might be proposed to the route would be outweighed by the additional time required to initiate and finalize the change. Almost all task interaction by the supervisor took place after the imbedded dyad had agreed upon a solution and had presented it to the supervisor for approval.

Team Experience

Type A Triads vs Type B Triads. Half of the triads were previously experienced in the task (Type A) but had not worked as a team before. Half of the triads (Type B) had previously experienced supervisors and inexperienced team members who underwent the standard pre-task training. This team experience difference did not yield an apparent difference in the supervisory task. Type A triads' performance was not significantly different than Type B triads' performance. However, the way the supervisors interacted with the teams was different. The supervisors that worked with the Type A teams allowed the imbedded team the opportunity to solve the task without interference. On the other hand supervisors with the Type B teams were observed to become more involved with the mechanics of solving the task. This was especially true during the first trial of the FTF mode. The type of transactions or conversations also indicates that the supervisors felt it was necessary to "help" the Type B teams. An actual statement of formal approval was provided by the supervisor to the experienced teams more often than to the inexperienced teams. This indicates that the supervisor performed his functions at the end of the imbedded dyads' effort, for Type A teams, and not during task accomplishment. The transactions that indicated that the supervisor was seeking information and providing guidance occurred more often with the Type B teams than with the Type A teams.

Group Effects

Leadership. A leader or supervisor was designated for this task. At no time was it observed that their status was in danger of being ignored or usurped by one of the other participants. The FTF mode may have eroded the supervisory position because of proximity, but did not cause any particular loss of status. The style of leadership varied primarily because of the communication mode rather than group effects. In the FTF mode the necessary division of duties between the imbedded dyad and supervisor suffered. The leaders did not allow the team to perform the task, rather they became part of the team. In the SYNCH+V mode the separation was easily maintained, and the supervisor had an environment that allowed deliberation, insulation, and the means for timely interaction, and presumably the opportunity to perform additional duties. In the ASYNCH mode, the time delay and the difficulty of communications did not allow the supervisor to make timely suggestions or to effect the task or process in real time.

Media Variables

Memory available in Computer-Mediated Communication. The capability of the computer to store data and to remember previous actions was available to assist the supervisors in the ASYNCH mode. They were able to piece together the previous actions and compare previously proposed alternatives. But the slow communication speed did not allow interaction with the team members in a timely fashion.

Communication Efficiency. The combination of graphic and voice communications in the synchronous mode allowed the supervisor to monitor the activity graphically and to hear the discussions that took place between the team members. Synchronous voice communica-

tions were more succinct and more task oriented than FTF voice communications. Graphic communications (pointing on map, marking of obstacles and bridges, highlighting of alternative routes, and so forth) in the synchronous and the asynchronous modes were task oriented, and normally easily understood.

Synchronous versus Asynchronous Communication. Based on previous experience with the synchronous and asynchronous modes (Linville, et al., 1989), it was hypothesized that the synchronous mode would offer the most advantages to the supervisor, and that the advantages offered by the asynchronous mode (data storage and retrieval, and time for deliberation as well as deliberate exchange of information), would be outweighed by the perceived disadvantages of the longer communication times. The results of this study support those hypotheses. In the synchronous mode the supervisor had the opportunity to make independent decisions and were able to affect task accomplishment in real time. They also had the advantage of interacting by voice, thereby retaining additional control and authority. In the asynchronous mode the difficulty of communications apparently outweighed potential advantages inherent in the mode.

# CONCLUSIONS

As with the previous dyad study, it was found that performance differences, both time and quality of solution, were negligible when comparing the face-to-face mode to the synchronous with voice mode. If an auxiliary voice channel is available, it appears that little is lost in team performance when transitioning from a face-to-face environment to computer-mediated communications. However, there were notable differences in task accomplishment times, but not in solution quality, from these two modes to the asynchronous mode. The existence or nonexistence of a voice communication channel, or other real time communication means, appears to be most responsible for performance differences rather than separation or computer-mediation. The communication time delay in the asynchronous mode may be an important design consideration for future C2 work stations and problem solving procedures.

The ability of a supervisor to interact with team members was not adversely affected by separation or computer-mediation when a voice channel was available. In fact computer-mediated communications, with an auxiliary voice channel or other real time communication means, may have certain advantages for the supervisor. The supervisors were most comfortable and most effective while separated from the team members, if an auxiliary voice channel and a remote screen showing the task activities were available. However his ability to interact with team members was adversely effected in the asynchronous mode. The supervisor was not able to monitor the task or to provide supervision in real time. The role of the supervisor may be an important design consideration for future C2 work stations and problem solving procedures.

The lethality of the battlefield increases the desirability of dispersion, from a survivability standpoint. The benefits of computer aiding, shared graphics, shared data bases, and two-way graphic communications have the potential of creating an environment that accommodates distribution of function and dispersion of assets. Just as important is the possibility of expanding the commander's sphere of influence by allowing supervision to take place from remote or distributed locations. The role of the supervisor and the task being performed must also be considered by the system designer. If the task they are to supervise is time-critical and requires real-time monitoring, decisions, and possible intervention; the system must provide for real time communications, voice or otherwise. However if the task is more routine and not time critical, the need for real time communication capability *may* be negated.

Based on the present and anticipated future demands on communication systems and the difficulty associated with the synchronization of individual work schedules, asynchronous communications would be the most desirable technological solution to distribution and computer-mediated communications. The present asynchronous systems communicate slowly and negatively impact computer sharing. The negative attributes of asynchronous contributed heavily to the poor performance, based on time, and the difficulty of supervisor interaction, in this study. An asynchronous system could support performance as well as other modes if it accommodates built-in task-specific activities, routine "work", message waiting "alerts", access to numerous data bases, and access to several communication nets serving numerous remote locations. Further research in the asynchronous mode needs to be done to determine if acceptable performance levels can be achieved through the application of a technology that allows multi-tasking capabilities, windowing, faster communication rates, multiple communication net access, automatic queuing of outgoing messages, and a means of allowing more timely access of key messages and information.

Because synchronous systems place heavy demands on communications channels, investigation of a voiceless condition should be pursued. One approach is to use a graphics communication language. A graphics language may decrease or possibly eliminate the need for auxiliary voice or text communications. This language must focus on dialogue for all command and staff tasks. It is hypothesized that a graphics communication language could eliminate the need for an auxiliary voice channel and would eliminate the need for textual communications that augment task activities or instructions. A limited examination of the effectiveness of graphic communications has been started.

It is also technically possible to store voice message in digital form and replay them at a later time at a distributed site. There are obvious advantages and disadvantages to both graphical language and digitized voice replay (e.g. the former is standard compact, easily tied to a location, and requires a smaller band width, but fairly inflexible; while voice replay is time or sequence oriented, and more flexible, but perishable). Digitized voice is another technology worthy of investigation.

Based on present studies, initial expectations for distributed C2 with computer-mediated communications are quite high for task activities similar to that used for this study; however, the applicability to the more global world of staff tasks must be investigated. There are limitations that must be addressed when projecting from the current planning task, with its commonality with other planning tasks, to other operational execution tasks.

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# APPENDIX A

# LABORATORY LAYOUT AND DESCRIPTION OF HARDWARE AND SOFTWARE

## HARDWARE AND SOFTWARE* USED FOR THE EXPERIMENTAL LABORATORY

The lab, as presently configured, consists of four IBM and Compaq personal computers running off the shelf and locally developed software to provide capabilities in communications, graphics presentations, textual exchange of information and the necessary cueing and event highlighting. The focus of the current lab allows experimental subjects to accomplish a military staff task, that requires coordination, collaboration, and supervision from separated (distributed) locations.

**The application software presently being used consists of:**

- Insynch Ver 2.0,
- Sidekick Ver 2.0,
- Superkey Ver 1.16A,
- Cross Talk XVI
- PC-DOS 3.2.

**Software developed by the experimenter provides for:**

- Data collection, data entry, and creation of time logs,
- Configuration files,
- Setup batch files,
- 9 task specific map sets (originally created using PC Paint, presently loaded with INSYNCH software).

**The hardware configuration presently being used consists of:**

Three IBM PC II with:

