THE EFFECT OF COMPUTER-GENERATED DELAYS OF VARYING DURATION UPON STUDENT ATTITUDES TOWARD COMPUTER ASSISTED INSTRUCTION

CENTRE FOR NEWFOUNDLAND STUDIES

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THE EFFECT OF COMPUTER-GENERATED DELAYS OF VARYING DURATION UPON STUDENT ATTITUDES TOWARD COMPUTER ASSISTED INSTRUCTION

by

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Abstract

Little research has been carried out on performance criteria for computer systems used in the classroom for computer assisted instruction (CAI). Brief interruptions and delays are common in such systems. Faster, more responsive equipment may be too expensive.

This study was initiated to investigate the effects of random computer-generated delays on the attitudes of both male and female students towards CAI. The study also sought to look into the effects of these delays on students' achievement in a CAI lesson.

Fifty-four third-year university students were randomly divided into three groups of eighteen subjects each. The first group, the control group, completed a CAI lesson in which there were no delays. The second group, an experimental group, was given a version of the same lesson in which they experienced seven delays with mean duration of eight seconds. The third group was given another experimental treatment, a version of the lesson in which the length of each delay had been doubled for a mean duration of sixteen seconds. At the end of the lesson each subject was required to complete a ten-item achievement test and an eleven-item semantic differential attitude questionnaire.
The scores from the attitude scale were statistically analysed using several applications of the analysis of variance technique. No differences in attitude towards CAI were found between the three subject groups nor between male and female subjects.

The scores from the achievement test were also analysed by analysis of variance tests. No differences were found in achievement scores between the three groups.

The results of this study indicate that, within certain limitations, random delays of up to sixteen seconds mean duration are tolerable in computer assisted instruction systems.
Acknowledgements

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Chapter I

INTRODUCTION

Computer Assisted Instruction (CAI) was developed over twenty years ago as an advanced teaching machine technique. The digital computer was seen as an ideal medium for programmed learning. Since then, CAI has become a much more sophisticated and cost-effective instructional method.

To minimize costs, CAI is often implemented on very small and inexpensive computers or larger systems with a great number of simultaneous users. For a variety of reasons, the users of such systems are frequently subjected to both predictable and unpredictable delays and interruptions. These can occur at any time during an interaction with the computer and may be of any duration. Under such conditions the users may experience annoyance and frustration.

In computer assisted instruction, student performance and attitude are related. Negative attitudes appear to cause poor learning outcomes. Student attitudes toward CAI are generally favourable, but equipment shortcomings hurt these attitudes.

Some research has been carried out to establish the types of computer equipment best suited to effective CAI. Much of this has dealt with the optimization of display
screens, graphics, sound, and other such attributes of the student terminal equipment. A very small number of investigators have looked into desirable computer performance characteristics.

The use of teaching machines for programmed learning was an application of psychological learning theories which emphasized the importance of immediate feedback to reinforce student behaviors. As computer assisted instruction grew out of this earlier technology, there has been significant interest in the educational effects of feedback delay. The duration of the information feedback interval is dependent on the system response time of the computer being used. As this is an important measure of computer performance, and one which is expensive to improve, a number of computer scientists have studied user tolerances to poor system response times.

There has been very little investigation of the effects of other types of computer equipment-related disruptions of an interactive session or CAI lesson. However, such delays and interruptions may have significant long term impact on students' attitudes toward computers and their ability to deal with them as well as an immediate effect on both their attitudes toward CAI and their learning outcomes.

In computer assisted instruction, delays and interruptions can occur not only during the information
feedback interval but at any time during the session. The
frequency and duration of such disruptions can vary widely
depending on their cause. Such delays may lead to negative
attitudes and poor learning outcomes. The purpose of this
study was to measure the effects of randomly occurring delays
on student attitudes toward CAL.
Chapter II

REVIEW OF THE LITERATURE

Background

The past few decades have witnessed a large number of innovations in the field of education. Solutions have been put forward for many problems. New developments have invaded practically all facets of teaching and learning. Basic educational goals and philosophies have been questioned and attacked. New types of instructional materials have been invented and produced. New teaching strategies and methods have been developed. Educators have been exposed to new methods of evaluation, system design, and administration. A major area of innovation has been the increasing adaptation of various technologies to produce an almost bewildering array of audiovisual aids and teaching tools.

However, real change comes very slowly. Many new solutions brought new problems and were discarded. Other ideas were never implemented to a large enough degree to be meaningful or to be properly evaluated. Many of the shiny technological tools such as teaching machines that promised to revolutionize the classroom lie rarely used and obsolete.

Few educational innovations have generated as much interest and attention as Computer Assisted Instruction (CAI). Computer Assisted Instruction may be defined as the
use of a computer system to provide on-line direct
interactive instruction, testing, and prescription (Unwin and
McAleese, 1978). Gillett (1973) describes it as "a man-
machine relationship in which the man is learner and the
machine is a computer system with a purpose of inducing human
learning and retention. The learner may interact directly
with the computer or with a terminal remotely connected to a
computer." Computer Assisted Instruction is also known as
Computer Assisted Learning (CAL). It is not to be confused
with other educational uses of the computer, both
instructional and non-instructional.

CAI programs may be broken down into five major
categories or levels of interaction. These are drill and
practice, tutorial, dialogue systems, simulation and gaming,
and problem solving and inquiry (Tuttle, 1971). These five
categories account for 89 percent of the 2810 entries listed
by Hoye and Wang in their 1973 Index to Computer Based
Learning.

Drill and practice is the simplest type of CAI and is
used to supplement other teaching methods. After the content
has been taught, the students use the computer exercises to
facilitate retention. Any new learning takes place mostly
through trial and error (Nager, 1982). Tutorial systems
allow the presentation of information to the learner, as well
as drill and practice (Tuttle, 1971). Most CAI programs have
been of this type (Hoye and Wang, 1973). Tutorial CAI limits interaction to the rigid constraints of programmed learning. Dialogue systems overcome this drawback. The machine and student are permitted to carry on an unrestricted dialogue about the content. This is the most complex type of CAI; and although a significant number of programs of this type have been prepared (Hoye and Wang, 1973), further progress is largely tied to research in natural languages and artificial intelligence (Howe, 1978). Simulations and games are used to teach the relationships between variables in computer models of real systems. The student alters the variables and observes the resulting effects on the whole model. There is no formalized learning guidance (Wager, 1982). The last type of CAI, problem solving and inquiry, allows the student to solve problems by means of real time computation and data retrieval (Tuttle, 1971).

Supporters of computer assisted instruction claim a number of advantages over other teaching methods. Individualized instruction, catering to the needs and abilities of each student, has become a popular educational concept. Such individualization of learning has been seen to be a major advantage of CAI (Tuttle, 1971; Jamison, Suppes, and Wells, 1974; McCulloch, 1980).

In a considerable number of studies, researchers have explored the effectiveness of CAI. Various reviews of the literature (Vinsonhaler and Bass, 1972; Jamison et al., 1974;
Thomas, 1979; Braun, 1980) indicate that CAI, when used as either a supplement to or as a replacement for traditional teaching methods, produces achievement and retention levels equal to or higher than the traditional methods alone.

Time-saving appears to be a major benefit of CAI. It has been shown that students using CAI take considerably less time to learn than those using other methods (Vinsonhaler and Bass 1972; Jamison et al., 1974; Edwards; Norton, Taylor, Weiss, and Dusseldorp, 1975; Thomas, 1979; Dence, 1980).

CAI can be of particular benefit to the educationally disadvantaged. Below average students make larger relative gains using CAI than other students (Jamison et al., 1974; Dence, 1980). Using common CAI programs, the quality of instruction in the schools can be partially equalized (National School Public Relations Association, 1968).

Computer literacy has become an issue in education. It has been stated that computers and related electronic equipment have such an important role in today's society that students who graduate from school without having been exposed to computers have had an incomplete education (Molnar, 1978; Luehrmann, 1980). Computer assisted instruction, with its necessary hands-on computer experience, is seen as a means of developing computer-literate graduates.

Two factors which are often listed among the most
important positive attributes of CAI have not been mentioned in this discussion. Immediate feedback is of prime importance in certain learning theories and was one of the reasons for the development of programmed learning and CAI. Student attitudes toward the medium are usually positive. Both these areas are central to this study and will be covered in some detail later in this chapter.

In spite of these apparent educational advantages of using CAI, there are a number of reasons why the practice has not become a standard in the schools. One reason is that school systems are very resistant to change. Although certain outward trappings may be different, the roles of the teacher, textbook, and classroom have not really changed in the past hundred years. The complexity of the machines, the lack of teacher experience with them, and bad experiences with other educational technologies not living up to promised results are all barriers to the adoption of CAI (Martellaro, 1980).

There is a fear that the computer can dehumanize the educational experience. Donoian (1979) sees the student who has been largely taught by CAI as lacking responsible adult role models, having affective needs unsatisfied, and being isolated from other people. Computers cannot train students to associate effectively with other people, present ideas and defend them from criticism, nor to speak effectively before a group (NSPRA, 1968).
Other educational drawbacks include emphasis on the lower levels of cognitive learning (Schoen, 1974), unsuitability for certain types of subject matter (Ellis, 1974), and lack of suitably trained teachers and specialists (Morrison, 1978; Aiken, 1980; Martellaro, 1980; Braun, 1981).

The computer systems themselves present significant problems. The field can be characterized by lack of standardization and rapid obsolescence. A CAI lesson written for one system cannot be easily transferred to another system unless both happen to support the same languages (Simonsen and Renshaw, 1974). This contributes to the high cost of CAI materials.

The cost of CAI, both the programs ("software"), and the machines themselves ("hardware"), has been the major reason why computer assisted instruction has not found greater acceptance (Litrell, 1973; Simonsen and Renshaw, 1974; Daellenbach, Schoenberger, and Wehrs, 1976). The cost of software development for a given CAI implementation may be greater than that of the hardware (NSPRA, 1968; Simonsen and Renshaw, 1974). Computers were very expensive. Gillett (1973) quoted figures of $180,000 to $2 million as typical. Leasing costs for one terminal hour were often four or five times that spent by the average school for all instruction. Such costs can not be borne by the school systems which, although they absorb a large portion of government
expenditures, always seem to exist at little better than a subsistence level. However, hardware prices are falling dramatically. The earliest electronic computers contained tens of thousands of vacuum tubes, required large staffs and special buildings, and cost millions. Today, computers of greater power are available for home use at less than a thousand dollars. The progress from vacuum tubes through transistors to integrated circuits has created huge savings in material, labour, environmental protection, and servicing (Robertson, 1979). Mass production techniques and accumulated experience in the manufacture of microelectronic components have also led to cost decreases. As the manufacture of electronic functions (a function being a single transistor, logic gate, etc.) increased by a factor of two thousand between 1960 and the late 1970's, this has also brought about significant cost reduction (Noyce, 1977).

