Communications Research Centre

A REVIEW OF THE EFFECT OF PROPAGATION DELAY ON VERBAL INTERACTION

by

W.C. Treurniet

CRC TECHNICAL NOTE NO. 686

Department of Communications

Ministère des Communications

OTTAWA, MAY 1977

COMMUNICATIONS RESEARCH CENTRE

DEPARTMENT OF COMMUNICATIONS
CANADA

A REVIEW OF THE EFFECT OF PROPAGATION DELAY ON VERBAL INTERACTION

by

W.C. Treurniet

(Technology and Systems Branch)

CRC TECHNICAL NOTE NO. 686

May 1977
OTTAWA

Standard Press — Wallaceburg, Ontario, Canada
Contract No. 660KX — 5 — 0001/1

TABLE OF CONTENTS

A REVIEW OF THE EFFECT OF PROPAGATION DELAY ON VERBAL INTERACTION

by

W.C. Treurniet

ABSTRACT

The effect of propagation delay on interactive verbal communication is examined by reviewing the results of various field and laboratory studies. It is concluded that most field studies failed to address themselves to the above issue. However, one field study and the laboratory investigations showed that communication patterns were disrupted by delay. Specifically, roundtrip delays equal to or greater than 600 msec resulted in (1) increased durations of utterances, simultaneous speech, and mutual silences, (2) increased number of confusions and (3) increased time to complete a problem solving task. However, the participants often were not aware of the true cause of the disruptions. Further, it is suggested that relatively long delays (e.g. 1800 msec) can cause the partner in the interaction to be perceived as less attentive.

1. INTRODUCTION

Speech interaction among humans is a process which is regulated by auditory and visual cues. That is, some of the information which facilitates or inhibits turn-taking appears to be made up of components of the speech itself, while additional relevant information is provided by some body movements. Satellite systems, which modify temporal interaction patterns, may interfere with the intended overall information content of speech messages occurring in an interactive environment. Modification of the temporal organization of the verbal exchanges could introduce incorrect semantic and affective information. Therefore, the long-term effects on a society making extensive use of such systems, should not be underestimated.

Duncan (1972) has identified one visual cue and five auditory cues which he has called "turn-yielding" signals: (1) termination of a hand gesticulation used during a speaking turn or relaxation of a tensed hand position, (2) intonation, or a change in voice pitch at particular syntactic locations, (3) drawl on the final syllable or on the stressed syllable of a terminal clause, (4) stereotyped expressions such as "but uh" or "you know", (5) a drop in voice pitch and/or loudness in conjunction with a stereotyped expression, (6) syntax;

specifically, the completion of a clause involving a subject-predicate combination. Duncan (1972) has also identified an "attempt-suppressing" signal. This signal, which inhibits an auditor from attempting to take the floor, consists of a speaker's hands being engaged in gesticulation in a direction away from the body.

Duncan and Niederehe (1974) further define speaker-state signals which indicate that an auditor has shifted to the speaker state. Previously, he may or may not have been participating in back-channel behaviour which consists of small units of speech such as "m-hm" or "yeah", but which do not pretend to claim the floor. The speaker-state signals were defined as (1) a shift away in head direction, (2) audible inhalation, (3) initiation of a gesticulation, and (4) paralinguistic overloudness. These cues were effective in predicting who would persist during termination of simultaneous speaking. That is, the member of a dyad who demonstrated the greater number of speaker-state signals was the one who continued speaking following simultaneous speech.

Most of the identified cues are auditory in nature. Therefore, it is not too surprising that Cook and Lalljee (1972) found no increase in verbal substitutes for visual signals when mutual viewing was prevented. They did find, however, that dyads who could not see each other while conversing, produced many more short utterances of less than five words in length compared to those who faced each other while conversing. Perhaps there existed an increased sensitivity to, or need for feedback signals from the person who could not be seen. Fewer interruptions in the no-vision condition than in the vision condition further suggests that the short utterances were voluntary and not caused by competition for floor time between members of the dyad.

It appears, therefore, that sufficient cues exist when visual cues are excluded, to allow dyadic vocal interaction to continue as smoothly as when mutual viewing is possible.

The distribution of speaker switching times has been shown to have a modal value around 200 to 300 msec (Jaffe and Feldstein, 1970). Such short switching times require that responses to turn-yielding signals occur immediately following emission of the signals. When a turn-yielding signal is given, the speaker has the intention of yielding the floor to someone else. If the implicit offer is not accepted immediately, it may be withdrawn and the speaker may continue. A tardy acceptance of the offer of the floor in excess of two or three hundred msec, might then result in confusion due to simultaneous speaking.