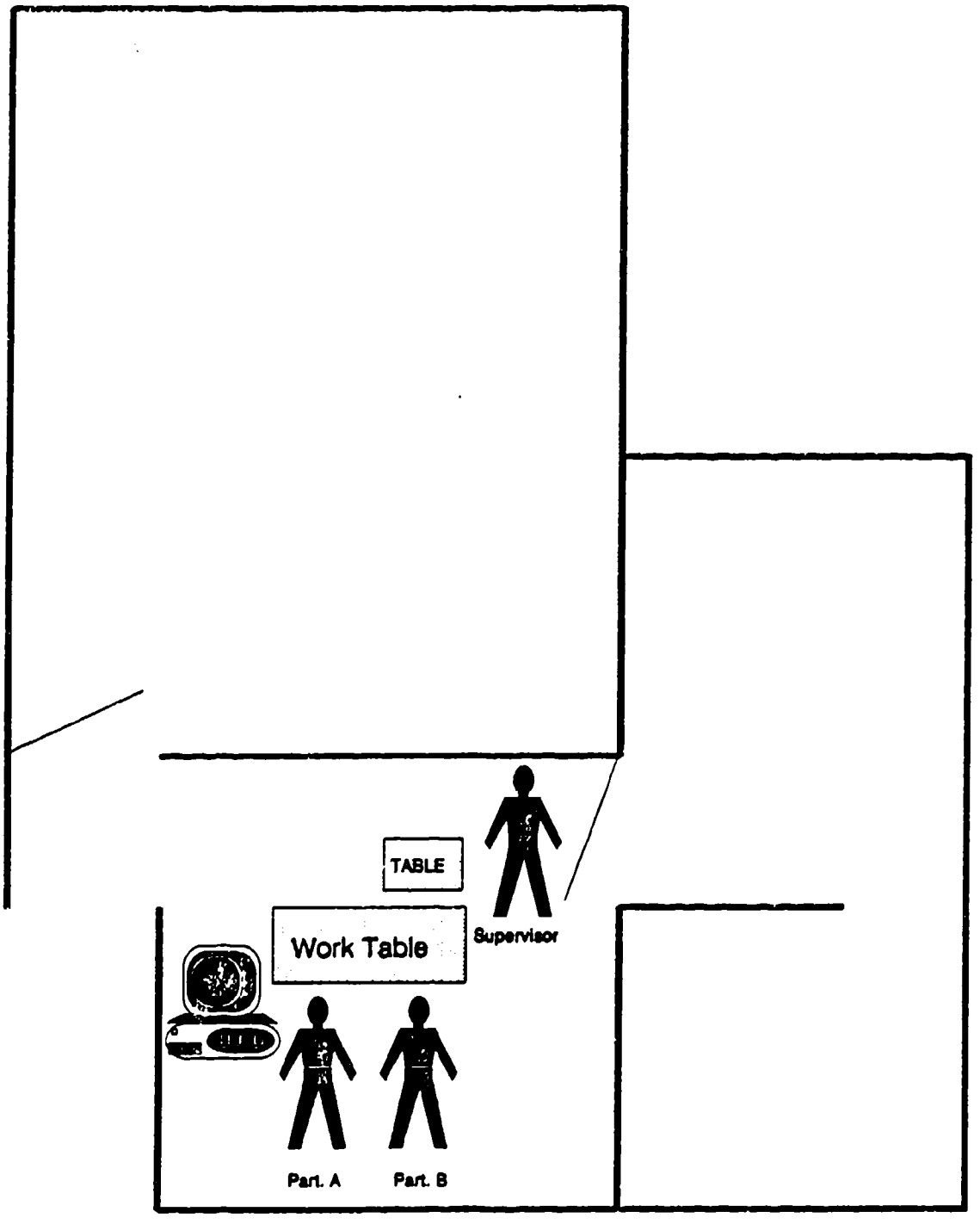
- 640 Kb,
- CGA graphic display,
- 360 Kb floppy drive. (1 machine has two drives),
- 20 Mb hard drive,
- 2 serial ports,
- 1 parallel port,
- Epson graphics printer,
- Hayes 1200 external modem,
- Microsoft Mouse,
- Two position data selector. (Modem or Insynch Cable),

- 3 foot male to male RS-232 cable,
- 3 foot male to female RS-232 cable,
- Crossed male to male RS-232 cables for Insynch.

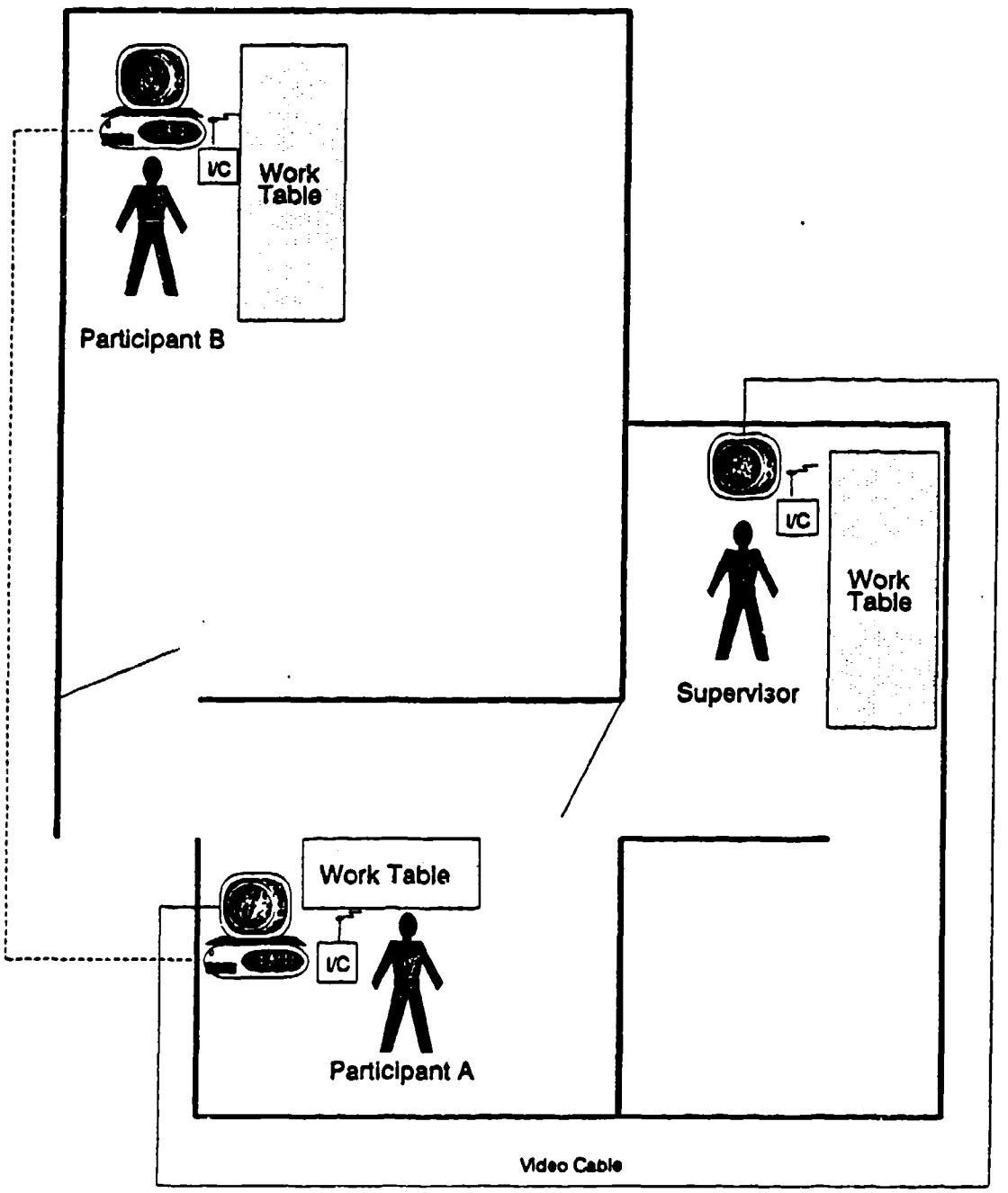
One Compaq portable PC with:

- 256 Kb,
- 2 360 Kb floppy drives,
- Internal 1200 baud modem.

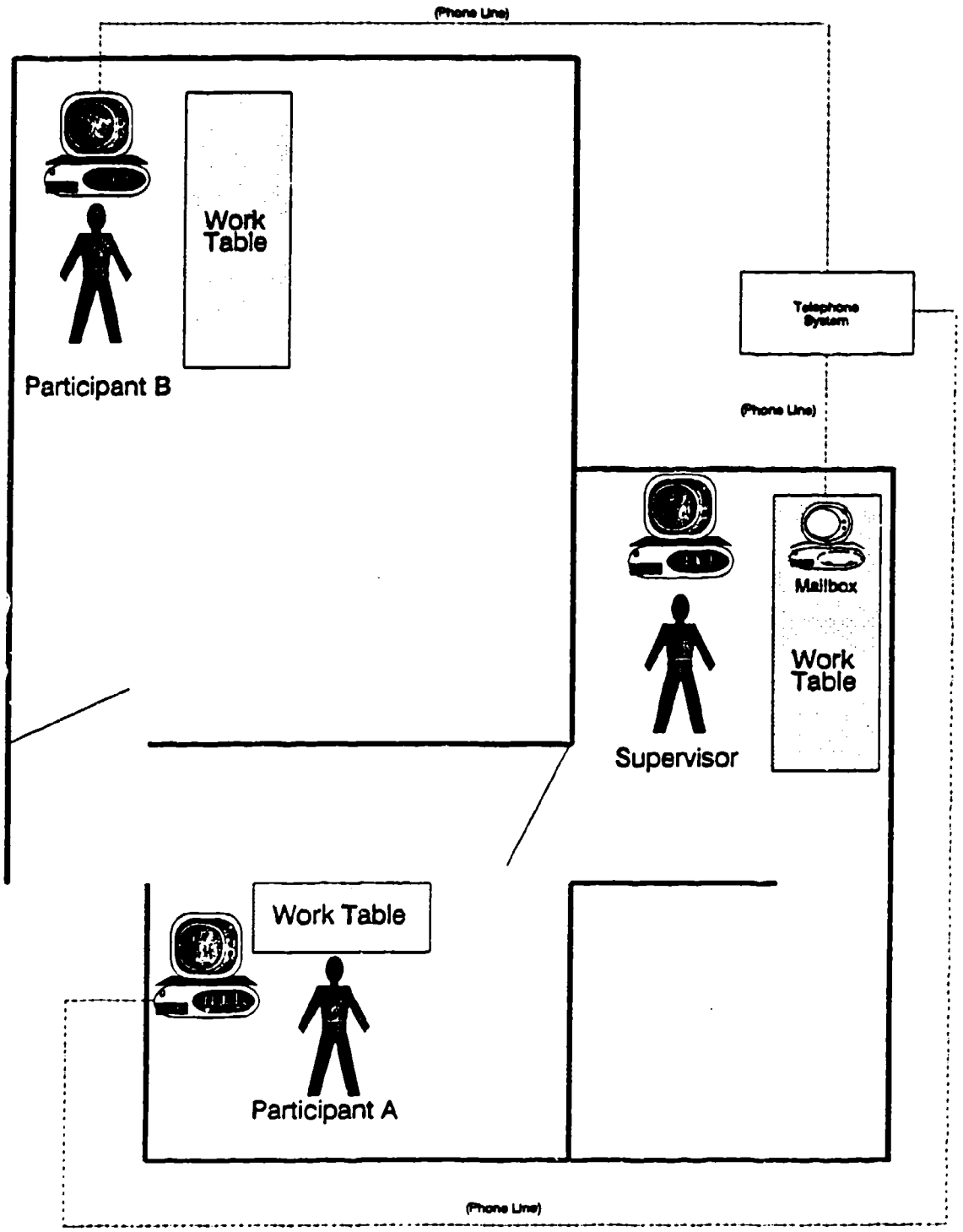
* Use of this hardware and software does not constitute an endorsement by the U.S. Army.