There appears to be no end in sight to this exponential gain in computer cost/performance ratios. Bubble and charge coupled device (CCD) memories are still in the early stages of their development. Optical techniques promise data storage densities ten to twenty times greater than presently possible. Communications improvements using satellites and fiber optics will allow much greater data transfer at a tiny fraction of present costs (Robertson, 1979). Superconducting computers promise to increase computer power and decrease cost greatly. By the end of the decade, a computer with
fifty times the power of today's large high speed computers may be able to reside in a six-inch cube (Matisee, 1980).

Frenzel (1980) plots the history of CAI against that of the computer industry. Each significant technical advance or price drop in the computer field resulted in a surge of interest in CAI: timesharing in the early 1960's, smaller timesharing computers in the late 1960's, inexpensive self-contained desktop units in the late 1970's. He states that each drop in price brings the computer closer to being a practical classroom tool and concludes that the new small and cheap computers have the greatest chance of making CAI cost-effective. Lipson (1980) believes that computer cost-effectiveness will continue (at least through the 1980's) to double every two years and projects that computer-controlled frame retrieval from videodisc will be available at one hundredth the cost of the printed page.

As computers become so much cheaper and mass distribution allows inexpensive software to become widely available (Frenzel, 1980), conventional instructional methods are becoming more expensive. Increases in the costs of textbooks, teacher salaries, conventional audiovisual equipment, and related materials are hastening the day when CAI will be a very economical method of instruction.
Literature critical to the study

Although the literature of computer assisted instruction is very large and much research on the subject has been done, very few studies have examined the characteristics of different computer systems that may affect their suitability for use in CAI. Delays, unexpected interruptions, and variable response times can be experienced in interactions with almost any computer system. The effects of these delays on the learner and on learning outcomes in CAI have, to a great extent, remained undocumented.

The research that has been carried out, by both computer scientists and educators, has largely been in the area of system response time (SRT). System response time can be defined as the interval between the operator's pressing the last key in the input operation and the system's first observable response (Maguire, 1982).

Lengthy SRTs can be caused by a number of factors. There are great differences in computational power between computers and programming languages (Gilbreath and Gilbreath, 1983). A slow computer or inefficient language can cause slow response especially where a complex computation is required. Such computations and access to bulk storage devices slow down the system (Nickerson, 1969). Certain bulk storage devices are much slower than others (i.e., magnetic
tape is slower than discs). In a timesharing system, where there may be a considerable number of concurrent users, the size of this load is another important factor (Nickerson, 1969).

Actual SRT durations are difficult to generalize and there are few examples in the literature. Gilbreath and Gilbreath (1983) used a single algorithm (for computing prime numbers) as a benchmark for comparing the execution speeds of a variety of languages and computers. Using the same FORTRAN program, one machine (a CRAY-I, one of the most powerful computers) took 0.110 seconds to complete the computation, compared to 509 seconds for another (an Apple II, an inexpensive desktop unit). A single computer (a small Hewlett-Packard model 85) took 21 seconds to complete the task when programmed in assembly language (a very low level type of computer language requiring much programming effort) and 3084 seconds when programmed in "BASIC.

A variety of bulk storage devices are used by computer systems to store both programs and data. Nickerson (1969), referring to large scale timesharing systems, describes users of magnetic tape storage as having to wait "a long time" in comparison to disc users. Jeffries (1983) lists the times taken by a variety of inexpensive personal computers to store ten thousand characters on a floppy disc (a relatively cheap storage system utilizing a removable non-rigid magnetic
medium). The times range from 11.4 seconds (for the IBM Personal Computer) to 46 seconds (for the Atari model 800). Such a delay must be expected whenever such a small computer has to load or save a program or data file. Audio cassette storage, available for the least expensive machines, is much slower.

Shneiderman (1979) gives a common design specification for SRTs of two seconds for 90 percent of commands and 10 seconds for the other ten percent. Writing about an interactive graphics system used in computer-aided design, Spence (1976) described calculation delays of up to 50 seconds.

Computer delays also occur at times other than those immediately following user input or commands. Systems sometimes "crash," or completely cease operation, without any warning or indication of the likely duration of the interruption. A user caught in the middle of an interactive session may lose a considerable amount of work (Nickerson, 1981). There are a number of other causes for work session interruptions. Tesler (1982) lists six different reasons why small single user systems can suddenly stop in the middle of an operation (in four of the cases the system will restart following a delay of unspecified duration). One of these delay conditions, "garbage collection" of outdated string variables by a number of popular BASIC interpreters) can have a duration of from less than a second to over half an hour.
Rapid system response times have been regarded as critical to computer assisted instruction as they represent delay of feedback to the learner. CAI grew out of the teaching machines of the 1950s and the work of B.F. Skinner, who believed that any delay between a student's response and the reinforcement of that response would result in poor learning. In a widely-acclaimed and influential article of 1954, Skinner created great interest and gained considerable support for his theories. Based upon his operant conditioning research with animals in "Skinner boxes," he stated:

It can be easily demonstrated that, unless explicit mediating behaviour has been set up, the lapse of only a few seconds between response and reinforcement destroys most of the effect. In a typical classroom, nevertheless, long periods of time customarily elapse (Skinner, 1954).

Skinner also criticized educational practice for using aversive consequences instead of using positive reinforcements, the lack of skillfully organized programs of studies building on small progressive steps, and the infrequency of reinforcement in the classroom. The process of education was presented as a scientific technology and almost all the problems of the school systems blamed on a lack of scientific rigour. He concluded with a call to arms:

There is a simple job to be done. The task can be stated in concrete terms. The necessary techniques
are known. The equipment needed can easily be provided. Nothing stands in the way but cultural inertia (Skinner, 1954).

However, certain areas of Skinner's work have since been subjected to considerable criticism. On a theoretical basis, his assumption that knowledge of results provides operant reinforcement has come under fire (Annet, 1969). In Renner's (1964) review of reinforcement delay studies, forty years of animal studies support Skinner's work. However, studies with human subjects do not. Delay of reinforcement or knowledge of results with human subjects showed no performance decrement (Renner, 1964).

Brackbill, Wagner, and Wilson (1964) pointed out the differences between human beings and animals in such experiments, stating that results from animal experiments are not generalizable to humans. "For the organism without language proficiency, the information and motivational effects of rewards and punishments are limited to the immediate present." They then went on to review the literature, including four experiments from their own laboratory, which indicated that the delay of feedback (feedback being defined as knowledge of results plus reinforcement, the reinforcement being dependent on motivation) during learning actually improved retention of the learned material, while immediate feedback during learning impaired retention.

This surprising finding has since been substantiated by
other researchers. More (1969) found retention improved significantly with feedback delays of two and one half hours and one day. Sasse and Yonge (1968) found retention improved by a delay of twenty-four hours and (1969) by a delay of only ten seconds. Similar results were reported by English and Kinzer (1966) and by Sturges (1978). Gay (1972) agreed that immediate feedback was not superior to delayed feedback, but found the optimal delay to be dependent on the complexity of the subject matter. She concluded that CAI delays in timesharing systems need not be an educational consideration.

The major focus of research in CAI has been on achieving the highest possible criterion performance in the shortest possible time for all students. Student attitude has been seen as a relevant factor only as it affects the attainment of this goal (Brown and Gilman, 1969). Different researchers have studied student attitudes toward CAI, the subject area being taught, and themselves, in terms of self-concept.

In a major U.S. Government study, James S. Coleman (1966) established the importance of student attitudes. Coleman measured three aspects of student attitudes, self-concept, sense of control, and interest in school and learning. He found that these attitudes accounted for more variation in achievement than either the total of all family background variables or all school variables. Smith (1973) used the Sears Self-Concept Inventory, the Coopersmith Self-
Esteem Inventory, and the Crandall Locus of Control Instrument to examine the attitudes of junior high school mathematics students. There was no significant difference in scores between CAI and non-CAI groups nor between pretests and posttests. The CAI group showed less stability in self-concept scores, but the means were not affected. Several studies with culturally and educationally disadvantaged students have shown improved self concept and interest in learning (Gipson, 1971; Bone, 1974; Maser, 1977). In a study dealing with high school algebra students, Dunn and Wastler (1972) reported that although the CAI group subjects had higher attitudes toward both CAI and mathematics, they showed slightly lower attitudes toward themselves and their school.

Most investigations of student attitude involve the comparison of the attitudes toward CAI and the subject matter of subjects exposed to the medium and those not exposed (Thomas, 1979). Such attitudes are also correlated with achievement (Brown and Gilman, 1969; Roid, 1971). Several reviews of the literature (Bundy, 1968; Beck, 1979; Thomas, 1979) indicate that students with CAI experience generally have more favourable attitudes than those without. Students using CAI think at least as highly of their courses of instruction as do students using other methods.

Brown and Gilman (1969) found high school students with CAI experience to have had more positive attitudes toward CAI
than those using a programmed text. Mathis, Smith, and Hansen (1970) compared the attitudes toward CAI of college psychology students in CAI and reading groups. Again the CAI group had higher scores. Both these studies used the same attitude measurement instrument, a 40-item Likert-type scale (Brown, 1966).

A number of other studies have produced similar results. An early IBM study (Long, Murphy, and Wengert, 1968) showed 88 percent of the test subjects (mixed high school and college students) had favourable attitudes. CAI - non CAI comparisons with positive findings included Broderick (1973), Johnson (1974), and Herrold (1974), all dealing with grade school students. Kockler (1973), Murphy and Appel (1978), Magidson (1978), and Knapper (1978) reported positive attitudes with college students. Research in military training (King, 1975; Lahey, Crawford, and Hurlock, 1975) and a prison school (Siegel, 1978) reached similar conclusions.

These positive attitudes have been found in a wide variety of disciplines. This is supported by studies in college physics (Gerell, 1977), teacher education in mathematics (Hall, 1969), business education (Weaver, 1975), ecology (Anderson, Klassen, Hansen, and Johnson, 1981), French (McEwan and Robinson, 1976), chemical engineering (Nuttall and Himmelblau, 1973), and medicine (Wells, Thompson, and Holm, 1973).
Studies of students with substantial long term CAI experience support these favourable findings and help rule out the influence of any novelty effect on research in the area (Magidson, 1978; Murphy and Appel, 1978). On the other hand Anderson et al. (1981) and Sherman and Klare (1970) showed that a short (15 minute) CAI experience can produce significant affective and cognitive results.

Researchers who found no significant attitudinal difference between CAI and non-CAI groups include Earle (1972), Denton (1972), Hughes (1976), Bickerstaff (1976), Goodson (1975), Cranford (1976), and Durall (1972).

