Communications Research Centre

MAN-MACHINE INTERACTION IN THE HERMES EXPERIMENTS

VOLUME III

EXECUTIVE SUMMARY

CONCLUSIONS AND RECOMMENDATIONS

by

D.A. PHILLIPS AND W.C. TREURNIET

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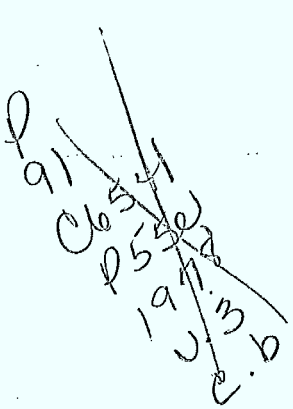

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EXECUTIVE SUMMARY

The Man-Machine Interaction Project was conducted by the Communications Research Centre during six Hermes experiments which provided experimental service in education, medicine, and Government administration during 1976–1977. The project focussed on human behavioural response to the telecommunications technology. Many aspects of technology are transparent to users and have no effect on behaviour. However, behaviour can be affected by three areas of the technology: the terminal equipment; the configurations of technology; and the characteristics of the channel provided by the satellite link. Terminal equipment provided the human with the possibility of transmitting and receiving auditory or visual signals. The type of equipment available and the functions it can perform obviously affects the type of signals that can be transmitted and may also affect the performance and attitudes of users. Many types of terminal equipment were used in the Hermes experiments to transmit various auditory and visual signals. Most of the equipment had been used previously but some of the functions it performed were extensions of previous work. Configurations of technology included the number of sites interacting during any one telecommunications session; whether groups or individuals are present at each site; the type of channel and terminal equipment between the sites. The six Hermes experiments studied a wide range of equipment configurations, many of which had not occurred before. For example, five or six sites in interaction at one time were tested in education experiments by the Public Service Commission and the British Columbia Satellite Tele-Education Project. As far as we were aware, such large configurations had not been tried before. As well as providing for new configurations and the use of a variety of terminal equipment, the satellite link is characterized by a propagation time delay which does not occur to the same extent in other types of links. The Hermes experiments all involved links with some time delay, most with a "one-hop" delay where the signal was transmitted to the satellite and back. A few sessions involved "two-hop" delays where two trips to the satellite were necessary resulting in twice as long a delay. Satellite delay is always present, but in combination with the terminal equipment and configurations, new information was available from the Hermes experiments.

The purpose of the Man-Machine Interaction Project was to study the relationship between the applied technology and the user in several Hermes experiments where similar technology was employed in more than one experiment. The reviews that resulted, presented in Volume II of this report, fall into two categories: those that focused on a particular aspect of technology, describing the variety of behaviour related to that technology, and those that focused on an aspect of human behaviour describing the effects of technology on that behaviour. While these two categories are not independent, they provide slightly different perspectives on the man-machine relationship.

Before presenting a summary of the results of these reviews, the methods used in the study will be described.

METHODS

The Hermes experiments provided an opportunity to collect data about human behaviour in situations that were close to normal operational services. Although similar experiments could be set up under laboratory conditions which would provide the investigator with greater control over the independent variables (terminals

and channels, configurations, delay), they would lack something in realism. While the Hermes experiments did not provide the experimental control possible in laboratory experiments, they did allow description of realistic situations similar to an operational service. Thus the research strategy of the Man-Machine Interaction Project was to describe a part of the behaviour that occurred during the six Hermes experiments; to take note of the variation in technology under which the behaviour occurred; and to attempt to draw tentative conclusions or form hypotheses by considering all of the information available about each behaviour-technology relationship.

The levels of independent variables were variations in the technology related to 1) audio systems, 2) video systems, 3) propagation time-delay, and 4) telemedicine terminal equipment. Audio systems included open-microphone, push-to-talk, and voice-switched systems with some further distinctions between the equipment actually in use. Video systems included symmetric (two-way) and asymmetric (one-way) video along with variations in network configurations. Propagation time-delay included one-hop and two-hop delays. Terminal equipment was most varied within the University of Western Ontario Telemedicine experiment with equipment used for radiology, electrocardiograms, electronic stethoscope and others, as well as the audio and video systems.