LABORATORY LAYOUT FOR FACE-TO-FACE - TRIAD




LABORATORY LAYOUT FOR SYNCHRONOUS WITH VOICE - TRIAD




LABORATORY LAYOUT FOR ASYNCHRONOUS MODE - TRIAD

## APPENDIX B

## BRIEF GUIDE TO IN-SYNCH SOFTWARE*

In-synch is a memory-resident program that connects two IBM PCs or IBM compatibles together, similar to most communication software. The difference is that In-synch also ties the keyboards together so that a key struck on one machine will cause an identical response on the other terminal. The machines respond as one, though working separately. In-synch requires a machine with at least 384 Kb and each machine in a conference set up must have a different copy (different serial number) of In-synch. A brief description of In-synch features follows:

### STARTING IN-SYNCH

In-synch is loaded into memory at all times and is activated by pressing the shift-ctrl keys simultaneously.

### ENDING IN-SYNCH

The In-synch menus include an option for end conference. This will hang up the phone. The system will then return to the In-synch Master Menu (or return to the last DOS operation if running an applications program within In-synch).

### HELP

Help will bring up a new screen that has a short description of all the options on the menu presently being displayed. To activate Help press F1.

### DIRECT - INDIRECT CALLS

Direct calling-- In-synch will dial the phone, make a connect, and pass ID information. Indirect calling-- In-synch will only convert an existing voice line to data and pass ID information.

### CONVERSION FROM VOICE-DATA OR DATA-VOICE COMMUNICATIONS

This feature allows converting data link to voice so that users can talk over phone line. F2 function key will start the procedure and the system will prompt for all steps. When ready to continue conferencing, any key strike will return phone line to a data line.

### LOCAL/IN-SYNCH

This feature allows stopping insynch of the keyboards temporarily, so that one or both users can work independently. To toggle between Local and In-synch modes press F3.

### APPLICATIONS PROGRAM OPTION

This option will return operator(s) to the last DOS operation. User will still be in In-synch's last mode. When entering Local mode, the other user will still be in In-synch. F3 will

toggle users from In-synch to Local. This will allow users to reach compatible positions. F3 again will return users to In-synch.

MESSAGE WINDOW

The message window allows users to communicate by typing without affecting the application software. To active the message window either user can press F4. To return from the message window feature, either user can press Esc.

MINUTES

Minutes are an electronic time-line of In-synch events. The Minutes store start and end of conference, and notes made through the option "add notes" in the minutes menu. Minutes saves the date of the conference and the time of each occurrence. Minutes are stored automatically and at the end of the conference each user will be given the option of saving them to a file.

SNAP SHOT

When running a program the other user doesn't have, the In-synch snapshot feature enables capturing any text or graphic screen, and sending it to the other user.

TRANSFER DATA

The Transfer Data menu will appear when In-synch first makes connection and synchronizes. This feature anticipates that software may be transferred between systems as needed for conferences. All software to be run at both PCs must reside on both PCs.

* Use of this software does not constitute an endorsement by the U.S. Army.

# APPENDIX C

## STATISTICS AND SOURCE TABLES FOR TASK VARIABLES

This Appendix contains descriptive statistics and the source tables of the analysis of the task variables. The descriptive statistics are in Tables C-1 through C-5. Source tables from the analysis follow the Tables, and Box Plots of the dependent variables follow the source tables.

### Descriptive Statistics

Notes for all Tables: Tvar = Task Measure Dependent Variable, Exp = Triad Type (A = experienced triad, B = partially experienced triad), and SDev = Standard Deviation. Times are presented in seconds.

Table C-1
Triad Statistics by Trials, Experience, and Communication Modes for Each Task Measure

| Tvar | Trial | Exp | | FTF | Synch+V | Asynch |
|---|---|---|---|---|---|---|
| Route ID Time | 1 | A | Mean | 2002.333 | 1558.000 | 7149.667 |
| | | | SDev | 753.155 | 618.243 | 1967.266 |
| | | B | Mean | 3550.667 | 3722.000 | 10936.000 |
| | | | SDev | 1231.952 | 2216.225 | 776.826 |
| | 2 | A | Mean | 1400.000 | 2047.333 | 7363.000 |
| | | | SDev | 288.777 | 512.255 | 1534.026 |
| | | B | Mean | 1963.000 | 1907.667 | 9139.333 |
| | | | SDev | 247.812 | 444.056 | 2985.112 |
| Route Agreement Time | 1 | A | Mean | 971.000 | 757.333 | 3744.000 |
| | | | SDev | 512.766 | 828.391 | 2230.760 |
| | | B | Mean | 2610.667 | 2394.000 | 7405.000 |
| | | | SDev | 1240.835 | 531.296 | 1558.413 |
| | 2 | A | Mean | 837.333 | 992.667 | 4081.667 |
| | | | SDev | 472.282 | 953.205 | 2165.736 |
| | | B | Mean | 1377.000 | 1013.333 | 6836.000 |
| | | | SDev | 275.543 | 77.835 | 2758.691 |
| Route Score | 1 | A | Mean | -3.667 | -2.000 | -3.333 |
| | | | SDev | 1.155 | 1.732 | 1.528 |
| | | B | Mean | -2.667 | -6.333 | -6.000 |
| | | | SDev | 1.155 | 3.512 | 2.000 |
| | 2 | A | Mean | -5.000 | -4.333 | -3.000 |
| | | | SDev | 1.732 | 2.309 | 2.000 |
| | | B | Mean | -3.667 | -0.667 | -3.667 |
| | | | SDev | 1.155 | 1.155 | 0.577 |
| Other Work | 1 | A | Mean | 104.700 | 75.100 | 43.333 |
| | | | SDev | 99.386 | 97.68 | 25.809 |
| | | B | Mean | 32.000 | 44.333 | 29.667 |
| | | | SDev | 10.577 | 38.596 | 11.237 |
| | 2 | A | Mean | 74.300 | 82.600 | 55.900 |
| | | | SDev | 88.584 | 92.022 | 12.398 |
| | | B | Mean | 42.033 | 80.833 | 39.300 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | SDev | 12.832 | 38.345 | 21.214 |

Table C-1 - (Continued)

| Tvar | Trial | Exp | | FTF | Synch+V | Asynch |
|---|---|---|---|---|---|---|
| Supervisor | 1 | A | Mean | 174.000 | 334.667 | 2249.667 |
| Ending | | | SDev | 66.551 | 301.281 | 339.656 |
| Time | | B | Mean | 27.667 | 322.667 | 1998.000 |
| | | | SDev | 9.292 | 302.665 | 1574.598 |
| | 2 | A | Mean | 117.667 | 215.333 | 2094.667 |
| | | | SDev | 173.529 | 151.110 | 467.108 |
| | | B | Mean | 106.667 | 173.667 | 1704.000 |
| | | | SDev | 102.725 | 155.004 | 173.908 |

Table C-2

Triad Statistics by Experience and Communication Modes for Each Task Measure

| Tvar | Exp | | FTF | Synch+V | Asynch |
|---|---|---|---|---|---|
| Route ID | A | Mean | 1701.167 | 1802.667 | 7256.333 |
| Time | | SDev | 354.864 | 564.794 | 1493.040 |
| | B | Mean | 2756.833 | 2815.833 | 10037.667 |
| | | SDev | 714.740 | 1182.842 | 1304.041 |
| Route | A | Mean | 904.167 | 875.000 | 3912.833 |
| Agreement | | SDev | 463.482 | 889.322 | 2184.771 |
| Time | B | Mean | 1993.833 | 1703.667 | 7120.500 |
| | | SDev | 758.180 | 727.099 | 1176.610 |
| Route | A | Mean | -4.333 | -3.167 | -3.167 |
| Score | | SDev | 1.258 | 1.041 | 1.443 |
| | B | Mean | -3.167 | -3.500 | -4.833 |
| | | SDev | 0.577 | 2.291 | 1.041 |
| Other | A | Mean | 89.500 | 78.850 | 49.617 |
| Work | | SDev | 93.971 | 94.844 | 13.224 |
| | B | Mean | 37.017 | 62.583 | 34.483 |
| | | SDev | 11.673 | 35.716 | 16.189 |
| Supervisor | A | Mean | 145.833 | 275.000 | 2172.167 |
| Ending | | SDev | 111.607 | 224.020 | 81.819 |
| Time | B | Mean | 67.167 | 248.167 | 1851.000 |
| | | SDev | 47.014 | 157.831 | 835.480 |