Such tardiness can result from conditions imposed by relatively recent technological developments. Specifically, communication over very long distances, such as over satellite circuits, is accompanied by a significant delay. A voice signal mediated by a satellite in geostationary orbit is delayed by approximately 260 msec. If the turn-yielding signal is delayed by that much, the emitter of the signal would be aware of the response to that signal more than one-half second after its emission. If he were unaware of the physical delay due to the circuit, he may continue speaking, following a period of high probability of a response, and the result would be simultaneous speaking if a response had merely been retarded due to the long transmission time. Similarly, delay of a speaker-state signal can also result in confusion if both parties emit such a signal, and the two signals are separated by less than the delay time of the circuit. Normally, a speaker-state signal can be inhibited if a similar signal is received from someone else. When the signal emitted first is delayed, however, a second person may emit a similar signal before receiving the prior one, and confusion may result as to who possesses the floor.

The period of high probability for a response mentioned above is not a fixed quantity. Although it has a modal value in the order of two or three hundred msec (Jaffe and Feldstein, 1970; Phillips et al., 1977), it has been shown to vary even for an individual. Feldstein (1972) has shown that the duration of a switching pause, defined as the period of joint silence bounded by vocalizations of different speakers, can be a function of the mean pause durations of either the preceding or following speaker. Specifically, in highly structured interviews, the durations of switching pauses were found to be more highly correlated with pause durations (during speaking) of the person who terminated, rather than began, the switching pause. However, in an unstructured conversation with peers, the duration of switching pauses were found to be more highly correlated with pause durations of the person who began the switching pause. In the unstructured situation, therefore, a speaker's pause behaviour appeared to exercise some control over the response time of his partner. Since the correlations were positive, the longer a speaker paused between successive utterances, the longer was the immediately succeeding switching pause terminated by his partner. In the structured interview situation, however, the duration of a switching pause terminated by one person appeared less dependent on the partner's pause durations.

The dependency between switching pause and pause durations in an unstructured conversation, would suggest that the disruptive effect of delay on interaction would be less when the conversants speak slowly rather than quickly. Slow speech, resulting in longer switching pauses, would allow turn-yielding signals and speaker-state signals to be received before speeches are initiated at inappropriate times.

It appears from the above discussion, that propagation delay will have disruptive effects on vocal interaction. The question of the seriousness of the effects are the subject of this paper, and should be the subject of further research.

The evidence concerning the disruptive effect of propagation delay on interactive vocal behaviour will be drawn from both laboratory simulations and field studies. In some studies, particularly the field studies, the effects of delay were unavoidably confounded with the effects of poor echo suppression. (Emling and Mitchell (1963) lucidly discuss the problem of echo in telephone conversation. Also see Gould and Helder (1970), and Richards and Buck (1960).) However, the types of problems perceived by the speakers allow some inferences to be made about the sources of difficulty.

Consideration of the data from field and laboratory studies appear to allow the following major conclusions to be made:

1) The questions typically asked of the telephone users in the field studies and in some laboratory studies, are useful mainly in ascertaining circuit quality. They do not directly address themselves to problems associated with the interactive nature of verbal communication.

2) Laboratory studies as well as one field study, show that delay alters the temporal pattern of interactive communication.

3) These alterations appear to be attributed by the participants in the interaction to modifications in the partner's behaviour rather than to the increased propagation time.

2. FIELD STUDIES

2.1 METHODOLOGY

Three methods of evaluating the usefulness of a telephone circuit are summarized and compared by Barstow (1966): (1) The callback method has been employed in order to gain the customer's own response to the call he has just completed. Generally, two questions of primary interest were:

a) Did you or the person you have called have any difficulty talking or hearing over that connection? If yes, what type of difficulty did you have?

b) Which of these four words comes closest to describing the quality of that connection: excellent, good, fair or poor?