The dependent variables were human responses related to 1) satisfaction and acceptability, 2) interaction frequency, interruption behaviour, and other vocal interaction, 3) coalition formation among group members at a site, and 4) concern for privacy. Satisfaction and acceptability were measured partly by a self-report scale developed for use in the experiments. Other methods used to measure these attitudes were self-report questionnaires; interviews, both face-to-face and by telephone, and observation. Interaction frequency and interruption behaviour were measured by a method developed during this project (Phillips, Treurniet, Tigges, and Lewis, 1977). Audio tape-recordings of the experimental sessions with each site recorded on a separate channel were submitted to electronic and computer analysis which produced mean lengths and frequencies of these variables. Coalition formation among group members at one site and concern for privacy proved impossible to measure during the Hermes experiments.

RESULTS

VOLUME I

Although the intention of the Man-Machine Interaction Project was to report on cross-experiment issues, a report of data collected from each of six Hermes experiments was also prepared.

Each Hermes experiment consisted of a complex configuration of equipment so that there was no simple way to describe each experiment. As well, the data collected from each experiment yielded a large volume of information. As a result, before preparing the reviews of all the experiments, reports on the data collected from each experiment were compiled. These reports are presented in Volume I. Reports of the issues are presented in Volume II.

A brief summary of the configurations and results is presented here. Details of the configurations and results from individual experiments can be found in Volume I. Conclusions and recommendations are presented in the final section of this summary.

BRITISH COLUMBIA SATELLITE TEL-EDUCATION EXPERIMENT

The system configuration involved six sites with asymmetric video such that one (Burnaby) could be seen and others could see. Programs were produced at Burnaby for audiences at the remote sites. Groups were present at each site. The sample of satisfaction data collected was small but what there was showed that some dissatisfaction existed. Interaction was quite frequent during interactive portions of the programs, with Burnaby

participants speaking most frequently and holding the floor for the longest intervals. It is unclear whether dissatisfaction was related to inability of those at remote sites to gain the floor but this possibility could be investigated further. (Volume I, Report 2).

UNIVERSITY OF WESTERN ONTARIO TELEMEDICINE EXPERIMENT

The system configuration included asymmetric video between hospitals in London and Moose Factory where London could see and Moose Factory could be seen. A satellite telephony line with no video linked Kashechewan Nursing Station with the hospitals at Moose Factory and London. Programs included medical consultation and education together with a variety of others. Satisfaction was relatively high in all program types although some programs were more highly rated than others on the satisfaction scale. Medical doctors expressed higher satisfaction than did nurses. Interaction frequency (exchange of speakers) was highest in the telephony link between Kashechewan and Moose Factory. A model of telemedicine use is proposed in which the amount of medical communication predicts the type of telecommunications equipment required, which in turn predicts the factors which will inhibit or facilitate use of equipment. This leads to identification of the required location of communications equipment for the practice of telemedicine. The model is a device which may help to organize and integrate the variety of information available about the use of telecommunications for telemedicine. Data from this experiment is related to the model. (Volume I, Report 3).

GOVERNMENT OF ONTARIO ADMINISTRATION EXPERIMENT

Persons at two sites communicated by means of a variety of video and audio systems. Asymmetric video resulted in stronger role definitions and less uncertainty about what was expected of them, in the minds of participants, when compared with reaction in symmetric video or no video conditions. Users of the open-microphone audio-system felt least confused about their role at the meeting compared to those using push-to-talk or combination systems. These latter two audio systems were more negatively evaluated than the open-microphone system. Poor audio quality and unstable audio volume led to more difficulty in communication and more negative reactions toward conversation partners. Familiarity with the system led to feelings that communication was easier and more friendly and cooperative. (Volume I, Report 4).