Table C-3
Triad Statistics by Trials and Communication Modes for Each Task Measure

| Tvar | Trial | | FTF | Synch+V | Asynch |
|---|---|---|---|---|---|
| Route ID | 1 | Mean | 2776.500 | 2640.000 | 9042.833 |
| Time | | SDev | 1246.267 | 1876.811 | 2467.860 |
| | 2 | Mean | 1681.500 | 1978.500 | 8251.167 |
| | | SDev | 391.167 | 435.341 | 2355.008 |
| Route | 1 | Mean | 1790.833 | 1575.667 | 5574.500 |
| Agreement | | SDev | 1235.958 | 1419.874 | 2642.509 |
| Time | 2 | Mean | 1107.167 | 1003.000 | 5458.833 |
| | | SDev | 454.931 | 604.972 | 2682.577 |
| Route | 1 | Mean | -3.167 | -4.167 | -4.667 |
| Score | | SDev | 1.169 | 3.430 | 2.160 |
| | 2 | Mean | -4.333 | -2.500 | -3.333 |
| | | SDev | 1.506 | 2.588 | 1.366 |
| Other | 1 | Mean | 68.350 | 59.717 | 36.500 |
| Work | | SDev | 74.708 | 68.534 | 19.312 |
| | 2 | Mean | 58.167 | 81.717 | 47.600 |
| | | SDev | 59.305 | 63.058 | 18.005 |
| Supervisor | 1 | Mean | 100.833 | 328.667 | 2123.833 |
| Ending | | SDev | 90.720 | 270.174 | 1028.052 |
| Time | 2 | Mean | 112.167 | 194.500 | 1899.333 |
| | | SDev | 127.680 | 138.799 | 380.999 |

Table C-4

Triad Statistics by Communication Mode for Each Task Measure

| Tvar | | FTF | Synch+V | Asynch |
|---|---|---|---|---|
| Route ID | Mean | 2229.000 | 2309.250 | 8647.000 |
| Time | SDev | 767.491 | 997.595 | 1972.973 |
| Route | Mean | 1449.000 | 1289.333 | 5516.667 |
| Agreement | SDev | 819.801 | 856.640 | 2355.800 |
| Time | | | | |
| Route | Mean | -3.750 | -3.333 | -4.000 |
| Score | SDev | 1.084 | 1.602 | 1.449 |
| Other | Mean | 63.258 | 70.717 | 42.050 |
| Work | SDev | 66.431 | 64.713 | 15.604 |
| Supervisor | Mean | 106.500 | 261.583 | 2011.583 |
| Ending | SDev | 87.881 | 173.937 | 559.315 |
| Time | | | | |

Table C-5
Triad statistics by Experience and Trial for each task measure (times in seconds)

| | Type A | | Type B | |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 1 | Trial 2 |
| **Route ID Time** | | | | |
| MEAN | 3570.0 | 3603.4 | 6069.6 | 4337.3 |
| STANDARD DEV | 771.9 | 755.6 | 950.1 | 1044.1 |
| STD. ERROR | 445.7 | 436.2 | 548.5 | 602.8 |
| **Route Agreement Time** | | | | |
| MEAN | 1824.1 | 1970.6 | 4136.6 | 3075.4 |
| STANDARD DEV | 1105.4 | 1180.4 | 669.3 | 984.1 |
| STD. ERROR | 638.2 | 681.5 | 386.4 | 568.2 |
| **Route Score** | | | | |
| MEAN | -3.0 | -4.1 | -5.0 | -2.7 |
| STANDARD DEV | 0.7 | 1.1 | 0.9 | 0.6 |
| STD. ERROR | 0.4 | 0.6 | 0.5 | 0.3 |
| **Other Work** | | | | |
| MEAN | 74.4 | 70.9 | 35.3 | 54.1 |
| STANDARD DEV | 69.0 | 63.7 | 18.8 | 23.3 |
| STD. ERROR | 39.9 | 36.8 | 10.8 | 13.5 |
| **Supervisor Ending Time** | | | | |
| MEAN | 919.4 | 809.2 | 782.8 | 661.4 |
| STANDARD DEV | 162.1 | 153.8 | 521.2 | 105.5 |
| STD. ERROR | 93.6 | 88.8 | 300.9 | 60.9 |

Source Tables

EXP is Triad Type (A or B) and MODES are Communication Modes (FTF, Synch+V, Asynch).

Route ID Time

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| EXP | 23524100.000 | 1 | 23524100.000 | 5.548 | 0.078 |
| error | 16961000.000 | 4 | 4240251.722 | | |
| TRIALS | 6493153.361 | 1 | 6493153.361 | 13.007 | 0.023 |
| error | 1996888.889 | 4 | 499222.222 | | |
| EXP*TRIALS | 7014552.250 | 1 | 7014552.250 | 14.051 | 0.020 |
| error | 1996888.889 | 4 | 499222.222 | | |
| MODES | 325457000.000 | 2 | 16272800.000 | 159.200 | 0.000 |
| error | 8177325.111 | 8 | 1022165.639 | | |
| EXP*MODES | 6106145.056 | 2 | 3053072.528 | 2.987 | 0.107 |
| error | 8177325.111 | 8 | 1022165.639 | | |
| TRIALS*MODES | 296876.722 | 2 | 148438.361 | 0.058 | 0.944 |
| error | 20306700.000 | 8 | 2538333.389 | | |
| EXP*TRIALS* MODES | 716936.167 | 2 | 358468.083 | 0.141 | 0.870 |
| error | 20306700.000 | 8 | 2538333.389 | | |

Route Agreement Time

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| EXP | 26275900.000 | 1 | 26275900.000 | 4.512 | 0.101 |
| error | 23294500.000 | 4 | 5823630.667 | | |
| TRIALS | 1882384.000 | 1 | 1882384.000 | 8.404 | 0.044 |
| error | 895962.222 | 4 | 223990.556 | | |
| EXP*TRIALS | 3280928.444 | 1 | 3280928.444 | 14.648 | 0.019 |
| error | 895962.222 | 4 | 223990.556 | | |
| MODES | 137767000.000 | 2 | 68883500.000 | 56.387 | 0.000 |
| error | 9772906.667 | 8 | 1221613.333 | | |
| EXP*MODES | 10213700.000 | 2 | 5106843.000 | 4.180 | 0.057 |
| error | 9772906.667 | 8 | 1221613.333 | | |
| TRIALS*MODES | 543794.000 | 2 | 271897.000 | 0.124 | 0.885 |
| error | 17542700.000 | 8 | 2192842.556 | | |
| EXP*TRIALS* MODES | 201696.889 | 2 | 100848.444 | 0.046 | 0.955 |
| error | 17542700.000 | 8 | 2192842.556 | | |

Supervisor Ending Time

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| EXP | 182044.444 | 1 | 182044.444 | 0.657 | 0.463 |
| error | 1107640.444 | 4 | 276910.111 | | |
| TRIALS | 120640.444 | 1 | 120640.444 | 0.543 | 0.502 |
| error | 888675.111 | 4 | 222168.778 | | |
| EXP*TRIALS | 277.778 | 1 | 277.778 | 0.001 | 0.973 |
| error | 888675.111 | 4 | 222168.778 | | |
| MODES | 26863600.000 | 2 | 13431800.000 | 51.903 | 0.000 |
| error | 2070290.889 | 8 | 258786.361 | | |
| EXP*MODES | 148125.056 | 2 | 74062.528 | 0.286 | 0.758 |
| error | 2070290.889 | 8 | 258786.361 | | |
| TRIALS*MODES | 84947.722 | 2 | 42473.861 | 0.157 | 0.858 |
| error | 2168547.556 | 8 | 271068.444 | | |
| EXP*TRIALS* MODES | 28609.389 | 2 | 14304.694 | 0.053 | 0.949 |
| error | 2168547.556 | 8 | 271068.444 | | |

Route Score

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| EXP | 0.694 | 1 | 0.694 | 0.192 | 0.684 |
| error | 14.444 | 4 | 3.611 | | |
| TRIALS | 3.361 | 1 | 3.361 | 7.563 | 0.051 |
| error | 1.778 | 4 | 0.444 | | |
| EXP*TRIALS | 26.694 | 1 | 26.694 | 60.062 | 0.001 |
| error | 1.778 | 4 | 0.444 | | |
| MODES | 2.722 | 2 | 1.361 | 0.349 | 0.716 |
| error | 31.222 | 8 | 3.903 | | |
| EXP*MODES | 12.056 | 2 | 6.028 | 1.544 | 0.271 |
| error | 31.222 | 8 | 3.903 | | |
| TRIALS*MODES | 14.389 | 2 | 7.194 | 1.805 | 0.225 |
| error | 31.889 | 8 | 3.986 | | |
| EXP*TRIALS* MODES | 24.389 | 2 | 12.194 | 3.059 | 0.103 |
| error | 31.889 | 8 | 3.986 | | |

Other Work

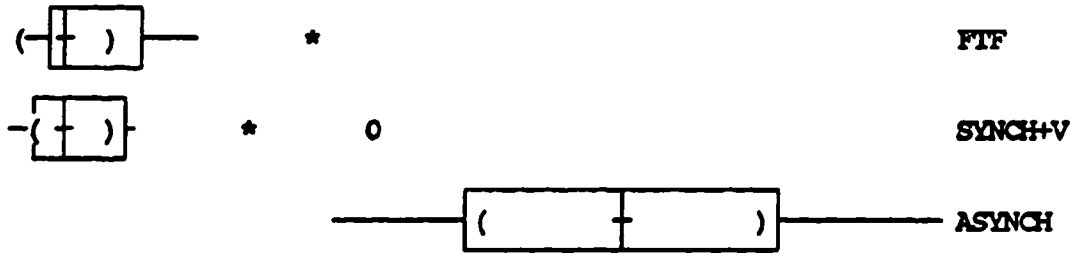
| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| EXP | 7036.414 | 1 | 7036.414 | 0.487 | 0.524 |
| error | 57749.199 | 4 | 14437.300 | | |
| TRIALS | 525.174 | 1 | 525.174 | 3.510 | 0.134 |
| error | 598.572 | 4 | 149.643 | | |
| EXP*TRIALS | 1105.563 | 1 | 1105.563 | 7.388 | 0.053 |
| error | 598.572 | 4 | 149.643 | | |
| MODES | 5308.792 | 2 | 2654.396 | 1.014 | 0.405 |
| error | 20950.394 | 8 | 2618.799 | | |
| EXP*MODES | 2707.954 | 2 | 1353.977 | 0.517 | 0.615 |
| error | 20950.394 | 8 | 2618.799 | | |
| TRIALS*MODES | 1607.557 | 2 | 803.779 | 4.472 | 0.050 |
| error | 1437.868 | 8 | 179.733 | | |
| EXP*TRIALS* MODES | 757.782 | 2 | 378.891 | 2.108 | 0.184 |
| error | 1437.868 | 8 | 179.733 | | |