Clearly, the wording of these questions biases the customer to consider factors such as noise level, voice quality and signal amplitude in forming his response. Consequently, the interviewing results can be of diagnostic value by indicating maintenance failures and design defects (Karlin, 1967). However, the quality of the interaction pattern which could be reflected by the amount of simultaneous speech, for example, is not an issue with these questions. (2) Some reservations regarding applicability to the study of interactive communication, may be applied to the "service observation" technique. With this method, used in some European studies, experienced observers monitor calls and report any observed difficulties. Such a method may be useful for detecting communication problems, but it is also subject to the bias imposed by the observers. (3) Finally, "circuit rejection counts", or the number of times that a customer was sufficiently annoyed with a circuit to request another from the operator, has been used as a measure of circuit quality. Such a measure, however, appears to be much too insensitive to be useful since too few rejections occur (Barstow, 1966).

The majority of field studies have used the callback technique. The apparently limited use of the service observation technique may be due to ethical considerations about monitoring calls. Nevertheless, Barstow (1966) feels that the callback technique magnifies small differences in service acceptability, and that the service observation method, because experienced observers are involved, has greater merit.

As well as the aforementioned reservations regarding the relevance of the data from the field studies to the question of the effect of delay on interactive communication patterns, the data may be obsolete from a technical point of view. That is, much of the difficulty reported with the longer delays, appeared to be a result of inadequate echo suppressor function. The severity of the reported problems could well be reduced with new echo suppression technology (e.g. Suyderhoud, Campanella and Onufry, (1975).

The field study results suggest that delay was not perceived as a cause of difficulty in communication, but they do conflict with laboratory data. They may therefore, be considered as the basis for continued research in this area.

2.2 RESULTS OF EARLY EVALUATIONS

Helder (1966a) compared transatlantic telephone cable circuits with delays added to increase the round trip delay to 90, 300, 600 and 800 msec. Various types of echo suppressors were used. The callback method was employed to study customer responses to the circuits.

The percentage of interviews indicating difficulty was an accelerating function of round trip delay. With the delay of 90 msec, about 12 percent of interviews reported difficulty, whereas about 30 percent reported difficulty with the 600 msec delay, and about 50 percent reported difficulty with the 800 msec delay. The function for fair or poor ratings was similar to the function for difficulty. The comments associated with difficulty ratings indicated that cutting and fading were the main symptoms while echo and delay comments were rare. The predominance of cutting and fading comments suggests that the echo suppressors employed were inadequate with long delays. In spite of the increased difficulty, the length of conversations was not affected by increasing the delay.

A succeeding study (Helder, 1966a, 1966b; Karlin, 1967) compared transatlantic cable circuits having a round trip delay of about 80 msec, with Early Bird satellite circuits having a delay of 544 msec. Results were consistent with those expected on the basis of the relationship between difficulty and delay obtained in Helder's (1966a) first study. More interviewees had difficulty with the satellite circuits than with the cable circuits, with perceived difficulty as a function of delay experienced by U.S. customers being equivalent to that experienced by customers in the U.K. and France (Karlin, 1967). Again, the source of the difficulties appeared to be the echo suppressors in the circuits, since most comments were related to cutting, fading, and echo. The delay itself did not appear to be noticed by the customers. Additionally, prior experience with satellite circuits appeared not to affect ratings of the just completed call.

A similar study was reported by Hutter (1967) who analyzed customer reactions to calls placed over the HS-303 satellite. The satellite circuits, having round trip delays of 540 msec were compared with transatlantic cable circuits which had round trip delays of about 70 msec. Circuits with longer delays were also obtained with calls routed via the satellite and then via cable, with or without additional simulated delay. Post-call interviews like those of Helder (1966a), revealed a very similar pattern of percentage interviews reporting difficulty as a function of delay. Specifically, 16 percent of interviewees reported difficulty with the 70 msec round trip delay, 33 percent with the 540 msec delay, and 60 percent with an 800 msec delay. Hutter (1967) also concludes that customer opinions are unaffected by increased exposure to satellite circuits.

Although the types of problems were not documented, it is conceivable that here, as in the Helder (1966) studies, difficulties arose from increasingly inappropriate actions of echo suppressors with increasing delay.

A method similar to the service observation technique was employed by De Jong (1967) to study the effect of delay over the Early Bird satellite on patterns of conversation. The most significant finding was a much higher frequency of simultaneous speech with satellite calls than with cable calls. Assuming that there was greater "pressure" to finish shorter calls than longer calls, the average time between two successive cases of simultaneous speech was calculated for satellite calls either shorter than or longer than four minutes in duration. For the shorter calls, the time between successive simultaneous speeches was approximately 1.5 minutes, while the corresponding time for the longer calls was about two minutes. Additionally, 30 percent of the simultaneous speech in the shorter calls resulted in confusion as opposed to eight percent in the longer calls.