UNIVERSITY OF QUEBEC: EVALUATION OF LIBRARY SERVICE

Sessions of two experiments, similar in that they linked a librarian with students, but differing in the satellite transmission delay (one-hop versus two-hop) and in use of asymmetric video versus audio only, were compared. Positive attitudes toward regular future use of the system was encouraged in both by good technical quality. The longer delay resulted in an increase in the number of times two people began speaking at the same time without being aware that the other had begun to speak, thus probably creating some confusion. None of the subjective variables distinguished the participants of long and short delay systems. (Volume I, Report 5).

UNIVERSITY OF QUEBEC: INTERVIEW REPORT

Because of the variety of experiments conducted by the University of Quebec, interviews were conducted with participants and observers from several different kinds of experiments. Asymmetric video produced differences between those at each end of the system in evaluation of the communication experience. Those who transmitted but did not receive video (they could be seen) evaluated the experience more negatively than those at the other end (they could see). Some lessening of the negative effect occurred with good audio quality and familiarity with the system. (Volume I, Report 6).

PUBLIC SERVICE COMMISSION MANAGEMENT EDUCATION EXPERIMENT

Five groups communicated by symmetric video and an open-microphone audio system with earphones. Instructors and course participants at one site and participants at the other four remote sites interacted regularly for three weeks in each of two courses. Video resolution was reduced at the instructors' site to one-quarter the normal resolution because the video from the four remote sites were transmitted over one video channel. Subjective ratings showed this video to be adequate for the educational application. Technical problems may have reduced enthusiasm for the audio system which yielded neutral ratings. Graphics, which were improvised using the video system in this experiment in education, proved to be an important feature. (Volume I, Report 7).

MEMORIAL UNIVERSITY OF NEWFOUNDLAND MEDICAL EDUCATION EXPERIMENT

Four remote sites were linked to a central site, (St. John's), with asymmetric video. Satisfaction was high in general. Interaction rates were low, with St. John's playing the dominant role. However, participants felt that interactive audio was essential to the educational task and that one-way video improved interaction. (Volume I, Report 8).

VOLUME II

Reviews of the cross-experiment issues relating technology and human behaviour fall into two categories; those that focus on an aspect of technology and describe behaviour related to it, and those that focus on an aspect of behaviour as it results from a variety of technologies. These two perspectives seem worthwhile because they encourage consideration of different evidence and lead to different hypotheses and recommendations.

REVIEWS FROM A TECHNOLOGICAL FOCUS

The effects of audio interaction systems on behaviour were reviewed by telephone interviews with experiment leaders, project coordinators or technical personnel from eight projects. Seven of these projects were Hermes experiments including the six already mentioned with the addition of the Carleton-Stanford Education experiment. The eighth project that provided data for this study was the University of Toronto/University of Waterloo Telemedicine experiment conducted via Bell Canada telephone lines between Toronto and remote centres in Northern Ontario. Audio interaction systems included open-microphone, press-to-talk and voice activated microphone systems with various finer distinctions in the specific equipment used. The number of sites in interaction at one time and the type of audio interaction system appeared to influence the procedures used for interaction. With more than two sites, a formal procedure was used except in an open-microphone system. With two-site exchanges, formal procedures were less frequent. It also appears to be important, with more than two sites, that speakers be identified at least by their location. Light systems were installed to perform this function in three experiments and the others evolved methods of verbally indicating the speaker's site.

Push-to-talk and voice-switched systems apparently require some adaptation of speakers to allow smooth interaction. In a push-to-talk system where remote site speakers cannot hear the interruptions of others, monopolization of the floor was a problem. Voice-switched systems sometimes created confusion in knowing who has the floor or by cutting off part of a speaker's sentence. (Volume II, Report 2).

Video communication systems and their effect on behaviour were reviewed by comparing asymmetric systems to symmetric systems or no video. Most previous investigations have studied symmetric video compared to symmetric audio or face-to-face. This study thus focused on information available from the Hermes

experiments that was relevant to understanding effects of asymmetric video systems. The evidence indicates that asymmetric video qualitatively affects interaction by making sessions more formal and impersonal then symmetric systems. Users feel generally less at ease with each other when employing asymmetric systems. The data also suggest that users who can be seen feel more observed while users who cannot be seen feel more comfortable and more dominant. Asymmetry in video systems does not appear to affect the interruption behaviour of one site relative to others participating in the interaction. Differences between sites noted in the proportion of unsuccessful to total (successful and unsuccessful) interruptions were apparently due to perceived status differences and not to the asymmetry in terminal equipment. (Volume II, Report 3).