Students taught only by computer miss human interaction with a teacher and other students (Summerlin, 1971; Alderman, 1978). Such attitudes can be improved by the addition of group activities (Gerrell, 1972; Alderman, 1978) and increased contact with teachers (Bunderson, 1979). Attitudes toward CAI can also be improved by increased use of graphics (Rigney and Lutz, 1976) and personalization, where the computer is programmed to mimic a human teacher by addressing the student by name and using praise. (Lippold, 1977; Tuttle, 1971).

Negative attitudes have often been equipment-oriented. Honeycutt (1974) found the noise and glare of the equipment to cause frustration. Students using typewriter terminals for CAI have been seriously bothered by the noise (Van der
Drift, Langerak, Moonen, and Vos, 1981). The use of Teletype machines as interactive terminals has been found to cause student frustration from slowness, noise, vibration, and inaccuracy (Schupbach, 1981; Lorton and Cole, 1981).

A number of authors report negative student attitudes associated with equipment delays and breakdowns. Eastmond and Nicholls (1975), Magidson (1978), and Knapper (1978) all reported poor attitudes caused by technical problems with the computer and terminal equipment. King (1975) suggested that poor system response times may cause tension and apprehension. Reid (1981) reported computer keyboard damage from severe "keybeating" when heavy loading increased response time or when the system malfunctioned. Wilcox and Schneider (1976) interviewed a number of student users of the TICCI-TCAI system. Thirty percent reported displeasure at the system becoming "unexpectedly inoperative." Twenty-five percent expressed frustration from poor response times and their inability to correct mistakes such as the inadvertent pressing of the wrong key. In a major comparison of four types of CAI systems, Van der Drift et al. (1981) found large differences in response times between the systems and in the individual students' tolerances of these delays. The fastest systems were judged best. Over forty percent of the students in the test groups encountered equipment breakdowns. They found these to be inconvenient and annoying, and particularly frustrating during computer-assisted testing sessions.
In computer assisted instruction, system response delays occur following student input to the computer. With most CAI modes, this will often be a delay of information feedback (IF). Some research has been carried out into the effects of such delays on attitude. Boersma (1966) studied the effects of delay of information feedback (IF) (0 and 8 seconds), post information feedback delays (0 and 8 seconds) and sex factors. He discovered frustration (defined as competing responses) to be generated during both types of delays and suggested that experiments with longer feedback delays might produce a critical delay where subjects could no longer cope with the frustration. Van Dyke and Newton (1972) looked at attitudes towards CAI under conditions of 0, 4, and 8 second information feedback delays. In this case, the female subjects showed significantly poorer attitude with the 8 second delay. Neither of these studies explored variable, unpredictable delays although these have been seen to be the most disruptive (Carbonnell, Elkind, and Nickerson, 1968). Neither dealt with the delays occurring outside the IF and post-IF intervals, although delays can happen at any time during a session. Neither dealt with delays of more than 8 seconds, although much longer delays are frequent.

Very few studies have examined the attitudinal consequences of CAI equipment breakdown or unscheduled interruption. Murray (1972) found repeated program defects to cause frustration which inhibited both achievement and
attitudes. Anderson et al. (1981) conducted a controlled experiment in which certain subjects were exposed to a simulated system failure about two-thirds of the way through a CAI lesson. This malfunction treatment produced little effect on the subjects' general attitudes and knowledge. However a significant difference was found in their sense of computer self-efficacy, or confidence in their ability to deal with computers. The students who had encountered the malfunction were less likely to have increased confidence in their ability to deal successfully with computers. This effect persisted through the follow-up tests administered six months later.

It must be remembered that students using computer assisted instruction are a small segment of the much larger population of computer equipment users. The literature of Computer Science provides an obvious source of information in this area. A number of authors refer to system delays and interruptions as being serious user problems, but few experiments have been carried out to determine their importance.

Two decades ago, computer time was extremely expensive. Nickerson, Elkind, and Carbonell (1968) noted that "hands on" computer use was restricted to a select, highly trained and motivated group of professionals who were willing to live with systems that were "anything but optimal from a human
As the cost of computer time was so much greater than that of the user, the former was economized even at the expense of the latter. The authors went on to state that the system response time is important to the user but very expensive to minimize. In another article (Carbonell, Elkind, and Nickerson, 1968), the same authors stated that longer SRTs cause decreasing user productivity and satisfaction, and that the users will tend to switch back and forth between tasks. Delays of constant duration were observed to be preferable to variable SRTs as unpredictable conditions disturbed the user. Nickerson (1969) reported that the frustration caused by a delay is not simply a function of its duration. It also depends on the user's uncertainty as to the length of the delay and its probable cause and the extent to which the delay contradicts his expectations.

By means of a data collection program installed on a large timeshared computer system, S.J. Boies (1974) investigated the relationship of system response time to user response time (defined as the time between the computer's prompting of the user and the user's next input). He found a strong correlation. As the SRT increased from 1 to 10 seconds, the user response time rose from 15 to 24 seconds.

IBM's R.B. Miller (1968) analyzed the psychological needs of computer users. He made the point that the impact on users of long SRTs depends on the complexity of the task...
engaged in. He suggested maximum system response times for seventeen different categories of user input. For most categories, he recommended that the system delay should be under two seconds, with delays of up to fifteen seconds tolerable for responses to certain inputs. However, even for changing topics, he gave a five second delay as the maximum allowable for CAI. Miller's response time recommendations were mostly expert estimates based on human thought process discontinuity studies and were not experimentally verified.

Shneiderman (1979) showed that users expect SRT lengths to differ according to the type of commands they have entered. Miller (1968) also introduced the idea that the amount of frustration caused by a delay is also dependent on when the delay occurs within the session. A delay following closure, completion of a task, will be less disruptive than one during the process of obtaining closure. Foley and Wallace (1974) found poor response times to cause boredom and unexpectedly long delays to cause panic. They refined the concept of closure to include three distinct levels for different tasks, each requiring a different maximum response time. Spence (1976) applied these theories to interactive computer graphics. His study showed that a designer will expect a dot on the screen to light up within a tenth of a second of being touched by a light pen but will tolerate delays of 30 seconds or more during a major calculation. Spence provided a "count-down clock" to remove the
unpredictability of the longer delays.

Several other experiments have been carried out in the area of system response times. Grossberg, Wiesen, and Yntema (1976) had subjects solving problems under four experimental conditions: mean SRT delays of 1, 4, 16, and 64 seconds on output commands. The actual delay durations varied randomly about these means. At the longer delays the number of commands given decreased and subjects avoided the delay causing commands. Goodman and Spence (1978) used fixed SRT durations of 0.16, 0.72, and 1.49 seconds between light pen input and display of a new curve. The longest delay degraded performance by about 50 percent.

Maguire (1982) noted the recent reversal of cost relationships between the computer's time and that of the user as well as the large number of non-expert users today who are less tolerant of poor human interface conditions. After a review of the literature, he made several recommendations concerning system response times. Maguire recommended that SRTs should be as short as possible and predictable in length. Variations in duration should be linked to the type of computer operation demanded and the strength of closure corresponding to the input. Where long delays cannot be avoided, interim responses (such as Spence's count-down clock) should be provided.

Several other issues related to system response time
have been studied. It has been suggested that fast system response can encourage or intimidate the user to behave impulsively and make an excessive number of rapid responses where a few considered responses would have a better effect (Fitter, 1979; Schneiderman, 1979). Boehm, Seven, and Watson (1971) experimented with the use of "lockout periods" of up to eight minutes following the computer's output. The subjects, engaged in complex problem solving, were forced to consider their answers before entering for this length of time. Although the five minute lockout group had the highest mean performance scores, all lockout groups expressed dissatisfaction with restricted access to the computer.

Two investigators have examined the effects of different display rates in video displays. Miller (1977) found no differences between the effects produced by different fixed display speeds, but variable display speeds produced significantly decreased user performances and attitude toward the system and the interactive environment. Bevan (1981) determined that very low displays speeds of 10-15 characters per second produced superior performance and attitudes.

Another related issue, and one of central importance to this study, is that of the effects of unexpected interruptions, delays, and equipment failures. As mentioned earlier, several educational researchers have done work in this area. However, very little such research has been
In a major review of the literature dealing with behavioral issues in the interactive use of computers, Miller and Thomas (1977) cited over 140 sources. Although the authors could find no research on the effects of such interruptions, they devoted a section of their report to the problem and stated that reliability is a very important system performance criterion. They observed that users will be unhappy with any degradation of system reliability. Nickerson (1981) refers to interruptions of work sessions as being both annoying and disruptive. He states that users faced with overly frequent and serious interruptions will avoid use of the system altogether or be "exceedingly unhappy" in their use of it. He went on to express the need for the investigation of the effects of interruptions:

A challenge to the researcher, who is interested in person-computer interaction is to determine, the behavioral effects of work session interrupts of different types and to quantify their implications for user attitudes and performance (Nickerson, 1981).

Rationale for the Study

A search of the literature of educational technology and computer science reveals an important area in which little real research has been carried out, the criteria which make a computer system most suitable for CAI. Many of these
criteria such as the availability of colour and sound, the ergonometic considerations of equipment design, and ideal computer-memory and program storage requirements, are outside the scope of this study. At least as important as any of the above factors and perhaps even more basic to the suitability of a computer system for CAI use are reliability and the lack of overly long or frequent delays and interruptions.

There is no indication in the literature that delays of reasonable duration will cause any immediate decline in achievement. In certain cases the opposite may even be true. However it has been suggested that there may be a critical point at which student frustration and lack of concentration begin to affect learning. Delays of duration sufficient to cause such effects have not been used in experiments so no critical delays have been properly established.

Achievement scores are not the only measure of the suitability of a system for educational purposes. Student attitude is an important variable. Although attitude and achievement are related, attitude measures may show significant effects not immediately reflected in achievement scores.

Student attitudes toward CAI have generally been favourable. However a number of studies have revealed negative attitudes toward certain attributes of the computer equipment, including delays and interruptions. These
conditions appear to have been encountered by a large number of CAI users.

There can be many reasons for an interruption in an interaction with a computer system. These include lengthy computation, loading and storage of programs or data, internal memory operations, queuing for shared resources, the overloading of multi-user systems, and equipment failure. Many of these situations can occur at any point in an interactive session.

Such interruptions can be minimized or eliminated, but only at great cost. Better quality equipment, more powerful central processing units, larger memory capacity, faster, more reliable data storage devices, and more efficient software all require much greater financial expenditure. Reducing the number of users sharing common computing resources both restricts access to the system and increases cost per user. Equipment which can handle peak load conditions without significant degradation of performance may not be economically feasible.