The cable calls yielded insufficient simultaneous speech to allow comparison of shorter calls with longer calls. However, the average time between successive simultaneous speeches in the longer calls was approximately 28 minutes, or about 26 minutes more than in the satellite calls.

In agreement with Helder's (1966a) finding, a Wilcoxon's test indicated no significant difference between call durations over satellite circuits and over cable circuits.

2.3 RELEVANCE OF USER GROUP TO THE EFFECTS OF DELAY

Barstow and Campanella (1973) report the results of callback interviews following a relatively small number of calls over single and double-hop satellite circuits between Brazil and Japan. The single-hop circuit used the Intelsat-IV satellite in tandem with terrestrial links, and had a round trip delay of 640 msec. The double-hop circuit was routed through the Intelsat-IV satellite and the Intelsat-III satellite, and had a round trip delay of 1070 msec. Sixteen percent of interviews reported difficulty with the double-hop circuit, while 10 percent reported difficulty with the single-hop circuit. However, call quality was rated higher for the double-hop circuit than for the single-hop circuit. Such incongruity between reports of difficulty and quality is unexpected since Helder (1966a) and Hutter (1967) showed with much larger samples, a parallel relationship between the two variables as a function of delay. The fact that the samples of Helder (1966a) and Hutter (1967) were drawn from North American and European populations, while Barstow and Campanella's (1973) samples were drawn from South American and Oriental populations, suggests that cultural differences might influence the response of users to circuits with delay. However, the possibility exists that the echo suppression which appeared to contribute to difficulty in circuits with long delays in Helder's (1966a) study, was improved in the INTELSAT network.

Campanella, Suyderhoud and Onufry (1970) provide evidence that circuits with long delays were acceptable for use by military and civilian U.S. government personnel who were experienced in communicating over world-wide military telephone networks. Two, three and four hop, real and simulated satellite circuits were employed in order to evaluate the usefulness of two or more satellites in tandem for global communication by this rather select user group. The round trip delays were, respectively, 1100, 1640 and 2220 msec. The callback interviews required that the call be rated in one of four categories:

1) better than usual

2) about the same

3) poorer than usual

4) unacceptable,

where "usual" stood for the usual oversea call. The results showed less than a 20 percent drop in the first rating category from the two hop to the four hop condition, almost no change in the second category, about a

17 percent increase in the third category and a 5 percent increase in the fourth category. A statistical test showed the responses to the four categories for the four-hop condition to be significantly different, at a confidence level of 95 percent, from the responses for the two-hop condition. The three hop condition resulted in intermediate responses not significantly different from the two-hop condition. It was also noted that, with the longest delay, participants changed their normal conversational habits. They appeared to become more polite by waiting until the other party was finished speaking before answering. Campanella et al. (1970) conclude that telephone circuits involving two satellite hops are perfectly satisfactory for the population from which their data was obtained, but they urge caution in extrapolating directly to a naive general public. Such a conclusion suggests that a user who is aware of the existence of delay, can learn to regulate his behaviour in order to compensate for its effects.

2.4 SUMMARY

The relevance of the field study data to understanding the effect of delay on interactive communication patterns suffers greatly because of the bias toward circuit quality of the questions posed during the callback interviews. Nevertheless, some conclusions can be stated with this limitation in mind.

1) Increasing difficulty with a circuit was associated with increasing delay (Helder, 1966a; Hutter, 1967).

2) Problems associated with increasing delays could often be attributed to poor echo suppressor action (Helder, 1966a).

3) Delay was rarely named as a cause of difficulty (Helder 1966a).

4) The length of conversations was not affected by delay (Helder, 1966a, De Jong, 1967).

5) Amount of prior exposure to satellite circuits did not influence the rating of a just completed call (Helder 1966a, Hutter, 1967).

6) Adaptation to delay may occur as indicated by modified conversational habits (Campanella, Suyderhoud and Onufry, 1970).

7) Delay causes an increase in simultaneous speaking (De Jong, 1967).

3. LABORATORY STUDIES

The results of the field experiments suggest that significant propagation delay results in poor performance of echo suppressors not designed for use in such circuits. The resulting channel degradation must be considered as one aspect of the effect of delay on interactive verbal communication, and has been evaluated in a more controlled environment. Laboratory studies have also been concerned with more direct effects of delay on the participants in the interaction. Delay has been shown to influence the quantity and temporal organization of speech, as well as the subjective responses of the participants. The various consequences of delay, as determined by laboratory investigation, are presented in this section.