Propagation time delays produced by the satellite were studied both during the University of Quebec Hermes Experiment (Volume I, Number 5), and in a laboratory experiment (Volume II, Number 4). A review of previous studies was also prepared (Treurniet, 1977). During the University of Quebec Hermes Experiment, responses to a one-hop delay (264 msec) and two-hop delay (528 msec) were compared. The longer delay resulted in increased number of challenges (the first interruption while one person has the floor) suggesting that some confusion existed during speaker exchange. Results of the laboratory study did not confirm this result for challenges; however, disruptive effects of a long delay (700 msec) appeared to be blamed on the conversational partner. These results support the conclusion reached from the review of previous studies of propagation time delay (Treurniet, 1977). It is not yet clear whether a two-hop delay (564 msec) is disruptive in any significant way. Previous studies indicate that users do not usually attribute any conversational problems to the delay itself, thus it was expected that people interviewed would report either not noticing the delay or that it was not a problem. However, some interviewees did report that delay seemed to cause more interruptions (Volume I, Report 5; Volume II, Report 4).

A review of the behavioural response to terminal equipment used in telemedicine (Volume II, Number 5) was based on the variety of equipment used in the University of Western Ontario Telemedicine experiment. The basic issue in the relationship between human behaviour and telemedicine technology is that performance standards do not exist. There is no guide for designers concerning the appropriate or required specifications for the equipment. To begin to solve this problem, technology is classified into diagnostic equipment (including that used for radiology, electronic stethoscopes, EEG and EKG, patient monitors, facsimile,) and equipment for visual and auditory interpersonal interaction. Performance standards for diagnostic equipment are especially required for radiology including a study of the effectiveness of slow-scan code for X-ray transmission. Convenience and training requirements for specific equipment could be improved.

REVIEWS FROM A BEHAVIOURAL VIEW POINT

The major behaviour of concern in the relation between technology and behaviour was satisfaction. A single satisfaction scale was used to measure this behaviour in five Hermes experiments. In addition some data collected by interviews and by the experimenters, which touched on this question, were considered. A review of satisfaction in telecommunications sessions (Volume II, Report 6) concluded that, in general, audio quality had an important influence on satisfaction with good audio quality yielding greater satisfaction. Video quality was apparently less important, especially if audio quality were good. In general, it was more satisfying in asymmetric video systems to see (receive video) than to be seen by others (transmit video). Satisfaction with particular configurations of audio and video technology depended in complex ways on the purpose of the experiment and the particular session. Satisfaction is increased by clear objectives for the sessions and is influenced by the type of program and the role a user plays in the organization. It was hypothesized, on the basis of data obtained, that technological and psychological conditions which allow more frequent interruptions among those interacting via telecommunications, lead to more satisfaction because the session seems more like a face-to-face session. Further work is required to clarify whether the number of groups interacting influences satisfaction.

A study of behaviour of two groups, communicating via telecommunications, began with a review of evidence from descriptive and experimental studies other than Hermes experiments. These suggested that some form of discrimination between groups occurred in some group-to-group telecommunications sessions. The

evidence indicated that individuals tend to favor those at their own end of the link and develop less positive attitudes toward those at the other end. No data were collected on this issue from the Hermes experiments; however, a review of the evidence collected from previous studies along with two possible theoretical perspectives is presented (Volume II, Report 7).

It can be concluded that such discrimination between groups does sometimes occur in telecommunications when it may not have occurred in face-to-face sessions for the same purpose. Why it occurs, when it can be expected, whether it is always a negative attitudinal response or is sometimes positive, are all unclear. Until these are known, it is difficult to say whether this phenomenon would tend to limit the use of telecommunications between groups or whether it affects communication between more than two groups.