BOX PLOTS OF VARIABLES

TASK MEASURES:

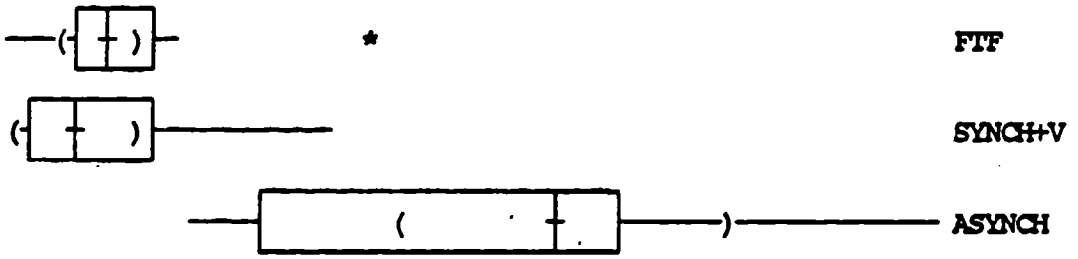
BOX PLOT OF VARIABLE: Route ID Time , N = 36
GROUPED BY VARIABLE: MODES

958.00 MINIMUM 12397.00 MAXIMUM



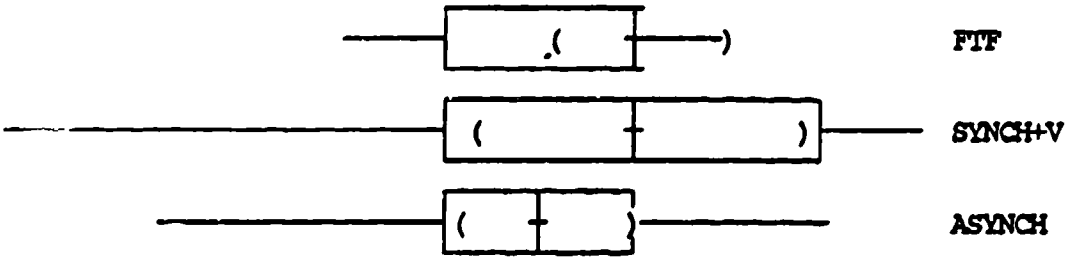

BOX PLOT OF VARIABLE: Route Agreement Time , N = 36
GROUPED BY VARIABLE: MODES

121.00 MINIMUM 9883.00 MAXIMUM



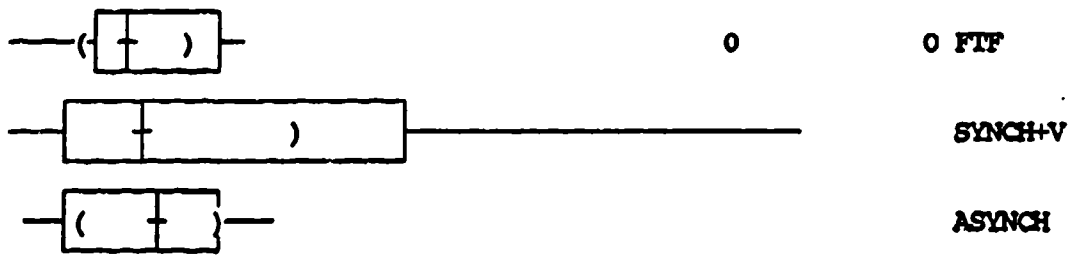

BOX PLOT OF VARIABLE: Route Score , N = 36
GROUPED BY VARIABLE: MODES

-10.00 MINIMUM 0.00 MAXIMUM



BOX PLOT OF VARIABLE: Other Work , N = 36
GROUPED BY VARIABLE: MODES

7.50 MINIMUM 218.30 MAXIMUM

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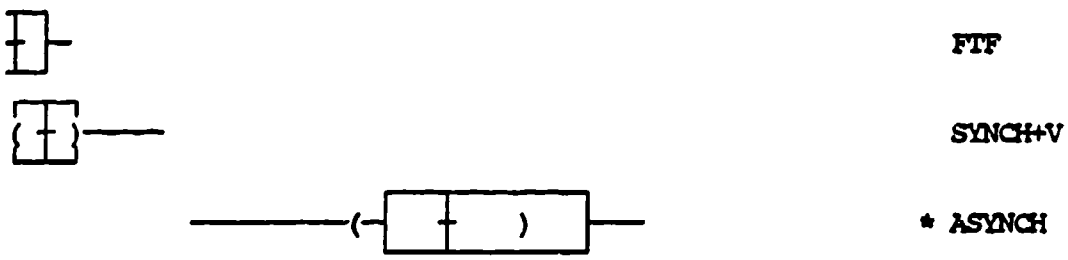
BOX PLOT OF VARIABLE: Supervisor Ending Time , N = 36
GROUPED BY VARIABLE: MODES

14.00 MINIMUM 3796.00 MAXIMUM

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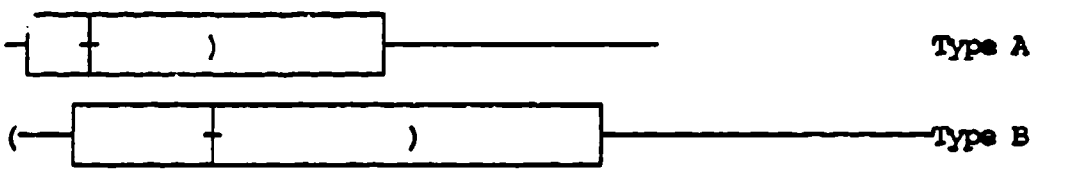
BOX PLOT OF VARIABLE: Route ID Time , N = 36
GROUPED BY VARIABLE: EXPERIENCE

8.00 MINIMUM 12397.00 MAXIMUM

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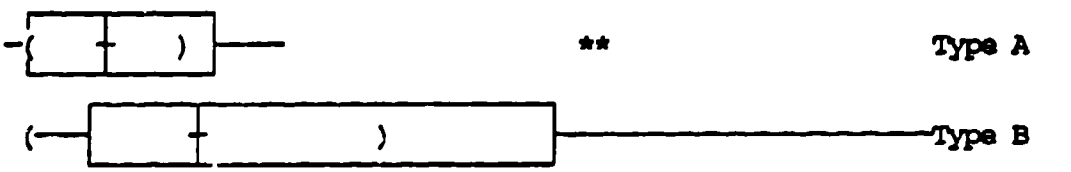
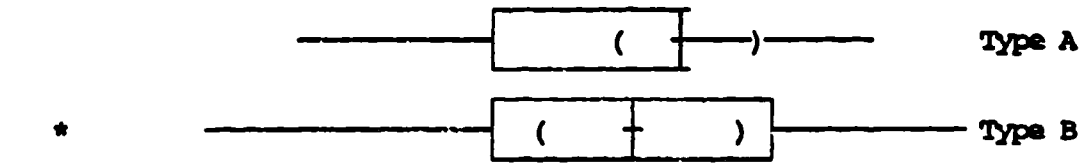
BOX PLOT OF VARIABLE: Route Agreement Time , N = 36
GROUPED BY VARIABLE: EXPERIENCE

121.00 MINIMUM 9883.00 MAXIMUM



BOX PLOT OF VARIABLE: Route Score , N = 36
GROUPED BY VARIABLE: EXPERIENCE

-10.00 MINIMUM 0.00 MAXIMUM

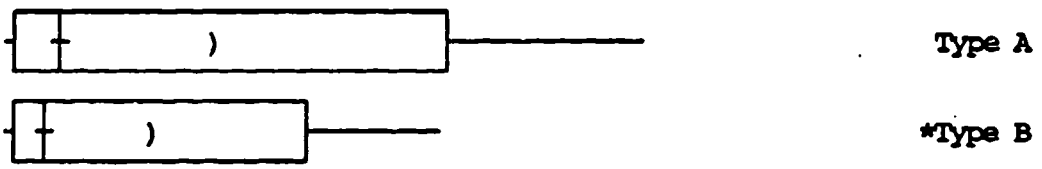



BOX PLOT OF VARIABLE: Other Work , N = 36
GROUPED BY VARIABLE: EXPERIENCE

7.50 MINIMUM 218.30 MAXIMUM

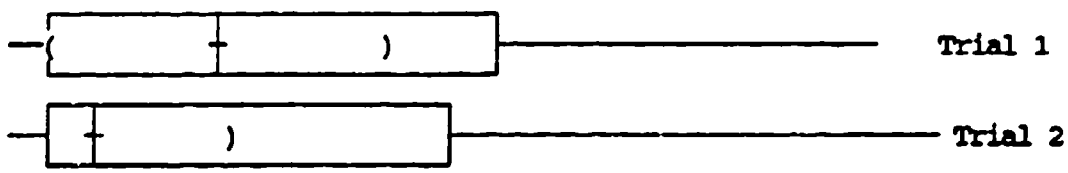

BOX PLOT OF VARIABLE: Supervisor Ending Time , N = 36
GROUPED BY VARIABLE: EXPERIENCE