3.1 CONTRIBUTION OF THE ECHO SUPPRESSOR TO USER DISSATISFACTION

Riesz and Klemmer (1963) have attempted to differentiate between the effects of delay alone and delay combined with echo suppression. The effect on user dissatisfaction of delay with and without the need for echo suppression was studied at Bell Telephone Laboratories in separate experiments using laboratory personnel as subjects. In the first experiment, artificial round trip delays of 600, 1200 and 2400 msec were unobtrusively inserted into existing echo-free telephone lines. The measure of transmission quality was the number of times in each condition that circuits were rejected. Rejection of the circuit and automatic replacement by a standard circuit was accomplished by dialing the digit "3". The number of rejections with 600 and 1200 msec delays was negligible until the 2400 msec delay was experienced for a limited time. Then the number of rejections with the shorter delays began to increase to about 40 percent as if sensitization to the effect of delay had occurred. Klemmer (1967) attempted to replicate this apparent sensitization effect with the same user population and found very slight sensitization with only the 1200 msec delay following limited exposure to the 2400 msec delay. At this point, therefore, the sensitization effect remains unconfirmed.

The second experiment reported by Riesz and Klemmer (1963) compared the standard circuit to those with echo suppressors and round trip delays of 50, 200, 600 and 1200 msec. The rate of rejection of the circuit was found to increase monotonically with delay up to about 40 percent. Circuit rejections occurred relatively more often with the inclusion of echo suppressors, than in their previous experiment where echo suppressors were not used. The implication, consistent with that inferred from Helder's (1966a) field study, is that the echo suppressors used performed inadequately with appreciable delays.

3.2 CONTRIBUTION OF ECHO TO USER DISSATISFACTION

If echo suppressors create problems for the user on circuits with significant propagation delay, how intolerable would be the unsuppressed echo? To determine the contribution of echo to user dissatisfaction with the telephone circuit, Williams and Moye (1971) manipulated the amount of echo cancellation in a simulation experiment with various round trip delays up to 1200 msec. Factory and laboratory staff were requested to report whether or not difficulty was experienced with the circuit. In general, the percentage of reports indicating difficulty increased with increasing delay. However, the percentage difficulty also interacted with the amount of echo-return loss. Specifically, the degree of difficulty appeared to be tolerable with an echo-return loss in excess of 37 dB, with any delay up to 1200 msec. Overall, echo appeared to be the main perceived cause of difficulty while delay accounted for a very small proportion. Obviously, suppression of echo is a necessary requirement.

3.3 OBJECTIVE EFFECTS OF DELAY ON INTERACTION

Krauss and Bricker (1967) investigated the effect of delay in voice circuits free of echo sources and echo suppressors. College students were requested to perform, in pairs, a task which required the transfer of information from a "sender" to a "receiver". Round trip delays of 50, 600 and 1800 msec were employed. The results indicated no differential effect on the interaction between the two shorter delays. However, the 1800 msec delay appeared to increase the number of words used by the sender relative to both of the shorter delays. But since no effect was noted on the number of utterances, it was concluded that the long delay tended to increase the length of the sender's utterances. No effect on the receiver's behaviour was noted.

Brady (1971) performed an extensive analysis of vocal interaction between dyads using echo-free telephone circuits with round trip delays of 0, 600 and 1200 msec. Three kinds of objective measurements were taken: (a) the first five minutes of each session was evaluated for the presence of confusion which was defined as a reaction to simultaneous speech (e.g. "What? "), or self-generated repeat, or a sudden halt in the middle of an utterance, (b) an objective loudness measurement was taken from the first five minutes of speech and (c) an automated on-off speech pattern analysis was performed over the entire duration of each experimental condition.

Each of 32 pairs of subjects conversed for ten minutes with the zero-delay condition and for a further ten minutes with either the 600 or 1200 msec delay. The delay and no-delay conditions were counter-balanced such that half the subjects were exposed to delay first and half to no-delay first. None of the subjects were told that the delay would be introduced into the circuit, and at the post-experiment interview, none professed to being familiar with delay circuits.

The number of confusions as measured by observers, was found to be significantly greater in both the 600 and 1200 msec delay conditions than in the zero delay condition. Further, the difference between the 600 and 1200 msec delays was not significant.