Privacy, and the concern for privacy among individuals, generated by innovations in telecommunications technology is obviously an important issue. Research on this issue in the Hermes experiments began with an attempt to find a means of measuring the concern for privacy expressed by the users. It was soon discovered that no appropriate means of measurement existed and that design of a measure would depend on a clearer understanding of what is meant by privacy. Effort was then focused on reviewing works on privacy, and privacy and telecommunications, attempting to formulate a concept that would clarify the issues for designers of systems and for those concerned with regulation (Volume II, Report 8).

Privacy was viewed as both the maintenance of control over personal information and the maintenance of an interpersonal boundary when in personal interaction with others. Telecommunications systems, along with computers, influence the individual's control over personal information by making storage, retrieval, integration of files and capture of interpersonal communication more practical than was previously possible. It is suggested that because the information passes out of the confines of a two person or two agent relationship, laws are required to control invasions of individual privacy. Invasions of privacy in interpersonal communications are also increased by telecommunications because it provides opportunity for interaction between persons whose cultural norms are dissimilar and probably because it reduces feedback necessary to formation of norms. Some telecommunication configurations, such as those which are asymmetric, may also tend to invade the privacy of those who provide more information, whether visual or auditory, than their conversational partners. The design of configurations of technology may have to be specifically and carefully tailored to the needs and purposes of communications to avoid invasions of privacy.

CONCLUSIONS AND RECOMMENDATIONS

Almost all of the data presented in this report are descriptive and do not result from studies which control for the influence of extraneous factors. As a result, any conclusions drawn about the influence of technology on behaviour are open to question; the result may have been produced by some other factor. Confidence in the results can only be a matter of judgement.

In our opinion, the conclusions fall into three categories: First, those conclusions which we draw with relative certainty because they have occurred in more than one study, and agree with previously drawn conclusions and/or there is no evidence to contradict them; second, those which we hold with less certainty because, although support for them is consistent, there are other factors that have not been ruled out as producing the result; third those conclusions which are really hypotheses and are put forward as urgent areas for further study.

The conclusions from the study are thus divided into these three sections with the first presenting both the relatively firm conclusions and the recommendations or suggestions for further technical development. The second section presents the moderately certain conclusions with recommendations that arise from them. The third section presents hypotheses which, without further comment, form recommendations for research.

CONCLUSIONS DRAWN WITH RELATIVE CERTAINTY

(1) The audio system design and functioning is important in a telecommunications project, probably more important than the video system. High quality audio (reliability without noise or echo and with stable volume) increases satisfaction and reduces frustration. Video quality becomes more important if audio quality is poor.

(2) The best type of audio interaction system (voice-switched, press-to-talk, open-microphone) depends in complex ways on the purpose and objectives of the session. Open-microphone facilities are most desirable although people adapt to the use of other speaker exchange systems.

(3) Where more than two sites are interacting at one time, participants want speakers to be identified, at least by the site from which they are speaking.

(4) Performance standards that would assist equipment designers and those purchasing new equipment are not available for many types of telemedicine equipment.

(5) Satellite transmission delay is probably disruptive when the one-way delay is above 600 msec and perhaps below that (Treurniet, 1977). When the delay becomes disruptive, users do not attribute the effects to the time delay but do attribute them to the partner in the interaction.

RECOMMENDATIONS BASED ON RELATIVELY FIRM CONCLUSIONS AND ON SUGGESTIONS OF EXPERIMENT PARTICIPANTS

(1) Both audio and video equipment and configurations should be designed with the purpose of the project clearly in mind and then used for that purpose for best results.

(2) Audio equipment for more than two sites should include a system of identifying speakers by site and could also include a *wish to speak* signal.

(3) An open-microphone system, which could be used for multi-site configurations without use of head sets and with automatic volume control, would be most desirable and should be developed if possible.

(4) Audio control of remote sites should be possible from a central control room.

(5) Audio equipment should be simple to install and operate and should be standard for all sites in a project as far as possible to avoid confusion.