Early computer users were mostly highly trained and motivated professionals. Less knowledgeable and more casual users, such as students using computer assisted instruction, may be much less tolerant of poor system performance. Thus it becomes important that a set of equipment performance guidelines be established for CAI. At what point will an
inadequate system cause significant frustration, negative attitudes, and poor learning outcomes? How can planners and supervisors set specifications for equipment purchasing or know when upgrading or replacement is necessary? How can they avoid paying too much for high levels of performance which are not really required?

These questions will become more important as CAI and other classroom uses of computers become more common. There is as yet no body of knowledge that can provide the answers. Such a body of knowledge can only be built up from research studies which investigate the effects on student attitude and achievement of predictable and unpredictable interruptions and delays of various frequencies and durations. These studies should be conducted with different modes of CAI and other computer uses and with a wide range of age groups and levels of computing experience.

Some research has been carried out in this area. However, practically all of these investigations have been concerned with one special case of computer delay, that of system response time. In CAI, this is generally equivalent to delay in the information feedback and post information feedback intervals. Very few studies have dealt with other, more randomly occurring delays.

Several researchers in the overall field have found sex differences to be significant. Females have displayed
frustration at conditions which had no measurable effect on the male subjects.

This study set out to investigate the effects of randomly occurring computer-generated delays of varying duration in computer-assisted instruction on the attitudes of the students toward CAI. The effects of sex difference were also measured, as was the achievement of the subjects under the test conditions.
Chapter III

Hypotheses

The problem under investigation in this study was the effect of computer-generated delays on the attitudes of students toward computer assisted instruction and on their achievement. To explore these relationships, the following specific hypotheses were proposed:

1. There is no significant difference in attitude toward CAI between students subjected to random delays of eight and sixteen seconds mean duration and those not subjected to delays.

This is the principal hypothesis of the study. Previous studies have rarely used delays of variable duration or delays occurring randomly throughout an interaction. However, studying the effects of information feedback delays, Boersma (1966) found an eight second delay produced significant frustration. Murray (1972) reported that repeated CAI program defects produced poor attitudes and achievement. A number of authors described negative attitudes produced by equipment problems and breakdowns. On the basis of these studies it was expected that this hypothesis would be rejected.
2. **There is no significant difference in attitude toward CAI between male and female students.**

This hypothesis grew out of the work of Van Dyke and Newton (1972). They discovered poorer attitudes towards CAI in female subjects confronted with an eight second information feedback delay. This result could not be generalized to delays occurring outside the information feedback interval. None of the literature describing such disruptions reported sex differences in attitude. Although precedents were established for investigation of sex effects in such a study, it was possible that this hypothesis would be either accepted or rejected.

3. **There is no significant difference in achievement in computer assisted instruction between students subjected to random delays of eight and sixteen seconds mean duration and those not subjected to delays.**

The third hypothesis was perhaps the least important to the study. Based on a number of studies of information feedback delays (Brackbill, Wagner, and Wilson, 1964; Sassenrath and Yonge, 1968 and 1969; More, 1969; and others), and on the results of Anderson et al. (1981) with simulated equipment breakdown, it was unlikely that this hypothesis would be rejected unless a critical delay duration (Boersma, 1966) or frequency were reached.
Chapter IV

DEVELOPMENT OF THE INSTRUCTIONAL MODULE

An original CAI module was produced for the experiment. A working, properly structured lesson was necessary for the testing of the experimental hypotheses. The choice of subject matter was considered to be of secondary importance. The subject matter chosen, an introduction to information theory, was decided upon for the lack of prior knowledge required of the students and its applicability to a learning resources program where it was tested.

The course in which the CAI module was tested, and for which it was designed, was a third year university credit course in introductory educational media (Memorial University's Education 3801). Students entering that course were expected to have had little or no experience with computers or CAI and no knowledge of the content of the unit. However, that the students were enrolled in such a course would indicate an interest in the general subject area.

Frame-oriented CAI imposes upon its authors a need for fairly rigorous analysis of the subject matter. As the amount of information which can be shown on a normal computer display is severely limited, each frame can only present a very small amount of information. The size and ordering of the instructional steps are therefore of prime concern. The
subject matter again lends itself well to this type of breakdown (see Appendix A).

Information theory is a branch of communications science first developed in the 1940's by Claude Shannon, Warren Weaver, and other Bell Telephone Company scientists. Although Shannon's model of the transmission of information is a set of complex mathematical formulae linking such variables as bandwidth, frequency, and the amount of transmitted information, many of the basic concepts and their relationships can be explained simply and without mathematics. These include the information source, message, transmitter, signal, communications channel, receiver, and destination. Definitions, explanations, and examples of such concepts and a diagram relating them to Shannon's model make up the content of the CAI unit.

The CAI module which was produced was of necessity a compromise between educational efficiency and the goals of the experiment. Although a computer has almost infinite program branching capabilities, this feature, normally taken advantage of in CAI, was not used. All subjects had to be exposed to an identical amount and sequencing of subject matter. The pacing of the instructional interaction (apart from the experimental delays) had to be left entirely up to the student.

Thus the instructional program was strictly linear in
structure, with no branching possible. Following a brief introduction, Shannon's basic diagram was introduced and explained, component by component. Several frames were built up in small stages, with the student controlling the pacing completely. Parts of the diagram were flashed on and off repeatedly as the appropriate text was introduced. Throughout, multiple choice questions were inserted which the student had to answer before progressing through the lesson. These questions were presented as separate frames and were followed by feedback frames in which the correct answers were given if necessary.

The instructional algorithm used was similar to the "linear tutorial" program structure presented by Wager (1982). The program followed four of that author's five rules for user oriented CAI. These four rules were the avoidance of text scrolling, student control of frame advance, standardized instructions for frame advance, and (in the program's final version) a minimum amount of text on the screen at one time. Wager's fifth guideline, the continuous display of tables updated by the student interaction, was not applicable.

After the CAI lesson, a fifteen-item true-false quiz was administered by the computer (see Appendix E). Each question was presented as a separate frame. No feedback was given for individual answers, but an overall score was returned to the student on the last frame of the interaction.
A major constraint of any computer program is the computer hardware on which it is to be implemented. Different sizes, brands, and models have different languages, operating systems, graphics capabilities and amounts of memory as well as different accessories such as printers and floppy disk or cassette tape data storage units. The Division of Learning Resources of Memorial University's Faculty of Education had a Radio Shack TRS-80 Model I computer with 48K (one K equals 1024 characters) of programmable random access memory, the Radio Shack Level II BASIC language, a cathode ray tube display, two floppy disk drives for the storage of programs and data, the TRSDOS operating system, and a dot matrix printer.

The amount of information per CAI frame was limited by the number of characters that could be displayed at the same time on the screen. The TRS-80 Model I used 16 lines of 64 characters each, for a maximum of 1024 characters. The character set of the computer included 64 special graphic shapes each constructed on a two by three grid. This enabled graphics displays with a resolution of 48 x 128 pixels. Alphanumeric and graphic characters could be mixed.

As this was the computer system used in the experiment, the CAI program was written in Level II BASIC to take best advantage of the features of the equipment. Graphics were used throughout to demonstrate and draw attention to the
various parts of the information theory model, to illustrate several other concepts, and to frame the questions of the true-false quiz. Likewise the printer was used at one point in the program (to demonstrate a message being duplicated in more than one communications channel). The floppy disk drives were used to load in the program for each subject as well as to store the scores of the subjects on the true-false quiz. The program contained nearly seven hundred lines of BASIC statements (see Appendix B).

After the experimental CAI program was written and working, ten delays were introduced. The positions of the delays in the program were derived from a sequence of random numbers in a published table (Glass and Stanley, 1970). A paper printout of the program was divided by length in proportion to these random numbers. At each of the division points, a timing loop was inserted into the program. Each of the ten timing loops was referenced to a number from a delay table. This number, when multiplied by a delay constant, set the number of iterations of the timing loop to cause a delay in seconds equal to the value of the number from the delay table. The ten numbers for the delay table were again taken from a random number sequence, weighted to give the desired mean delay.

Three sets of weightings were used, to create three different delay tables and thus, three different versions of
the program. The first version used a weighting factor of zero, to fill the delay table with zeros and thus produce no effective delays. The second delay table was obtained by weighting the random numbers to produce a mean delay of 12 seconds. The third table was produced by doubling each of the numbers thus obtained, giving a mean delay of 24 seconds.

Thus three versions of the program were derived: a control version with no delays and two experimental versions with mean delays of 12 and 24 seconds. Each was stored on a separate floppy diskette so that the loading and starting procedures were identical for each version.

A pilot study was undertaken in which six graduate students in Learning Resources interacted with the various versions of the CAI unit, completed a semantic differential attitude questionnaire, and were interviewed at some length about the program.

Regardless of the version of the program which they had completed, all the subjects found the exercise too long (up to twenty-nine minutes). Other common negative comments included too much information on the screen at one time and in total, and not enough interaction and opportunity for response.

The delays, although normal in certain real life computer environments, were also found to be too long for a population of computer novices. As the delays had been
randomized around a certain mean, the longer delays, particularly in the twenty-four second mean delay version, were quite long indeed (up to forty-two seconds). When faced with such delays, students tended to assume complete breakdown of the system, and did not wait for the resumption of the lesson.

However, students did express frustration at the delays which they encountered and their attitudinal questionnaires reflected this. As such a small number of subjects were unlikely to produce significant or meaningful results, no statistical analysis was attempted.

Following the pilot study, the CAI lesson program was revised. If too much information was being presented for graduate students, most of whom had at least had some previous experience with the subject matter, it was assumed that the unit would serve as a poor introduction for third year students. Therefore the amount of material was reduced by more than half, the remainder being spread out over a larger number of simpler frames. More concrete examples were used with more opportunity for student response and interaction. The true-false quiz, designed to both provide performance scores and demonstrate that the unit indeed worked as a functioning CAI lesson, was shortened from fifteen to ten items.

The delays were reduced in number from ten to seven and
in duration, with experimental mean delays of eight and sixteen seconds. The same procedure was followed in determining the location and length of the delays.

The new program, with less text being presented in each frame, was more in keeping with Wagner's (1982) rules for good CAI authoring. The shorter lesson duration facilitated the inclusion of the CAI unit in the Education 3801 laboratory exercises. CAI lessons of such length have been shown to produce significant cognitive and affective results (Sherman and Klare, 1970; Anderson et al., 1981).

Thus a computer assisted instruction lesson on information theory was developed for testing with third year students. The computer program, written in Radio Shack BASIC, was completed in three versions, one with no delays, a second with seven delays with an eight second mean duration, and a third with double length delays for a mean duration of sixteen seconds (see Appendix B).
Chapter V
PROcedures

Administration

The population which was studied was that of post-secondary students. The sample was drawn from two third year university classes in an introductory level educational media course. Participation in the study was made part of the laboratory portion of the course. All students were required to sign up for available time slots. Students who did not show up at the required time were rescheduled for later slots. In all, fifty-four students fully participated in the experiment. Two other students who took part could not be included due to failures in the computer equipment. The students were not informed that they were taking part in an experiment. To them, the CAI unit, the content of which was part of their course subject matter, was simply a part of their laboratory work.