The speech loudness measurements showed that delay had no significant effect on loudness of speaking.

The analysis of temporal patterns of vocal interaction was performed using the methodology described by Brady (1965). A significant increase from the zero-delay condition, in the amount of simultaneous speech and of mutual silence was found in the data from the 600 and 1200 msec delay conditions. Further, there were no significant differences between the 600 and 1200 msec delay conditions with respect to these measures.

In general, the effects of the 1200 msec delay were similar to those of the 600 msec delay. Brady (1971) concludes that the magnitude of the disturbance produced by delay on dyadic vocal interaction, asymptotes at around 600 msec.

Finally, Vartabedian (1966) studied some reactions to assymetric delays in a 3-node conferencing circuit. Each of nodes A, B and C were connected to a convergence point (CP) which, in a real situation, might be an operator's switchboard. The round trip delay was 1200 msec between A and CP, 600 msec between C and CP and zero between B and CP. The control experiment consisted of the same configuration without the presence of delays. Each group of three subjects was required to perform a problem solving task involving the transfer of information among the nodes.

The results indicated that the groups with delay circuits took significantly longer to complete the tasks than did the groups with no-delay circuits. However, possibly as a consequence of the slower rate of performance, the groups with delay committed significantly fewer errors than did the groups without delay.

To determine whether or not the magnitude of the delay influenced the selection of a chairman within a group, a chairman was defined as the person with the highest frequency of initiating the task subsets. Using an expected probability of 1/3 for task initiation for each of the three nodes, a chi-squared test indicated any deviation from chance behaviour. When a significant deviation occurred, the person with the highest number of initial responses was designated chairman. No consistent pattern was apparent between chairmanship and circuit condition.

3.4 SUBJECTIVE EFFECTS OF DELAY ON INTERACTION

Each of the studies discussed in the preceding section also took note of subjective reactions of the participants. Specifically, Krauss and Bricker (1967) found that subjects in the 1800 msec delay condition, rated their partners as significantly less attentive. Such a perception might be considered the result of longer response latencies forced by the long round trip delay.

Brady (1971) interviewed his subjects separately following the experimental session, and asked if they had noticed anything unusual about the circuit. None of the subjects' opinions reflected any awareness of the existence of the delays. Two pairs in the 1200 msec delay condition said that confusion had occurred but the problem was not attributed to any circuit characteristic.

Vartabedian (1966) also found that the questionnaire data indicated that no awareness of the presence of delay in the circuits had developed, although some participants complained of increased simultaneous speaking. Additionally, the post-experiment questionnaire inquired directly if a conference chairman had emerged. If two of the three persons of a group agreed, their selection was designated as chairman of the group. Again, the probability of someone being selected chairman appeared not to be related to any delay condition.

3.5 SUMMARY

The laboratory studies confirm some field study results and also provide data more relevant to the issue of the effect of delay on the behaviour and attitude of the participants. The following conclusions can be stated.

1) Echo suppressors used in circuits with delay cause undesirable effects as judged by the user, thus confirming Helder's (1966a) conclusion (Riesz and Klemmer, 1963).

2) Echo-return loss in excess of 37 dB is desirable in circuits with delay (Williams and Moye, 1971).

3) Delay increases the length of utterances (Krauss and Bricker, 1967).

4) Delay increases the number of confusions in an interaction (Brady, 1971).

5) Delay increases the amount of simultaneous speech and mutual silence (Brady, 1971).

6) Delay increases the time to complete a task, but reduces the number of errors in performing the task (Vartabedian, 1966).

7) Delay causes partners in an interaction to appear less attentive (Krauss and Bricker, 1967).

8) Participants tend not to be aware of propagation delay when they are exposed to it (Brady, 1971; Vartabedian, 1966).