14.00 MINIMUM 3796.00 MAXIMUM



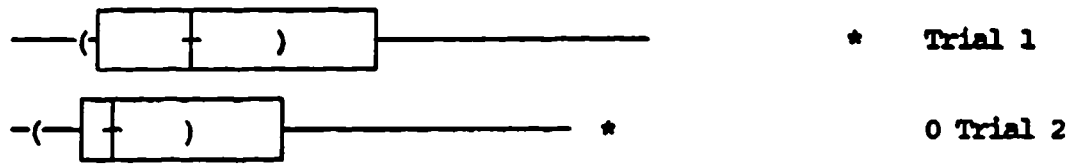

BOX PLOT OF VARIABLE: Route ID Time , N = 36
GROUPED BY VARIABLE: TRIAL

958.00 MINIMUM 12397.00 MAXIMUM



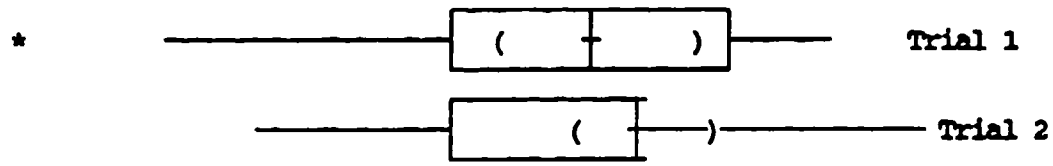
BOX PLOT OF VARIABLE: Route Agreement Time , N = 36
GROUPED BY VARIABLE: TRIAL

121.00 MINIMUM 9883.00 MAXIMUM



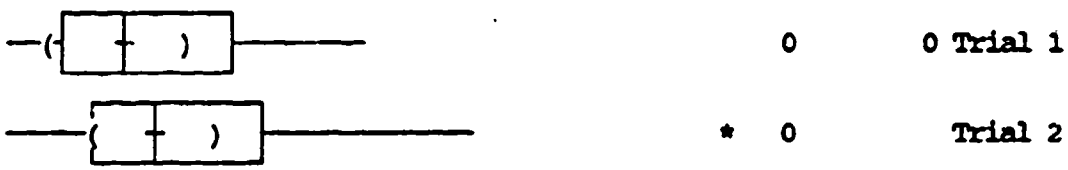

BOX PLOT OF VARIABLE: Route Score , N = 36
GROUPED BY VARIABLE: TRIAL

-10.00 MINIMUM 0.00 MAXIMUM



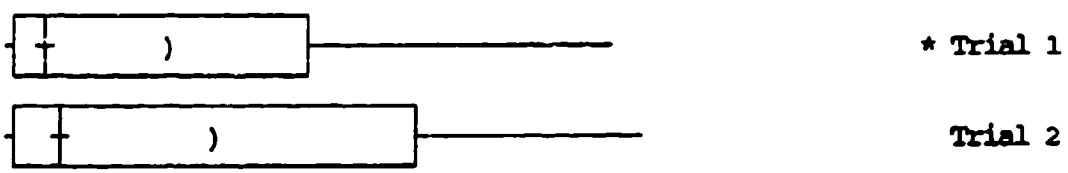

BOX PLOT OF VARIABLE: Other Work , N = 36
GROUPED BY VARIABLE: TRIAL

7.50 MINIMUM 218.30 MAXIMUM




BOX PLOT OF VARIABLE: Supervisor Ending Time , N = 36
GROUPED BY VARIABLE: TRIAL

14.00 MINIMUM 3796.00 MAXIMUM



| Legend: | | |
|---|---|---|
| | 0 | Far Outlying Value |
| | * | Outlying Value |
| | \| + \| | Median Value |
| | ( ) | 95% confidence level |
| | ——— + + ——— | Semi-interquartile range (Box) |
| | ——— | Value within and closest to 1.5 times the semi-interquartile range (Whisker) |

## APPENDIX D

### SOURCE TABLES FOR THE COMMUNICATION MODES ANALYSIS OF THE TRIAD TASK VARIABLES

EXP is Triad Type (A or B). Comparisons were:

Face-to-Face to Synch+V,
Face-to-Face to Asynch, and
Synch+V to Asynch.

This analysis was done in conjunction with the overall task analysis reported in Appendix C, therefore, the interaction between the comparisons and Experience are reported. All times are in seconds.

Route ID Time

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| FTF-Synch+V | 154561.500 | 1 | 154561.500 | 0.061 | 0.818 |
| error | 10205600.000 | 4 | 2551406.000 | | |
| EXP*FTF-Synch+V | 10837.500 | 1 | 10837.500 | 0.004 | 0.951 |
| error | 10205600.000 | 4 | 2551406.000 | | |
| FTF-Asynch | 98857700.000 | 1 | 988577000.000 | 177.179 | 0.000 |
| error | 22318200.000 | 4 | 5579548.333 | | |
| EXP*FTF-Asynch | 17867600.000 | 1 | 17867600.000 | 3.202 | 0.148 |
| error | 22318200.000 | 4 | 5579548.333 | | |
| Synch+V-Asynch | 964010000.000 | 1 | 964010000.000 | 233.132 | 0.000 |
| error | 16540100.000 | 4 | 4135033.333 | | |
| EXP* | | | | | |
| Synch+V-Asynch | 18758500.000 | 1 | 18758500.000 | 4.536 | 0.100 |
| error | 16540100.000 | 4 | 4135033.333 | | |

Route Agreement Time

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| FTF-Synch+V | 611842.667 | 1 | 611842.667 | 0.408 | 0.558 |
| error | 5993609.333 | 4 | 1498402.333 | | |
| EXP*FTF-Synch+V | 408726.000 | 1 | 408726.000 | 0.273 | 0.629 |
| error | 5993609.333 | 4 | 1498402.333 | | |
| FTF-Asynch | 397102000.000 | 1 | 397102000.000 | 52.315 | 0.002 |
| error | 30362200.000 | 4 | 7590556.333 | | |
| EXP*FTF-Asynch | 26915500.000 | 1 | 26915500.000 | 3.546 | 0.133 |
| error | 30362200.000 | 4 | 7590556.333 | | |
| Synch+V-Asynch | 428888000.000 | 1 | 428888000.000 | 76.994 | 0.001 |
| error | 22281600.000 | 4 | 5570401.333 | | |
| EXP* | | | | | |
| Synch+V-Asynch | 33957800.000 | 1 | 33957800.000 | 6.096 | 0.069 |
| error | 22281600.000 | 4 | 5570401.333 | | |

Supervisor Ending Time

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| FTF-Synch+V | 577220.167 | 1 | 577220.167 | 5.182 | 0.085 |
| error | 445534.667 | 4 | 111383.667 | | |
| EXP*FTF-Synch+V | 16120.167 | 1 | 16120.167 | 0.145 | 0.723 |
| error | 445534.667 | 4 | 111383.667 | | |
| FTF-Asynch | 87104200.000 | 1 | 87104200.000 | 57.390 | 0.002 |
| error | 6071057.333 | 4 | 1517764.333 | | |
| EXP*FTF-Asynch | 352837.500 | 1 | 352837.500 | 0.232 | 0.655 |
| error | 6071057.333 | 4 | 1517764.333 | | |
| Synch+V-Asynch | 73500000.000 | 1 | 73500000.000 | 49.787 | 0.002 |
| error | 5905153.333 | 4 | 1476288.333 | | |
| EXP* | | | | | |
| Synch+V-Asynch | 519792.667 | 1 | 519792.667 | 0.352 | 0.585 |
| error | 5905153.333 | 4 | 1476288.333 | | |

Route Score

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| FTF-Synch+V | 4.167 | 1 | 4.167 | 0.568 | 0.493 |
| error | 29.333 | 4 | 7.333 | | |
| EXP*FTF-Synch+V | 13.500 | 1 | 13.500 | 1.841 | 0.246 |
| error | 29.333 | 4 | 7.333 | | |
| FTF-Asynch | 1.500 | 1 | 1.500 | 0.113 | 0.754 |
| error | 53.333 | 4 | 13.333 | | |
| EXP*FTF-Asynch | 48.167 | 1 | 48.167 | 3.613 | 0.130 |
| error | 53.333 | 4 | 13.333 | | |
| Synch+V-Asynch | 10.667 | 1 | 10.667 | 0.408 | 0.558 |
| error | 104.667 | 4 | 26.167 | | |
| EXP*Synch+V-Asynch | 10.667 | 1 | 10.667 | 0.408 | 0.558 |
| error | 104.667 | 4 | 26.167 | | |

Other Work

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| FTF-Synch+V | 1335.042 | 1 | 1335.042 | 0.948 | 0.385 |
| error | 5635.507 | 4 | 1408.877 | | |
| EXP*FTF-Synch+V | 7869.882 | 1 | 7869.882 | 5.586 | 0.077 |
| error | 5635.507 | 4 | 1408.877 | | |
| FTF-Asynch | 10795.042 | 1 | 10795.042 | 0.743 | 0.437 |
| error | 58134.113 | 4 | 14533.528 | | |
| EXP*FTF-Asynch | 8370.135 | 1 | 8370.135 | 0.576 | 0.490 |
| error | 58134.113 | 4 | 14533.528 | | |
| Synch+V-Asynch | 19722.667 | 1 | 19722.667 | 1.274 | 0.322 |
| error | 61932.747 | 4 | 15483.187 | | |
| EXP*Synch+V-Asynch | 7.707 | 1 | 7.707 | 0.000 | 0.983 |
| error | 61932.747 | 4 | 15483.187 | | |

## APPENDIX E

### A COMPARISON OF DYAD AND TRIAD PERFORMANCE

Descriptive statistics by task measure (times in seconds)

| | DYAD | | TRIAD | |
|---|---|---|---|---|
| | FTF | Synch+V | FTF | Synch+V |
| Route ID Time | | | | |
| MEAN | 1066.500 | 1152.643 | 1872.333 | 1758.083 |
| STANDARD DEV | 323.839 | 278.875 | 612.749 | 831.098 |
| Route Agreement Time | | | | |
| MEAN | 579.429 | 607.429 | 1166.833 | 953.417 |
| STANDARD DEV | 162.562 | 203.504 | 584.138 | 712.816 |
| Route Score | | | | |
| MEAN | -2.500 | -3.000 | -3.750 | -3.333 |
| STANDARD DEV | 1.345 | 2.219 | 1.422 | 3.025 |