The time slots were twenty minutes long. Each subject received a very brief verbal explanation of which buttons to press, and then without further contact with the experimenter, interacted with the instructional program. Following the computerized lesson and quiz, the subject was then required to complete an eleven-pair semantic differential attitude questionnaire.
Research Design

The research design used was a post-test-only control group type (Campbell and Stanley, 1963). A three group version of the design was employed with a control group and two experimental groups, each experimental group receiving a different experimental treatment (the eight and sixteen second mean delays in the CAI program). Table V.1 shows this design.

In the table, each line represents one of the three groups and their treatment in temporal order. R indicates random group allocation, $X_1$ and $X_2$ experimental treatments, and O the subsequent testing.

<table>
<thead>
<tr>
<th>TABLE V.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Design</td>
</tr>
<tr>
<td>R</td>
</tr>
<tr>
<td>R</td>
</tr>
<tr>
<td>R</td>
</tr>
</tbody>
</table>

Although a post-test-only design is recommended for studies in which entirely novel instructional materials or subject matter (in this case, both) are presented, it relies heavily on the random allocation of the subjects to groups, as there is no other means of ensuring the equality of the groups before the differential experimental treatment.
This random allocation of the students to groups was accomplished in several ways. As described earlier, the subjects were allowed to select their own time slots. Then the version of the test unit which each subject received was on a strict rotation basis. Thus the first subject on the first day received the first version of the program, the second the second, the third the third, the fourth the first, and so on. This rotation was also adhered to between the days on which the experiment was run, helping eliminate any bias which could possibly be caused by having students who signed up for a given time of day or day of the week being allocated to a particular group. Each individual thus belonged to a different group from both the subjects who preceded and succeeded him.

In this way the fifty-four subjects were evenly and randomly divided between groups. Eighteen were members of the control group, receiving no delays. Eighteen received the eight second mean delay treatment, and eighteen the sixteen second mean delay experimental treatment.

The Achievement Instrument

Two measuring instruments were used for data gathering. The first of these was built into the CAI program itself and consisted of a ten item true-false quiz designed to test the subjects' learning of the content of the unit. It was
automatically administered at the end of the computer session. The only scores obtained and recorded on the computer's floppy disk system were the total number of questions which each subject answered correctly. No data was gathered on the correctness of the student's responses to the various multiple-choice questions posed throughout the lesson or the scores on the individual quiz items. The quiz items are shown in Appendix E.

The quiz was included for two reasons. First the CAI unit itself had to be shown to be effective. The primary interest of the study was in examining the effects of the experimental delay treatments, not in demonstrating the effectiveness of the instructional module. However, were it not an effective lesson, few conclusions could be drawn from any other experimental measures. For this reason an extra control group was set up. The 45 students enrolled in the same course the following year completed a written version of the quiz without having been exposed to the lesson. The effectiveness of the CAI unit could be demonstrated by a comparison of the scores of those students with those of the subjects of the experiment. Second, it was also of importance to find out whether the different experimental treatments would cause any significant difference in achievement. The lack of such a difference became one of the hypotheses to be tested.
The Attitude Instrument

The instrument to test the major hypothesis, of attitude towards CAI under the various experimental treatments, was an eleven-pair semantic differential questionnaire. Subjects were required to indicate their sex, then choose the appropriate step of seven on a scale, between adjectives of opposite meaning for each of the eleven pairs of adjectives. Twelve adjective pairs were chosen from a list of fifty which had been investigated and reported by Charles Osgood (Osgood and Suci, 1955). They tested each of the semantic pairs on a large sample (also university undergraduates) and used factor analysis to determine loadings for each pair on each of three scales. These scales are evaluative (good-bad), potency (strong-weak), and activity (fast-slow). Thus inter-group differences in attitude could be analyzed on each of these scales.

Of the twelve semantic pairs chosen from Osgood's list for this study, one (deep-shallow) produced only neutral responses during the pilot study and was dropped from the final version of the instrument. The questionnaire is shown in Appendix D.

Statistical Procedures

Using the data obtained by these instruments, the
various hypotheses were tested by the statistical procedures outlined in the following table.

<table>
<thead>
<tr>
<th>Hypotheses, statistical measures used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There is no significant difference in attitude towards CAI between students subjected to random delays of eight and sixteen seconds mean duration and those not subjected to delays.</td>
</tr>
<tr>
<td>Two way analyses of variance (attitude score totals, both weighted and unweighted, by group and sex).</td>
</tr>
<tr>
<td>One way analyses of variance (individual item scores by group).</td>
</tr>
<tr>
<td>2. There is no significant difference in student attitude towards CAI between male and female students.</td>
</tr>
<tr>
<td>Two way analyses of variance (as above).</td>
</tr>
<tr>
<td>One way analyses of variance (individual item scores by sex).</td>
</tr>
<tr>
<td>3. There is no significant difference in achievement in computer assisted instruction between students subjected to random delays of eight and sixteen seconds mean duration and those not subjected to delays.</td>
</tr>
<tr>
<td>One way analysis of variance (achievement scores by group).</td>
</tr>
</tbody>
</table>

All hypothesis were accepted or rejected at the 0.05 level of significance.

Summary

Fifty-four third year university students were evenly divided into three groups and participated in an experiment
of the posttest-only control group design. Each of the groups completed the same CAI lesson. The two experimental groups were subjected to variable duration delays with mean values of 8 and 16 seconds respectively. The control group experienced no delays.

Each subject completed two measuring instruments, a computer-administered ten-item achievement quiz and an eleven scale semantic differential questionnaire administered by the experimenter. This data was then subjected to various statistical procedures to test the hypotheses.
Chapter VI

EVALUATION

The three experimental hypotheses were investigated by statistical analysis of the data which had been collected using the procedures outlined in the previous chapter. That data consisted of the individual scores of each of the subjects on the semantic differential attitude questionnaire, their sex and group membership, and the scores from the computer-administered achievement test.

Hypothesis 1. There is no significant difference in attitude toward CAI between students subjected to random delays of eight and sixteen seconds mean duration and those not subjected to delays.

For each subject, the attitude scores were computed by assigning to each response a number between one and seven. That number corresponded to the position of that response on the seven-step scale, the larger scores indicating more positive attitude responses. The treatment group (no delay, eight second delay, or sixteen second delay) and the sex of each subject were also recorded.

Further scores for each subject were calculated from the semantic differential data. By multiplying the score on each semantic differential scale by its factor loadings (Osgood...
and Suci, 1955), and then adding for each of the three factors, evaluative, potency, and activity totals were obtained for each item (see Appendix F). In addition, unweighted total scores were obtained by adding each subject's scores on the eleven scales. All these scores, the eleven scale responses, the evaluative, potency, and activity weighted totals, the unweighted totals, and the sex and group data were then analyzed using various applications of the analysis of variance technique.

The main statistical procedure used to test this hypothesis was two-way analysis of variance. This was carried out for each of the four attitude response totals (evaluative, potency, activity, and unweighted) by the independent variables, group and sex.

Table VI.1 shows the mean scores and standard deviations for the evaluative, potency, and activity totals and the unweighted total by experimental treatment.
TABLE VI.1

Mean weighted and unweighted total scores of subjects on semantic differential questionnaires, by group.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group 1 (Control)</th>
<th>Group 2 (8 sec delay)</th>
<th>Group 3 (16 sec delay)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
</tr>
<tr>
<td>Evaluative</td>
<td>32.22 6.27</td>
<td>33.78 3.51</td>
<td>32.31 5.04</td>
</tr>
<tr>
<td>Potency</td>
<td>5.94 1.08</td>
<td>5.32 0.72</td>
<td>5.84 0.88</td>
</tr>
<tr>
<td>Activity</td>
<td>9.06 2.05</td>
<td>9.07 1.48</td>
<td>8.15 2.08</td>
</tr>
<tr>
<td>Total unweighted</td>
<td>57.83 11.11</td>
<td>59.94 5.35</td>
<td>56.89 8.71</td>
</tr>
</tbody>
</table>

The results of the two-way analysis of variance procedures are reported in Table VI.2 through VI.5.

TABLE VI.2

Summary of analysis of variance results on Evaluative factor totals

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sums of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Signif. of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Effects</td>
<td>3</td>
<td>31.71</td>
<td>10.57</td>
<td>0.39</td>
<td>0.76</td>
</tr>
<tr>
<td>Group</td>
<td>2</td>
<td>27.67</td>
<td>13.83</td>
<td>0.51</td>
<td>0.60</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>4.06</td>
<td>4.06</td>
<td>0.15</td>
<td>0.70</td>
</tr>
<tr>
<td>Interaction</td>
<td>2</td>
<td>12.2</td>
<td>6.10</td>
<td>0.25</td>
<td>0.80</td>
</tr>
</tbody>
</table>
### TABLE VI.3
Summary of analysis of variance results on Potency factor totals

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sums of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Signif. of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Effects</td>
<td>3</td>
<td>3.23</td>
<td>1.08</td>
<td>1.29</td>
<td>0.29</td>
</tr>
<tr>
<td>Group</td>
<td>2</td>
<td>2.52</td>
<td>1.26</td>
<td>1.51</td>
<td>0.23</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.93</td>
<td>0.93</td>
<td>1.12</td>
<td>0.30</td>
</tr>
<tr>
<td>Interaction</td>
<td>2</td>
<td>0.92</td>
<td>0.46</td>
<td>0.55</td>
<td>0.58</td>
</tr>
</tbody>
</table>

### TABLE VI.4
Summary of analysis of variance results on Activity factor totals

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sums of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Signif. of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Effects</td>
<td>3</td>
<td>11.79</td>
<td>3.92</td>
<td>1.05</td>
<td>0.38</td>
</tr>
<tr>
<td>Group</td>
<td>2</td>
<td>7.66</td>
<td>3.83</td>
<td>1.03</td>
<td>0.37</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>1.80</td>
<td>1.79</td>
<td>0.48</td>
<td>0.49</td>
</tr>
<tr>
<td>Interaction</td>
<td>2</td>
<td>2.17</td>
<td>1.09</td>
<td>0.29</td>
<td>0.75</td>
</tr>
</tbody>
</table>
TABLE VI.5
Summary of analysis of variance results on Unweighted response totals

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sums of squares</th>
<th>Mean squares</th>
<th>F</th>
<th>Signif. of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Effects</td>
<td>3</td>
<td>98.85</td>
<td>31.95</td>
<td>0.45</td>
<td>0.75</td>
</tr>
<tr>
<td>Group</td>
<td>2</td>
<td>92.22</td>
<td>46.11</td>
<td>0.58</td>
<td>0.57</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>7.76</td>
<td>7.74</td>
<td>0.09</td>
<td>0.76</td>
</tr>
<tr>
<td>Interaction</td>
<td>2</td>
<td>40.76</td>
<td>20.38</td>
<td>0.26</td>
<td>0.78</td>
</tr>
</tbody>
</table>

As can be seen from the above tables, none of these tests produced results which were significant at the 0.05 level.