4. DISCUSSION

The basic findings from the field studies appear to suggest that increased propagation times are not perceived as a problem by the telephone customer. Rather, criticisms of the circuits, when they occurred, resulted from changes in voice quality such as fading and cutting. One might surmise then, that users either are not bothered by increased propagation times, or are not able to causally relate the increased difficulty of interaction with the increased propagation time. The bulk of the evidence favours the latter interpretation. As De Jong (1967) suggests, "if he (the telephone customer) has complaints, he will formulate them by means of concepts he knows from everyday conversation. Thus he will be quite unfamiliar with the phenomenon of delay time, and therefore he should not be expected to comment upon delay time when faced with its results". That disruptive changes in interaction patterns do occur as a consequence of delay is indicated by the increased simultaneous speech found in De Jong's (1967) field study, and by other effects found in several laboratory investigations. Krauss and Bricker (1967) found that perceived attentiveness of the partner decreased, and that the length of utterances appeared to increase with increasing delay. Vartabedian (1966) found that time for task completion was longer with than without delay, and that more subjects complained of simultaneous speaking with than without delay. Brady (1971) found increased confusion during interaction with delay, as well as increased durations of simultaneous speech and mutual silence. And yet, subjective reports by most of the subjects involved in the various studies, indicated no awareness that confusions or long switching pauses were a consequence of a physical characteristic of the circuits involved. Rather, perceived difficulties tended to be interpreted as originating with the partner in the interaction (e.g. the inattentiveness reported by Krauss and Bricker (1967)). This observation is reminiscent of the finding by Werner and Latané (1976) that responsive partners in an interaction were judged more likable and persuasive, and were considered to have discussed better than non-responsive partners. If apparent non-responsiveness is a concomitant of long delays, similar effects on person perception could be present during interaction mediated by circuits with long propagation times.

5. CONCLUSIONS

Field studies which investigated the effects of long propagation delays in telephone circuits, suggested that users were mostly bothered by circuit problems other than the delay conditions per se. However, laboratory studies showed that delay does disrupt normal interaction patterns, and that these disruptions can be bothersome. The field studies which specifically inquired about problems with the circuit, may have missed any problems which the user did not attribute to the circuit. The disturbance of interaction patterns was rarely attributed by the participants to circuit characteristics in either the field or laboratory studies. Rather, the effects appeared to be attributed to the partner's behaviour. The data strongly suggest that disturbances of interaction patterns become significant at roundtrip delays in excess of 600 msec, although the lower limit needs to be investigated further.

6. RECOMMENDATION FOR RESEARCH

It appears that circuits with long propagation times are usable for interactive voice communication. Precisely because these circuits will continue to be used, it is important to better understand the more subtle effects of propagation delay on person perception and creation of a social bond. Perceived inattentiveness due to long propagation times, as observed by Krauss and Bricker (1967), may be only one psychological dimension among many that may be affected. Certainly, this is an area that needs to be researched more fully in order to understand the behavioural effects of communication via satellite. A specific area which remains relatively unexplored, is the social dynamic of interaction among a number of groups linked by multi-hop satellite circuits which impose various delays.

7. REFERENCES

Barstow, J.M., *Results of User Reaction Test on Communication Via Early Bird Satellite*. Progress in Astronautics and Aeronautics, 19:77-83. New York: Academic Press, 1966.

Barstow, J.M., and Campanella, S.J., *Geostationary Satellite Telephone Circuit Transmission Quality*. Telecommunication Journal, 40:83-87, 1973.

Brady, P.T., *A Technique for Investigation On-Off Patterns of Speech*, Bell System Technical Journal, 44:1-22, 1965.

Brady, P.T., *Effects of Transmission Delay on Conversational Behaviour on Echo-free Telephone Circuits.* Bell System Technical Journal, 50:115-134, 1971.

Campanella, S.J., Suyderhoud, H.G., and Onufry, M., *Subjective Evaluation of Dedicated Multiple-hop Satellite Communications for Government and Military Users.* IEEE Transactions on Communication Technology, COM-18:663-671, 1970.

Cook, M., and Lalljee, M.G., *Verbal Substitutes for Visual Signals in Interaction.* Semiotica, 6:212-221, 1972.

De Jong, C., *Observations on Telephone Calls Between the Netherlands and the U.S.A.*. Het P.T.T.-Bedrijf, May, 32-36, 1967.

Duncan S., *Some Signals and Rules for Taking Speaking Turns in Conversations.* Journal of Personality and Social Psychology 23:283-292, 1972.

Duncan, S. and Niederehe, G., *On Signalling that it's Your Turn to Speak.* Journal of Experimental Social Psychology, 10:234-247, 1974.

Emling, J.W. and Mitchell, D., *The Effects of Time Delay and Echoes on Telephone Conversations*. Bell System Technical Journal, 42:2869-2891, 1963.

Feldstein, S., *Temporal Patterns of Dialogue: Basic Research and Reconsiderations*, in Studies in Dyadic Communications, A.W. Siegman, and B. Pope, Eds., New York: Pergamon Press, 1972.