Comparison source tables. GRP is group ty[illegible]ad or triad)

ROUTE ID TIME

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| GRP | 6434702.935 | 1 | 6434702.935 | 16.059 | 0.001 |
| error | 9616822.315 | 24 | 400700.930 | | |
| FTF to Synch+V | 2552.345 | 1 | 2552.345 | 0.014 | 0.908 |
| error | 4485579.982 | 24 | 186899.166 | | |
| GRP * FTF to Synch+V | 129738.960 | 1 | 129738.960 | 0.694 | 0.413 |
| error | 4485579.982 | 24 | 186899.166 | | |

ROUTE AGREEMENT TIME

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| GRP | 2814717.960 | 1 | 2814717.960 | 8.898 | 0.006 |
| error | 7592157.982 | 24 | 316339.916 | | |
| FTF to Synch+V | 111071.715 | 1 | 111071.715 | 1.013 | 0.324 |
| error | 2632335.458 | 24 | 109680.644 | | |
| GRP * FTF to Synch+V | 188295.715 | 1 | 188295.715 | 1.717 | 0.203 |
| error | 2632335.458 | 24 | 109680.644 | | |

ROUTE SCORE

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| GRP | 8.099 | 1 | 8.099 | 2.085 | 0.162 |
| error | 93.208 | 24 | 3.884 | | |
| FTF to Synch+V | 0.022 | 1 | 0.022 | 0.005 | 0.947 |
| error | 117.208 | 24 | 4.884 | | |
| GRP * FTF to Synch+V | 2.715 | 1 | 2.715 | 0.556 | 0.463 |
| error | 117.208 | 24 | 4.884 | | |

## APPENDIX F

### ANALYSIS OF TRIAD TRANSCRIPT DATA

The order for each class is Sentence, Style, Content Code, and Word. Total and Supervisor-only are given for each class.

Total Sentence

| | Sentence Type | | | |
|---|---|---|---|---|
| | Comp | Incomp | Falstrt | TOTAL |
| 1.0 | 580 | 17 | 19 | 616 |
| Trial | | | | |
| 2.0 | 576 | 20 | 17 | 613 |
| TOTAL | 1156 | 37 | 36 | 1229 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.361 | 2 | 0.835 |

| | Triad | | |
|---|---|---|---|
| | A | B | TOTAL |
| 1.0 | 306 | 310 | 616 |
| Trial | | | |
| 2.0 | 303 | 310 | 613 |
| TOTAL | 609 | 620 | 1229 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.007 | 1 | 0.931 |

| | Communication Mode | | | |
|---|---|---|---|---|
| | FTF | Synch+V | Asynch | TOTAL |
| 1.0 | 209 | 207 | 200 | 616 |
| Trial | | | | |
| 2.0 | 207 | 206 | 200 | 613 |
| TOTAL | 416 | 413 | 400 | 1229 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.005 | 2 | 0.998 |

| | Sentence Type | | | |
|---|---|---|---|---|
| | Comp | Incomp | Falstrt | TOTAL |
| A Triad | 581 | 16 | 12 | 609 |
| B | 575 | 21 | 24 | 620 |
| TOTAL | 1156 | 37 | 36 | 1229 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 4.609 | 2 | 0.100 |

| | Communication Mode | | | |
|---|---|---|---|---|
| | FTF | Synch+V | Asynch | TOTAL |
| A Triad | 205 | 204 | 200 | 609 |
| B | 211 | 209 | 200 | 620 |
| TOTAL | 416 | 413 | 400 | 1229 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.049 | 2 | 0.976 |

| | Sentence Type | | | |
|---|---|---|---|---|
| | Comp | Incomp | Falstrt | TOTAL |
| FTF Mode | 362 | 34 | 20 | 416 |
| Synch+V | 394 | 3 | 16 | 413 |
| Asynch | 400 | 0 | 0 | 400 |
| TOTAL | 1156 | 37 | 36 | 1229 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 77.785 | 4 | 0.0 |

Supervisor-only Sentence

| | Sentence Type Comp | Incomp | Falstrt | TOTAL |
|---|---|---|---|---|
| Triad A | 293 | 6 | 4 | 303 |
| Triad B | 294 | 5 | 13 | 312 |
| TOTAL | 587 | 11 | 17 | 615 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 4.727 | 2 | 0.094 |

| | Communication Mode FTF | Synch+V | Asynch | TOTAL |
|---|---|---|---|---|
| Triad A | 102 | 101 | 100 | 303 |
| Triad B | 109 | 103 | 100 | 312 |
| TOTAL | 211 | 204 | 200 | 615 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.120 | 2 | 0.942 |

| | Sentence Type Comp | Incomp | Falstrt | TOTAL |
|---|---|---|---|---|
| Mode FTF | 187 | 11 | 13 | 211 |
| Mode Synch+V | 200 | 0 | 4 | 204 |
| Mode Asynch | 200 | 0 | 0 | 200 |
| TOTAL | 587 | 11 | 17 | 615 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 37.481 | 4 | 0.0 |

Total Style

| | Sentence Style Declar | Quest | Unfin | Inter | TOTAL |
|---|---|---|---|---|---|
| Trial 1.0 | 455 | 119 | 4 | 12 | 590 |
| Trial 2.0 | 457 | 112 | 5 | 14 | 588 |
| TOTAL | 912 | 231 | 9 | 26 | 1178 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.478 | 3 | 0.924 |

| | Triad A | B | TOTAL |
|---|---|---|---|
| Trial 1.0 | 296 | 294 | 590 |
| Trial 2.0 | 295 | 293 | 588 |
| TOTAL | 591 | 587 | 1178 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.0 | 1 | 1.0 |

| | Communication Mode FTF | Synch+V | Asynch | TOTAL |
|---|---|---|---|---|
| Trial 1.0 | 196 | 197 | 197 | 590 |
| Trial 2.0 | 193 | 198 | 197 | 588 |
| TOTAL | 389 | 395 | 394 | 1178 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.022 | 2 | 0.989 |

| | Sentence Style Declar | Quest | Unfin | Inter | TOTAL |
|---|---|---|---|---|---|
| Triad A | 467 | 109 | 3 | 12 | 591 |
| Triad B | 445 | 122 | 6 | 14 | 587 |
| TOTAL | 912 | 231 | 9 | 26 | 1178 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 2.403 | 3 | 0.493 |

| | Communication Mode | | | |
|---|---|---|---|---|
| | FTF | Synch+V | Asynch | TOTAL |
| Triad A | 196 | 198 | 197 | 591 |
| Triad B | 193 | 197 | 197 | 587 |
| TOTAL | 389 | 395 | 394 | 1178 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.012 | 2 | 0.994 |

| | Sentence Style | | | | |
|---|---|---|---|---|---|
| | Declar | Quest | Unfin | Inter | TOTAL |
| FTF Mode | 261 | 96 | 6 | 26 | 389 |
| Synch+V | 284 | 108 | 3 | 0 | 395 |
| Asynch | 367 | 27 | 0 | 0 | 394 |
| TOTAL | 912 | 231 | 9 | 26 | 1178 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 128.168 | 6 | 0.0 |

Supervisor-only Style

| | Sentence Style | | | | |
|---|---|---|---|---|---|
| | Declar | Quest | Unfin | Inter | TOTAL |
| Triad A | 223 | 69 | 0 | 6 | 298 |
| Triad B | 190 | 101 | 2 | 3 | 296 |
| TOTAL | 413 | 170 | 2 | 9 | 594 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 11.654 | 3 | 0.009 |

| | Communication Mode | | | |
|---|---|---|---|---|
| | FTF | Synch+V | Asynch | TOTAL |
| Triad A | 98 | 99 | 101 | 298 |
| Triad B | 98 | 99 | 99 | 296 |
| TOTAL | 196 | 198 | 200 | 594 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.013 | 2 | 0.993 |

| | Sentence Style | | | | |
|---|---|---|---|---|---|
| | Declar | Quest | Unfin | Inter | TOTAL |
| FTF | 92 | 93 | 2 | 9 | 196 |
| Mode | | | | | |
| Synch+V | 136 | 62 | 0 | 0 | 198 |
| Asynch | 185 | 15 | 0 | 0 | 200 |
| TOTAL | 413 | 170 | 2 | 9 | 594 |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 107.874 | 6 | 0.0 |