In case one or more individual items in the semantic differential instrument had produced significant scores, statistical tests were made on these individual item scores. One-way analysis of variance procedures were carried out on each of the eleven semantic differential items by group membership. Table VI.6 shows the mean response and standard deviation on each of the items for each group.
TABLE VI.6

Mean responses of subjects on items of semantic differential questionnaire, by group

<table>
<thead>
<tr>
<th>Item</th>
<th>Group 1 (Control)</th>
<th>Group 2 (8 sec delay)</th>
<th>Group 3 (16 sec delay)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
</tr>
<tr>
<td>good/bad</td>
<td>5.44 1.46</td>
<td>6.17 0.79</td>
<td>5.83 1.04</td>
</tr>
<tr>
<td>strong/weak</td>
<td>5.28 1.13</td>
<td>5.67 0.84</td>
<td>5.17 1.04</td>
</tr>
<tr>
<td>valuable/worthless</td>
<td>5.83 1.25</td>
<td>5.89 0.90</td>
<td>5.44 1.09</td>
</tr>
<tr>
<td>pleasant/unpleasant</td>
<td>5.61 1.82</td>
<td>5.72 1.23</td>
<td>5.67 1.37</td>
</tr>
<tr>
<td>relaxed/tense</td>
<td>4.72 1.56</td>
<td>4.38 1.38</td>
<td>4.94 1.76</td>
</tr>
<tr>
<td>short/long</td>
<td>4.56 1.46</td>
<td>4.72 0.96</td>
<td>4.28 0.96</td>
</tr>
<tr>
<td>clear/hazy</td>
<td>5.39 1.82</td>
<td>5.94 1.39</td>
<td>5.72 1.36</td>
</tr>
<tr>
<td>nice/awful</td>
<td>5.72 1.13</td>
<td>5.56 1.04</td>
<td>5.33 1.34</td>
</tr>
<tr>
<td>active/passive</td>
<td>5.44 1.62</td>
<td>5.39 1.18</td>
<td>4.89 1.57</td>
</tr>
<tr>
<td>fast/slow</td>
<td>4.11 1.18</td>
<td>3.94 1.43</td>
<td>3.67 1.33</td>
</tr>
<tr>
<td>fair/unfair</td>
<td>5.72 1.36</td>
<td>6.56 0.62</td>
<td>5.94 1.06</td>
</tr>
</tbody>
</table>

Table VI.7 gives a summary of the one-way analyses of variance of the subject's responses on the items of the semantic differential questionnaire by group.
TABLE VI.7

Analysis of variance, one way for responses of subjects on items of semantic differential questionnaire, by group

<table>
<thead>
<tr>
<th>Sum of Squares</th>
<th>Mean Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Groups</td>
</tr>
<tr>
<td>good/bad</td>
<td>4.70</td>
</tr>
<tr>
<td>strong/weak</td>
<td>2.48</td>
</tr>
<tr>
<td>val./worthless</td>
<td>2.11</td>
</tr>
<tr>
<td>pleasant/unpleasant</td>
<td>0.11</td>
</tr>
<tr>
<td>relaxed/tense</td>
<td>2.81</td>
</tr>
<tr>
<td>short/long</td>
<td>1.81</td>
</tr>
<tr>
<td>clear/hazy</td>
<td>2.81</td>
</tr>
<tr>
<td>nice/awful</td>
<td>4.37</td>
</tr>
<tr>
<td>active/passive</td>
<td>3.37</td>
</tr>
<tr>
<td>fast/slow</td>
<td>1.81</td>
</tr>
<tr>
<td>fair/unfair</td>
<td>6.70</td>
</tr>
</tbody>
</table>

This analysis by the individual questionnaire items also produced no results which were significant at the 0.05 level.

No significant difference was detected in attitude towards CAI between the experimental treatment (8 and 16 second mean delays) and control (no delay) groups. The null hypothesis was therefore accepted.
Hypothesis II. There is no significant difference in attitude toward CAI between male and female students.

The data for the investigation of this hypothesis also came from the semantic differential attitude questionnaire. The method of deriving the evaluative, potency, activity and unweighted totals are described above.

Table VI.8 shows the mean scores and standard deviations for the evaluative, potency, and activity totals and the unweighted total by sex.

<table>
<thead>
<tr>
<th></th>
<th>Females (n = 27)</th>
<th>Males (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Evaluative</td>
<td>32.50</td>
<td>5.90</td>
</tr>
<tr>
<td>Potency</td>
<td>5.92</td>
<td>1.12</td>
</tr>
<tr>
<td>Activity</td>
<td>9.03</td>
<td>2.20</td>
</tr>
<tr>
<td>Unweighted Total</td>
<td>57.96</td>
<td>10.50</td>
</tr>
</tbody>
</table>

The main statistical procedures used to test this hypothesis were again two-way analyses of variance for each of the total attitude scores by both the independent
variables, experimental group and sex.

The results of these procedures have been reported above in Tables VI.2 through VI.5. As can be seen from these tables, no significant (at the 0.05 level) results or interactive effects were produced.

Although none of the main measures had produced a significant result between the sexes, each of the individual item scores were again investigated in case one or more of the individual items had produced significant results. One-way analysis of variance procedures were carried out on each of the eleven semantic differential items by sex. Table VI.9 shows the mean response and standard deviation for each item by sex.
<table>
<thead>
<tr>
<th>Item</th>
<th>Females Mean</th>
<th>Females S.D.</th>
<th>Males Mean</th>
<th>Males S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>good/bad</td>
<td>5.93</td>
<td>1.04</td>
<td>5.70</td>
<td>1.27</td>
</tr>
<tr>
<td>strong/weak</td>
<td>5.72</td>
<td>1.15</td>
<td>5.52</td>
<td>0.85</td>
</tr>
<tr>
<td>valuable/worthless</td>
<td>5.63</td>
<td>1.21</td>
<td>5.82</td>
<td>0.96</td>
</tr>
<tr>
<td>pleasant/unpleasant</td>
<td>5.48</td>
<td>1.60</td>
<td>5.85</td>
<td>1.32</td>
</tr>
<tr>
<td>relaxed/tense</td>
<td>4.26</td>
<td>1.61</td>
<td>5.11</td>
<td>1.42</td>
</tr>
<tr>
<td>short/long</td>
<td>4.52</td>
<td>1.12</td>
<td>4.52</td>
<td>1.19</td>
</tr>
<tr>
<td>clear/hazy</td>
<td>5.81</td>
<td>1.62</td>
<td>5.56</td>
<td>1.45</td>
</tr>
<tr>
<td>nice/awful</td>
<td>5.52</td>
<td>1.31</td>
<td>5.56</td>
<td>0.85</td>
</tr>
<tr>
<td>active/passive</td>
<td>5.41</td>
<td>1.73</td>
<td>5.07</td>
<td>1.14</td>
</tr>
<tr>
<td>fast/slow</td>
<td>4.07</td>
<td>1.41</td>
<td>3.74</td>
<td>1.19</td>
</tr>
<tr>
<td>fair/unfair</td>
<td>6.11</td>
<td>1.31</td>
<td>6.04</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Table VI.10 gives a summary of the one-way analyses of variance of the subjects' responses on the items of the semantic differential questionnaire by group.
TABLE VI.10

Analysis of variance, one way for responses of subjects on items of semantic differential questionnaire, by sex

<table>
<thead>
<tr>
<th>Item</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Groups</td>
<td>Within Groups</td>
<td>Between Groups</td>
<td>Within Groups</td>
</tr>
<tr>
<td>good/bad</td>
<td>0.67</td>
<td>69.48</td>
<td>0.67</td>
<td>1.34</td>
</tr>
<tr>
<td>strong/weak</td>
<td>1.19</td>
<td>53.41</td>
<td>1.19</td>
<td>1.03</td>
</tr>
<tr>
<td>val./worthless</td>
<td>0.46</td>
<td>62.37</td>
<td>0.46</td>
<td>1.20</td>
</tr>
<tr>
<td>pleasant/unpleas.</td>
<td>1.85</td>
<td>112.14</td>
<td>1.85</td>
<td>2.16</td>
</tr>
<tr>
<td>relaxed/tense</td>
<td>9.80</td>
<td>119.9</td>
<td>9.80</td>
<td>2.30</td>
</tr>
<tr>
<td>short/long</td>
<td>0.0</td>
<td>69.48</td>
<td>0.0</td>
<td>69.48</td>
</tr>
<tr>
<td>clear/hazy</td>
<td>0.91</td>
<td>122.74</td>
<td>0.91</td>
<td>2.36</td>
</tr>
<tr>
<td>nice/awful</td>
<td>0.02</td>
<td>63.41</td>
<td>0.02</td>
<td>1.22</td>
</tr>
<tr>
<td>active/passive</td>
<td>1.50</td>
<td>122.37</td>
<td>1.50</td>
<td>2.16</td>
</tr>
<tr>
<td>fast/slow</td>
<td>1.50</td>
<td>89.04</td>
<td>1.50</td>
<td>1.71</td>
</tr>
<tr>
<td>fair/unfair</td>
<td>0.07</td>
<td>67.63</td>
<td>0.07</td>
<td>1.22</td>
</tr>
</tbody>
</table>

This procedure produced one statistically significant result. Female subjects responded closer to the 'tense' end of the 'relaxed-tense' scale. This result is significant at the .05 level.

This single item result was not sufficient to cause rejection of the hypothesis. As no significant difference was detected in attitude towards CAI between male and female subjects, the null hypothesis was accepted.
Hypothesis III. There is no significant difference in achievement in computer assisted instruction between students subjected to random delays of eight and sixteen seconds mean duration and those not subjected to delays.

The achievement data-gathering instrument was a ten item true-false quiz on the lesson content. The quiz was administered by the computer at the end of the CAI lesson. The only data recorded by the computer were group and score. As the experimenter administered the attitude questionnaire independently, this data could not be related to the achievement scores for the individual subjects. Table VI.11 gives a breakdown of these scores by number of subjects and experimental group.