(6) Narrowband lines should be available for uses other than voice, such as facsimile, slow-scan television, graphics transmissions, especially for education.

(7) Research to provide the necessary information to set performance standards for telemedical equipment should be done before the next set of telemedicine experiments. Performance standards are required for equipment used for radiology, electronic stethoscope, EKG & EEG, patient monitors, facsimile. Problems are related to visual and auditory perception and to design for convenience and ease of training.

(8) Satellite circuits with more than 600 msec one-way delay should be avoided for interpersonal communication. Project coordinators or producers should be aware of the fact that users do not usually notice delay and there is a tendency to perceive the partner less positively as delay increases.

CONCLUSIONS DRAWN WITH MODERATE CERTAINTY

The following conclusions are well supported with no contradictory evidence available. However, since other factors may have affected the results obtained, the conclusions are less certain.

(1) When technological and psychological conditions allow for more frequent interruptions, satisfaction with the session is greater and rating of the partner more positive.

(2) Asymmetric video systems make interaction more formal and impersonal than either symmetric video or audio-only systems. Receivers in asymmetric video systems are more at ease and find sessions more spontaneous and less tiring than do those that transmit video images of themselves.

(3) Satisfaction with a telecommunications session is increased by clear objectives for the session. Satisfaction is related to conditions which produce better interpersonal relations between sites and less fatigue.

RECOMMENDATIONS BASED ON MODERATELY CERTAIN CONCLUSIONS

(1) Audio systems that allow interruption to occur freely should be given preference over other systems where possible.

(2) Asymmetric video systems should be avoided where the video is mainly used to transmit images of one conversational partner, except where the asymmetry matches previously established formal relationships (the observer is dominant). Asymmetric video used for transmission of other images such as X-rays or textual material is probably more acceptable.

(3) Telecommunications sessions should have clear objectives of which participants are aware.

CONCLUSIONS DRAWN WITH RELATIVE UNCERTAINTY

The following hypotheses are "best guesses" from the data available but require confirmation before recommendations can be made. They are thus firm recommendations for further research.

(1) Effects of satellite transmission delay on subjective response to the conversational partner are indicated by changes in amount and mean duration of mutual silence. Short delays (170 msec) reduce mutual silence and improve subjective ratings of the partner over both no delay and long delay conditions. Knowledge of transmission delay does not influence these effects.

(2) A large number of groups in interaction at one time may produce dissatisfaction when expectations are that individuals will have an opportunity for discussion.

(3) Exchange of speakers in telecommunications sessions requires formal procedures when more than two sites are interacting at one time or in two-site interactions where groups are at each end and the audio system is not open-microphone.

(4) Higher status persons in two-site interactions via telecommunications have a lower proportion of unsuccessful to total interruptions than do lower status persons. Asymmetry in the video system does not affect these relative proportions.

(5) Doctors find telemedicine more satisfying than do nurses.

(6) Satisfaction with telecommunication sessions increases with experience and familiarity with the system, probably because the system becomes more transparent to the user.

(7) Telecommunications between two groups sometimes results in negative attitudes and behaviour toward the group at the other end of the system. This could be the result of the physical separation between sites which creates the conditions for in-group favoritism and out-group discrimination, or it could be the result of a group having one set of transmit and receive facilities which focuses their attention. The two explanations lead to different predictions about the outcome of intergroup communication between two groups. No predictions can be made about three or more groups in communication.

(8) Privacy can be considered to be two different issues in relation to telecommunications 1) privacy as control over personal information which has been communicated, 2) privacy as control over the amount and type of interaction. Personal information which has been communicated must be controlled by laws since it has left the confines of a relationship between two people. Telecommunications and computers increase the potential for invasion of this type of privacy by making storage and retrieval of information more practical. Interpersonal interaction is controlled by norms which indicate how to communicate without invading the others' privacy. Telecommunications increases the potential for invasion of this type of privacy by bringing people with different norms together, by reducing the feedback which is probably necessary for creating new norms, and by creating inequalities in the information flow between two persons.

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