Total Content Code

| | Content Code | | | | | |
|---|---|---|---|---|---|---|
| | A | C | CR | F | GI | NTO |
| 1.0 | 1.49 | 1.04 | 1.08 | 3.17 | 6.17 | .57 |
| Trial | | | | | | |
| 2.0 | 1.90 | 1.17 | .95 | 1.99 | 3.48 | .09 |
| TOTAL | 3.39 | 2.22 | 2.03 | 5.16 | 9.65 | .66 |
| N | 107 | 70 | 64 | 163 | 305 | 21 |

| | P | PO | TO | TS | U | TOTAL | N |
|---|---|---|---|---|---|---|---|
| 1.0 | 4.05 | .32 | 18.27 | 21.37 | .85 | 58.37 | 1844.00 |
| Trial | | | | | | | |
| 2.0 | 3.13 | .28 | 12.95 | 15.10 | .57 | 41.63 | 1315.00 |
| TOTAL | 7.19 | .60 | 31.21 | 36.47 | 1.42 | 100.00 | |
| N | 227 | 19 | 986 | 1152 | 45 | 3159 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 25.194 | 10 | 0.005 |

| | Triad | | | |
|---|---|---|---|---|
| | A | B | TOTAL | N |
| 1.0 | 24.09 | 34.28 | 58.37 | 1844.00 |
| Trial | | | | |
| 2.0 | 22.13 | 19.50 | 41.63 | 1315.00 |
| TOTAL | 46.22 | 53.78 | 100.00 | |
| N | 1460 | 1699 | 3159 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 43.634 | 1 | 0.0 |

| | Communication Mode | | | | |
|---|---|---|---|---|---|
| | FTF | Synch+V | Asynch | TOTAL | N |
| Trial 1.0 | 35.58 | 17.95 | 4.84 | 58.37 | 1844.00 |
| Trial 2.0 | 19.72 | 15.86 | 6.05 | 41.63 | 1315.00 |
| TOTAL | 55.30 | 33.81 | 10.89 | 100.00 | |
| N | 1747 | 1068 | 344 | 3159 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 65.195 | 2 | 0.0 |

| | Content Code | | | | | |
|---|---|---|---|---|---|---|
| | A | C | CR | F | GI | NTO |
| Triad A | 1.65 | 1.36 | .89 | 1.99 | 5.41 | .57 |
| Triad B | 1.74 | .85 | 1.14 | 3.17 | 4.24 | .09 |
| TOTAL | 3.39 | 2.22 | 2.03 | 5.16 | 9.65 | .66 |
| N | 107 | 70 | 64 | 163 | 305 | 21 |

| | P | PO | TO | TS | U | TOTAL | N |
|---|---|---|---|---|---|---|---|
| Triad A | 3.07 | .38 | 13.01 | 17.06 | .82 | 46.22 | 1460.00 |
| Triad B | 4.12 | .22 | 18.20 | 19.40 | .60 | 53.78 | 1699.00 |
| TOTAL | 7.19 | .60 | 31.21 | 36.47 | 1.42 | 100.00 | |
| N | 227 | 19 | 986 | 1152 | 45 | 3159 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 49.779 | 10 | 0.0 |

| | Communication Mode | | | | |
|---|---|---|---|---|---|
| | FTF | Synch+V | Asynch | TOTAL | N |
| Triad A | 24.47 | 15.76 | 5.98 | 46.22 | 1460.00 |
| Triad B | 30.83 | 18.04 | 4.91 | 53.78 | 1699.00 |
| TOTAL | 55.30 | 33.81 | 10.89 | 100.00 | |
| N | 1747 | 1068 | 344 | 3159 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 13.335 | 2 | 0.001 |
| LIKELIHOOD RATIO CHI-SQUARE | 13.302 | 2 | 0.001 |

| | Content Code A | C | CR | F | GI | NTO |
|---|---|---|---|---|---|---|
| FTF | .66 | 1.11 | .85 | 4.02 | 6.55 | .63 |
| Mode Synch+V | 1.77 | 1.08 | 1.04 | 1.14 | 2.91 | .03 |
| Asynch | .95 | .03 | .13 | .00 | .19 | .00 |
| TOTAL | 3.39 | 2.22 | 2.03 | 5.16 | 9.65 | .66 |
| N | 107 | 70 | 64 | 163 | 305 | 21 |

| | P | PO | TO | TS | U | TOTAL | N |
|---|---|---|---|---|---|---|---|
| FTF | 2.28 | .09 | 19.56 | 18.42 | 1.11 | 55.30 | 1747.0 |
| Mode Synch+V | 3.45 | .28 | 8.99 | 12.88 | .22 | 33.81 | 1068.0 |
| Asynch | 1.46 | .22 | 2.66 | 5.16 | .09 | 10.89 | 344.0 |
| TOTAL | 7.19 | .60 | 31.21 | 36.47 | 1.42 | 100.00 | |
| N | 227 | 19 | 986 | 1152 | 45 | 3159 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 290.485 | 20 | 0.0 |

Supervisor-only Content Code

| | Content Code FA | G | I | TOTAL | N |
|---|---|---|---|---|---|
| A | 2.75 | 21.98 | 15.93 | 40.66 | 74.00 |
| Triad B | 1.10 | 27.47 | 30.77 | 59.34 | 108.00 |
| TOTAL | 3.85 | 49.45 | 46.70 | 100.00 | |
| N | 7 | 90 | 85 | 182 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 4.789 | 2 | 0.091 |

| | Communication Mode FTF | Synch+V | Asynch | TOTAL | N |
|---|---|---|---|---|---|
| Triad A | 25.27 | 12.64 | 2.75 | 40.66 | 74.00 |
| Triad B | 37.91 | 15.93 | 5.49 | 59.34 | 108.00 |
| TOTAL | 63.19 | 28.57 | 8.24 | 100.00 | |
| N | 115 | 52 | 15 | 182 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 0.629 | 2 | 0.730 |

| | Content Code FA | G | I | TOTAL | N |
|---|---|---|---|---|---|
| FTF Mode | .55 | 30.22 | 32.42 | 63.19 | 115.00 |
| Synch+V | .55 | 15.38 | 12.64 | 28.57 | 52.00 |
| Asynch | 2.75 | 3.85 | 1.65 | 8.24 | 15.00 |
| TOTAL | 3.85 | 49.45 | 46.70 | 100.00 | |
| N | 7 | 90 | 85 | 182 | |

| TEST STATISTIC | VALUE | DF | PROB |
|---|---|---|---|
| PEARSON CHI-SQUARE | 40.227 | 4 | 0.0 |

Word

Number of Different Words

Triad Type A

| | DIFFWF | DIFFWV | DIFFWA |
|---|---|---|---|
| MEAN | 321.50 | 240.67 | 112.17 |
| STANDARD DEV | 147.15 | 81.27 | 27.25 |

Triad Type B

| | DIFFWF | DIFFWV | DIFFWA |
|---|---|---|---|
| MEAN | 330.33 | 275.00 | 119.17 |
| STANDARD DEV | 10.00 | 67.04 | 25.01 |

Total Number of Words

Triad Type A

| | TOTWF | TOTWV | TOTWA |
|---|---|---|---|
| MEAN | 1455.50 | 924.33 | 241.83 |
| STANDARD DEV | 1037.63 | 594.86 | 119.53 |

Triad Type B

| | TOTWF | TOTWV | TOTWA |
|---|---|---|---|
| MEAN | 1822.83 | 1204.33 | 270.17 |
| STANDARD DEV | 270.96 | 504.02 | 73.37 |

WORD VARIABLES

NUMBER OF DIFFERENT WORDS

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| Experience | 2516.694 | 1 | 2516.694 | 0.351 | 0.586 |
| error | 28710.444 | 4 | 7177.611 | | |
| Modes | 276207.056 | 2 | 138103.528 | 10.214 | 0.006 |
| error | 108172.889 | 8 | 13521.611 | | |
| Experience x Modes | 1400.722 | 2 | 700.361 | 0.052 | 0.950 |
| error | 108172.889 | 8 | 13521.611 | | |
| Trials | 9248.028 | 1 | 9248.028 | 4.199 | 0.110 |
| error | 8809.778 | 4 | 2202.444 | | |
| Experience x Trials | 5801.361 | 1 | 5801.361 | 2.634 | 0.180 |
| error | 8809.778 | 4 | 2202.444 | | |
| Modes x Trials | 18435.056 | 2 | 9217.528 | 6.806 | 0.019 |
| error | 10834.222 | 8 | 1354.278 | | |
| Experience x Modes x Trials | 10294.056 | 2 | 5147.028 | 3.801 | 0.069 |
| error | 10834.222 | 8 | 1354.278 | | |

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| FTF vs. Synch+V | 115149.667 | 2 | 57574.833 | 0.787 | 0.515 |
| error | 292483.333 | 4 | 73120.833 | | |
| FTF vs. Asynch | 1060941.667 | 2 | 530470.833 | 8.586 | 0.036 |
| error | 247131.333 | 4 | 61782.833 | | |
| Synch+V vs. Asynch | 489555.333 | 2 | 244777.667 | 8.948 | 0.033 |
| error | 109422.667 | 4 | 27355.667 | | |

TOTAL NUMBER OF WORDS

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| Experience | 456525.444 | 1 | 456525.444 | 1.321 | 0.315 |
| error | 1382817.222 | 4 | 345704.306 | | |
| Modes | 11587900.000 | 2 | 5793972.333 | 8.092 | 0.012 |
| error | 5727850.444 | 8 | 715981.306 | | |
| Experience x Modes | 185884.222 | 2 | 92942.111 | 0.130 | 0.880 |
| error | 5727850.444 | 8 | 715981.306 | | |
| Trials | 1058841.000 | 1 | 1058841.000 | 7.711 | 0.050 |
| error | 549248.556 | 4 | 137312.139 | | |
| Experience x Trials | 914573.444 | 1 | 914573.444 | 6.661 | 0.061 |
| error | 549248.556 | 4 | 137312.139 | | |
| Modes x Trials | 1436412.667 | 2 | 718206.333 | 8.255 | 0.011 |
| error | 696020.444 | 8 | 87002.556 | | |
| Experience x Modes x Trials | 624226.889 | 2 | 312113.444 | 3.587 | 0.077 |
| error | 696020.444 | 8 | 87002.556 | | |

| SOURCE | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| FTF vs. Synch+V | 7976163.333 | 2 | 3988081.66 | 0.908 | 0.473 |
| error | 17570200.000 | 4 | 4392562.16 | | |
| FTF vs. Asynch | 46605100.000 | 2 | 23302600.00 | 8.450 | 0.037 |
| error | 11030800.000 | 4 | 2757695.83 | | |
| Synch+V vs. Asynch | 16061700.000 | 2 | 8030841.66 | 5.571 | 0.070 |
| error | 5766070.667 | 4 | 1441517.66 | | |

# END

# FILMED

DATE:
10-91

# DTIC