TABLE VI.11
Achievement scores by number of subjects

<table>
<thead>
<tr>
<th>SCORE</th>
<th>NO DELAY</th>
<th>GROUP 8 SEC</th>
<th>16 SEC : TOTAL</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 : 0</td>
<td>0</td>
<td>1 : 1</td>
<td></td>
<td>1.9</td>
</tr>
<tr>
<td>6 : 3</td>
<td>4</td>
<td>2 : 9</td>
<td></td>
<td>16.7</td>
</tr>
<tr>
<td>7 : 6</td>
<td>5</td>
<td>2 : 13</td>
<td></td>
<td>24.1</td>
</tr>
<tr>
<td>8 : 6</td>
<td>3</td>
<td>7 : 16</td>
<td></td>
<td>29.6</td>
</tr>
<tr>
<td>9 : 2</td>
<td>5</td>
<td>5 : 12</td>
<td></td>
<td>22.2</td>
</tr>
<tr>
<td>10 : 1</td>
<td>1</td>
<td>1 : 3</td>
<td></td>
<td>5.6</td>
</tr>
<tr>
<td>MEAN</td>
<td>7.556</td>
<td>7.667</td>
<td>7.889</td>
<td></td>
</tr>
</tbody>
</table>
The effectiveness of the instructional unit was tested by a comparison of the achievement scores of the three groups involved in the study with those of another group which had not experienced the CAI lesson. This group, the entire class of the following year, all completed the questionnaires without having been exposed to the subject matter. The assignment of subjects to the experimental CAI group and the following year's non-CAI group was not truly random. The students assigned themselves by enrolling in different years. A t-test for two independent samples to compare the performances of the groups was used as an indicator of the effectiveness of the CAI lesson. The results of this test are shown in Table VI.12.

Table VI.12
Summary of t-test on achievement scores CAI and non-CAI groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>S.D.</th>
<th>Standard Error</th>
<th>df</th>
<th>t-value</th>
<th>1-tailed probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (CAI)</td>
<td>7.704</td>
<td>1.207</td>
<td>0.164</td>
<td>97</td>
<td>4.80</td>
<td>0.000</td>
</tr>
<tr>
<td>2 (non-CAI)</td>
<td>6.600</td>
<td>1.053</td>
<td>0.157</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This statistic indicated a highly significant (p<0.0005) difference between the achievement scores of students who
took part in the experiment and who completed the CAI lesson and those who did not experience the lesson.

The third hypothesis was tested by a one way analysis of variance of the achievement scores by group membership. The results of that procedure are shown in Table VI.13.

Table VI.13

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F ratio</th>
<th>F probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>2</td>
<td>1.037</td>
<td>0.5185</td>
<td>0.347</td>
<td>0.709</td>
</tr>
<tr>
<td>Within groups</td>
<td>51</td>
<td>76.222</td>
<td>1.4946</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>77.259</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although Table VI.11 indicated higher achievement scores with longer delays, the analysis of variance procedure produced no significant differences at the 0.05 level. The third null hypothesis was therefore accepted.

Summary

Following the administration of the experimental treatments and the collection of data using the semantic differential attitude questionnaire and the achievement quiz, the three proposed hypotheses were tested by various
The first hypothesis, that there is no significant difference in attitude towards CAI between the experimental treatment and control group subjects, was tested by analyzing the semantic differential attitude data. Analysis of variance techniques were used to test the delay effects on the unweighted response totals, weighted totals, and individual item responses. As no statistically significant differences were found between groups, the hypothesis was accepted.

The second hypothesis, that there is no significant difference in attitude towards CAI between males and females, was also tested by analysis of the semantic differential attitude data. Analysis of variance techniques revealed only one significant statistic. Female students reported being more tense on the "tense-relaxed" scale. However the hypotheses was accepted.

The third hypothesis, that there is no significant difference in achievement levels in CAI between the experimental treatment and control group subjects, was tested by an analysis of the data from the computer-administered achievement quiz using analysis of variance techniques. Although longer delays showed slightly higher achievement, the differences were shown to be not significant. The hypothesis was accepted.
Fifty-four third year university students took part in an experiment on the effect of random computer-generated delays on attitude towards Computer Assisted Instruction (CAI). The subjects were randomly divided into three groups of eighteen subjects each. The first group, the control group, completed a CAI lesson in which there were no delays. The second group, an experimental group, was given a version of the same lesson in which they experienced seven delays with mean duration of eight seconds. The third group was given another experimental treatment, a version of the lesson in which the length of each delay had been doubled for a mean duration of sixteen seconds. The subjects were exposed to the lesson individually. At the end of the lesson each subject was required to complete a ten item true-false achievement test and an eleven item semantic differential attitude scale. Three hypotheses were tested in the experiment.

Results

The testing of the three hypotheses produced the following results.

Hypothesis I. There is no significant difference in attitude...
toward CAI between students subjected to random delays of eight and sixteen seconds mean duration and those not subjected to delays.

The hypothesis was accepted. No differences in attitude towards CAI were found between the experimental treatment and control groups. This result appears to contradict other studies that have been conducted into attitudes towards computer delays. Most experimenters and observers in the field have reported confusion, frustration, and negative attitudes with delays even shorter than those used in this study. Boersma (1966) found that eight second delays of information feedback and in the post information feedback interval both produced frustration and predicted a longer critical delay duration in which students would not be able to cope with their frustration. This experiment produced no evidence of frustration. Unlike Boersma's study, this project used variable and unpredictable delays.

Hypothesis II. There is no significant difference in student attitude toward CAI between male and female students.

The hypothesis was accepted. Van Dyke and Newton (1972) discovered that female subjects showed more negative attitudes when subjected to eight second delays in information feedback. This study offers partial support for
their findings. Although the attitude instrument produced no overall differences in attitude between the sexes, one item on the questionnaire produced a significant result. Female subjects in all groups responded more negatively on the "relaxed-tense" scale. Whether this actually reflects male and female traits is difficult to state. This result might have been different if the experimenter supervising the CAI lesson and administering the questionnaire had been female.

Hypothesis III. There is no significant difference in achievement in computer assisted instruction between students subjected to random delays of eight and sixteen seconds and those not subjected to delays.

The hypothesis was accepted. This result is supported by the literature. The majority of delay studies have focused on the information feedback interval and have not dealt with random delays throughout the lesson. These studies have shown that delays do not adversely affect achievement, and can improve retention (Brackbill, 1964; Sassenrath, 1968, 1969; More, 1969; Gay, 1972). It is possible that this retention-improving effect of delays is responsible for the slightly higher achievement means observed in the longer delay groups in this experiment.
Conclusions

Several conclusions can be drawn from the results of this study. It would appear that randomly occurring delays with mean durations of up to sixteen seconds are acceptable in computer assisted instruction. Students who have encountered such computer-generated delays in CAI have as favourable attitudes towards the medium as do those students who have not experienced delays. This applies to students of both sexes. The students' achievement level in CAI lessons should not be affected by these delays.

These conclusions imply that freedom from operational delays is not a critical issue in the selection of computer hardware and software systems for computer assisted instruction, as long as the delays generated by the systems do not exceed a mean of sixteen seconds. Thus costs per student can be significantly reduced. Timesharing and resource sharing systems can support greater numbers of users. Very small computers with less memory and slower access storage devices may be practical for CAI.

Limitations

There are a number of factors which limit the extent to which the results of this study can be generalized.

A major limiting factor is the population from which the
subjects were drawn. The subjects used in this study were third year university undergraduate students. Subjects of a different age group or educational background might react differently to the same type of delays.

Another characteristic of the subjects used in this study was their lack of prior experience with the medium. The novice subjects were chosen for several reasons. A more knowledgeable computer user would perhaps realize that, there being no explicable reason for the delay, there were either technical malfunctions or an experiment was being conducted. To fool sophisticated users would be difficult. The floppy disc drives could possibly have been activated during the delays, their lights and sounds indicating storage or retrieval of data. Even this ruse would only explain delays between rather than during the various components of the lesson. For more knowledgeable computer users to be tested, a more sophisticated hardware set-up would probably be called for, such as a simulated multi-user timesharing system, a large "black box" with computer terminals attached. The conclusions drawn from this experiment may only be applicable to computer novices and possibly casual users. The uniformly high attitudes may reflect a novelty effect.

A further limitation lies in the frequency of the experimental delays. As explained earlier, the seven delays were randomly distributed throughout the lesson. As the overall duration of the CAI lesson depended on the speed of
the subjects' responses, the average delay interval varied from subject to subject in the range of two to three minutes. More frequent delays than those used in this study might have a significant effect on the same dependent variables, even with the same delay durations.

It is important to note that the student attitudes measured in this study were limited to attitudes toward the instructional medium, computer-assisted instruction. The results can therefore not be generalized to include other areas of student attitudes, such as self-concept.

Recommendations for further research

It is recommended that considerable research be conducted in the area of computer performance requirements for classroom CAI use so that useful guidelines can be established.

It is specifically recommended that further research be carried out with attitude and computer delays in CAI. Previous studies have largely dealt with delays in the information feedback and post-information feedback intervals and delays of uniform duration. This study used randomly occurring delays of random duration. Computer scientists could perhaps provide more sophisticated and realistic interruption frequency and duration characteristics than
those generated by either of these approaches. Critical
delay locations, durations, and frequencies could hopefully
be discovered.

Although such an approach might present difficulties in
finding suitable subjects and in administering experiments,
further studies should use subjects with more computer
experience or be conducted over a period of time, perhaps
several months, that would allow the students to gain this
experience. As mentioned above, this might necessitate the
use of more sophisticated computer equipment. The
replication of the present study using more experienced
subjects might produce different results.

Future studies should also use subjects of different age
and education levels, and employ a variety of subject matter.
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Appendix A

Instructional breakdown of CAI module content

Topic: Information Theory

Principle: Claude Shannon's communications model.

Concept A: Communication
Rules:
1. Any information-sharing activity
2. Includes all forms of the transmission of messages
3. A dynamic process
4. A receiver is influenced by a sender.

Concept B: Information source
Rules:
1. Selects a message from a set of possible messages

Concept C: Message
Rules:
1. Can take any of many forms
2. Can be simple or complex

Concept D: Transmitter
Rules:
1. Operates on the message to produce a signal
2. Involves coding process

Concept E: Signal
Rules:
1. The encoded output of the transmitter
2. Sent over the channel

Concept F: Channel
Rule:
1. The medium used to carry the signal from the transmitter to the receiver.