Gould, R.G. and Helder, G.K., *Transmission Delay and Echo Suppression*. IEEE Spectrum, 7:47-54, 1970.

Helder, G.K., *Customer Evaluation of Telephone Circuits with Delay*. Bell System Technical Journal, 45:1157-1191, 1966a.

Helder, G.K., *Subjective Evaluation of Telephone Communications via Early Bird Satellite and Cable Circuits*. Progress in Astronautics and Aeronautics, 19:85-93, New York: Academic Press, 1966b.

Hutter, J., *Customer Response to Telephone Circuits Routed Via a Synchronous-orbit Satellite*. The Post Office Electrical Engineers' Journal, 60:181-186, 1967.

Jaffe, J. and Feldstein, S., *Rhythms of Dialogue*, New York: Academic Press, 1970.

Karlin, J.E., *Measuring the Acceptability of Long Delay Transmission Circuits Used During the "Early Bird" Transatlantic Tests in 1965*. Het P.T.T.-Bedrijf, May, 25-31, 1967.

Klemmer, E.T., *Subjective Evaluation of Transmission Delay in Telephone Conversations*. Bell System Technical Journal, 46:1141-1147, 1967.

Krauss, R.M., and Bricker P.D., *Effects of Transmission Delay and Access Delay on the Efficiency of Verbal Communication*. Journal of the Acoustical Society of America, 41:286-292 1967.

Phillips, D.A., Treurniet, W.C., Tigges, W.S., and Lewis, P., *Time Analysis of Vocal Interaction: A Report on Methodology*. CRC Technical Note 684, March 1977.

Richards, D.L. and Buck, G.A., *Telephone Echo Test*. Proceedings of the I.E.E., 107B:553-556, 1960.

Riesz, R.R. and Klemmer, E.T., *Subjective Evaluation of Delay and Echo Suppressors in Telephone Communications*. Bell System Technical Journal, 42:2919-2941, 1963.

Suyderhoud, H.G., Campanella, S.J. and Onufry, M., *Results and Analysis of Worldwide Echo Canceller Field Trial*, Third International Conference on Digital Satellite Communications, Kyoto, Japan, 1975.

Vartabedian, A.G., *The Effects of Transmission Delay in Four-wire Teleconferencing*. Bell System Technical Journal, 45:1673-1688, 1966.

Webb, J.I., *Interview Synchrony: An Investigation of Two Speech Rate Measures*, in Studies in Dyadic Communication, A.W. Seigman and B. Pope, Eds., New York: Pergamon Press, 1972.

Werner, C. and Latané B., *Responsiveness and Communication Medium in Dyadic Interactions*. Bulletin of the Psychonomic Society, 8:569-571, 1976.

Williams, G. and Moye, L.S., *Subjective Evaluation of Unsuppressed Echo in Simulated Long-delay Telephone Communications*. Proceedings of the I.E.E., 118:401-408, 1971.

CRC DOCUMENT CONTROL DATA

1. ORIGINATOR: Department of Communications/Communications Research Centre

2. DOCUMENT NO: CRC Technical Note No. 686

3. DOCUMENT DATE: May 1977

4. DOCUMENT TITLE: A Review of the Effect of Propagation Delay on Verbal Interaction

5. AUTHOR(s): W.C. Treurniet

6. KEYWORDS: (1) Delay
(2) Interaction
(3) Verbal

7. SUBJECT CATEGORY (FIELD & GROUP: COSATI)

05 Behavioral and Social Sciences

05 10 Psychology

8 ABSTRACT:

The effect of propagation delay on interactive verbal communication is examined by reviewing the results of various field and laboratory studies. It is concluded that most field studies failed to address themselves to the above issue. However, one field study and the laboratory investigations showed that communication patterns were disrupted by delay. Specifically, roundtrip delays equal to or greater than 600 msec resulted in (1) increased durations of utterances, simultaneous speech, and mutual silences, (2) increased number of confusions and (3) increased time to complete a problem solving task. However, the participants often were not aware of the true cause of the disruptions. Further, it is suggested that relatively long delays (e.g. 1800 msec) can cause the partner in the interaction to be perceived as less attentive.

9. CITATION:

DATE DUE
DATE DE RETOUR

LOWE-MARTIN No. 1137

Government of Canada
Gouvernement du Canada