Concept G: Receiver
Rules:
1. An inverse transmitter
2. Decodes the signal back into the message
3. Passes the message on to the destination

Concept H: Destination
Rule:
1. The person or thing for which the message is intended

Concept I: Noise
Rules:
1. Any outside force which acts on the signal to vary it from the original
2. Is added between transmission and reception
3. Can be overcome by redundancy in the message
4. Can be overcome by the duplication of the message in other signals and channels
5. Can be overcome by careful beaming of signal
APPENDIX B

BASIC program listings for CAI module

I. Original Control group version (no delays)
10 EXPERIMENTAL CAIL LESSON ON INFORMATION THEORY
20 VERSION #1
30 MEAN DELAY = 0 SECONDS

---

200 . DELAY CONSTANTS (SECONDS * .339)
210 DIM DY(10)
220 FOR N=1 TO 10: DY(N) = 0: NEXT N

---

490 INTRODUCTORY TEXT
500 CLS: PRINT: PRINT
505 PRINT: WELCOME TO A COMPUTER ASSISTED INSTRUCTION UNIT ON
510 PRINT: INFORMATION THEORY.
520 PRINT: PRINT: TO ADVANCE THE LESSON, YOU MUST PRESS THE APPROPRIATE KEYS ON
525 PRINT: THE COMPUTER KEYBOARD. THE ONLY KEYS REQUIRED ARE THE SPACE BAR
530 PRINT: AT THE BOTTOM OF THE KEYBOARD, THE KEYS NUMBERED 1, 2, 3, AND 4
535 PRINT: (EITHER AT THE TOP OR FAR RIGHT OF THE KEYBOARD), AND THE
540 PRINT: LETTERS T AND F, SHOULD YOU PRESS A KEY AND NOTHING HAPPENS,
545 PRINT: PRESS AGAIN.
550 PRINT: PRINT: THE CUE AS TO WHICH KEY TO PRESS WILL ALWAYS APPEAR ON
555 PRINT: AT THE BOTTOM OF THE SCREEN, LIKE THIS:
570 GOSUB 1900
590 GOSUB 2400
600 CLS: GOTO 2500
610

---

620 LINES 910-1670 CONTAIN THE VARIOUS GRAPHICS SUBROUTINES
900 GRAPHIC SUBROUTINE WITH DELAY
910 FOR N=0 TO 168
920 READ A: PRINT CHR$(A): NEXT N
940 FOR N=1 TO DY(B): NEXT N
960 FOR N=169 TO 255
970 READ A: PRINT CHR$(A): NEXT N
980 RESTORE
990 RETURN
1000 MAIN GRAPHIC SUBROUTINE
1020 FOR N=0 TO 255
1040 READ A: PRINT CHR$(A): NEXT N
1100 DATA
156,140,140,140,140,140,140,140,140,140,172,128,128,128,128,128
9:128
1110 DATA
1425 PRINT 0,256, "\"RETURN
1430 PRINT@156, "\n1435 RETURN
1500 FOR N=1 TO 10:PRINT@45, "\n1503 FOR C=1 TO 30:NEXT C
1505 PRINT@45, "SOURCE":FOR C=1 TO 60:NEXT C:NEXT N
1510 PRINT@256, "\"RETURN
1520 FOR N=1 TO 10:PRINT@10, "\n1522 FOR 'C=1 TO 30:NEXT C
1525 GOSUB 1400:FOR C=1 TO 30:NEXT C
1530 NEXT N:PRINT@256, "\"RETURN
1540 FOR N=1 TO 10:PRINT@82, "\n1542 FOR C=1 TO 30:NEXT C
1545 PRINT@82, "TRANS-":PRINT@146, "MITTER":FOR C=1 TO 30:NEXT C
1550 NEXT N:PRINT@256, "\"RETURN
1560 FOR N=1 TO 10:PRINT@27, "\n1563 FOR C=1 TO 30:NEXT C:GOSUB 1400
1565 FOR C=1 TO 30:NEXT C
1570 NEXT N:RETURN
1580 FOR N=1 TO 10:PRINT@156, "\n1583 FOR C=1 TO 50:NEXT C
1585 GOSUB 1420:FOR C=1 TO 30:NEXT C
1590 NEXT N:PRINT@256, "\"RETURN
1600 FOR N=1 TO 10:PRINT@102, "\n1603 FOR C=1 TO 30:NEXT C
1605 PRINT@102,"RECEIVER":FOR C=1 TO 30:NEXT C
1610 NEXT N:RETURN
1620 FOR N=1 TO 10:PRINT@119, "\n1623 FOR C=1 TO 30:NEXT C
1625 PRINT@119, "DESTI-":PRINT@103, "NATION":FOR C=1 TO 30:NEXT C
1630 NEXT N:RETURN
1640 FOR N=1 TO 10:PRINT@285, "\n1643 FOR C=1 TO 30:NEXT C
1645 PRINT@285,"NOISE":FOR C=1 TO 30:NEXT C
1650 NEXT N:RETURN
1670 FOR C=1 TO 400:NEXT C:RETURN
1680
1690 "MISC. SUBROUTINES"
1700 FOR C=1 TO 100:NEXT C:RETURN
1750 PRINT"PRINT 1, LIGHT"
1755 PRINT"2, WORD"
1760 PRINT"3. PRINTED PAGE"
1765 PRINT"4. EYE"
1780 RETURN
1790 PRINT"THIS IS AN EXAMPLE OF WHICH METHOD OF COMBATING NOISE?"
1800 PRINT"1. USE OF REDUNDANCY"
1. INCREASED TRANSmitter POWER
2. MESSAGE DUPLICATED IN OTHER CHANNELS
3. CAREFUL BEAMING OF THE Signal
4. FOR N=129 TO 933 STEP 4: PRINT@N:CHR$(253): NEXT N
5. RETURN

STUDENT RESPONSE INPUT SUBROUTINES
T=INKEY$: PRINT@960,* * PRESS T (TRUE)
OR F (FALSE) x ;
R=INKEY$
IF R<>"F" AND R<>"T" THEN 2160
2190 RETURN
2400 T=INKEY$: PRINT@960,* * PRESS THE SPACE BAR WHEN
YOU ARE READY TO PROCEED * ;
2410 R=INKEY$
2415 IF R<>"*" THEN 2410
2420 RETURN
2450 T=INKEY$: PRINT@960,* * PRESS THE CORRECT
NUMBER KEY * ;
2455 R=INKEY$
2460 IF R="1" GOTO 2450 ELSE IF R="4" GOTO 2450
2465 R=PEEK (14352): RETURN
2470 PRINT CHR$(23): PRINT@408,"WRONG!": PRINT
CHR$(23): PRINT@448,*
2475 RETURN
2480 PRINT CHR$(23): PRINT@472, "CORRECT!": PRINT CHR$(28)
2490 RETURN
2530 MAIN TEXT STARTS HERE
2500 PRINT* IN THE LATE 1940s, A SMALL NUMBER OF
AMERICAN
2505 PRINT* MATHEMATICIANS AND SCIENTISTS FOUND THE NEW
AREA OF
2510 PRINT* THEORETICAL SCIENCE, THAT OF INFORMATION
THEORY, NOBERT
2515 PRINT* WEINER, CLAUDE SHANNON, AND OTHERS DERIVED A
STATISTICAL MODEL
2520 PRINT* OF THE PROCESS OF COMMUNICATION. THEIR THEORY
IS LARGELY
2525 PRINT* MATHEMATICAL, RELATING A NUMBER OF THE
TECHNICAL VARIABLES
2530 PRINT* ESSENTIAL TO THE ENGINEERING DESIGN OF
COMMUNICATIONS SYSTEMS.
2535 PRINT* A MAJOR ACHIEVEMENT OF INFORMATION THEORY,
HOWEVER, IS THAT
2540 PRINT* PROFESSIONALS IN A VARIETY OF DISCIPLINES HAVE
FOUND THAT THE
2545 PRINT* THEORY CAN BE APPLIED TO THEIR WORK. IT
PROVIDES A COMMON
PRINT 'LANGUAGE VALUABLE TO MANY FIELDS OF ENDEAVOUR.
EDUCATIONAL
PRINT 'MEDIA IS AN OBVIOUS EXAMPLE.
PRINT 'IN ITS WIDEST SENSE, COMMUNICATION CAN
BE DEFINED AS ANY
PRINT 'INFORMATION-SHARING ACTIVITY. IT INCLUDES ALL
FORMS OF THE
PRINT 'TRANSMISSION OF MESSAGES FROM ELECTRICAL
INFUSIONS TO HUMAN
PRINT 'LANGUAGES.
PRINT 'IT IS A DYNAMIC PROCESS IN WHICH A
MESSAGE SENDER
PRINT 'CONSCIOUSLY OR UNCONSCIOUSLY AFFECTS A RECEIVER.
PRINT 'THROUGH
PRINT 'MATERIALS OR AGENCIES USED IN SYMBOLIC WAYS.
PRINT 'THE CONTENT OF
PRINT 'WHAT IS EXCHANGED IS CALLED 'INFORMATION'. AT
PRINT 'ITS SIMPLEST,
PRINT 'THIS PROCESS CAN BE REPRESENTED BY THIS
PRINT 'DIAGRAM:
PRINT 'THE SOURCE ORIGINATES A MESSAGE. THE
PRINT 'TRANSMITTER CHANGES
PRINT 'THIS MESSAGE TO A SIGNAL WHICH IS THEN SENT
PRINT 'THROUGH THE
PRINT 'COMMUNICATIONS CHANNEL TO A RECEIVER. THE
PRINT 'RECEIVER CHANGES THE
PRINT 'SIGNAL BACK INTO THE MESSAGE BEFORE IT REACHES
PRINT 'THE DESTINATION.
PRINT 'THE FUNCTION OF THE INFORMATION SOURCE IS
PRINT 'TO SELECT A
3415 PRINT "DESIRED MESSAGE OUT OF A SET OF POSSIBLE MESSAGES.
3420 PRINT
3425 PRINT "THIS SET OF POSSIBLE MESSAGES MAY BE AS LARGE AND COMPLEX.
3430 PRINT "AS ALL THE THOUGHTS AND IDEAS OF WHICH THE HUMAN MIND IS.
3435 PRINT "CAPABLE. IT MAY BE AS SIMPLE AS THE 'ON' AND 'OFF' STATES OF.
3440 PRINT "AN ELECTRIC CIRCUIT.
3450 GOSUB 1900
3460 GOSUB 2400
3470 CLS: GOSUB 1030
3475 GOSUB 1400
3480 GOSUB 1420
3490 GOSUB 1520
3715 PRINT "THIS MESSAGE, WHICH HAS BEEN SELECTED BY THE SOURCE, CAN.
3720 PRINT "BE OF MANY FORMS. IT MAY CONSIST OF WORDS,
3725 PRINT "PICTURES, MUSIC,
3730 PRINT "ETC. IT MAY BE VERY SIMPLE OR VERY COMPLEX.
3735 PRINT "THE MESSAGE PROVIDES THE CONTENT OF THE
3740 PRINT "COMMUNICATIONS.
3750 GOSUB 1900
3760 GOSUB 2400
3800 CLS: GOSUB 1030
3805 GOSUB 1400
3810 GOSUB 1420
3815 GOSUB 1540
3820 PRINT "THE TRANSMITTER OPERATES ON THE MESSAGE
3825 PRINT "IN SOME WAY TO
3830 PRINT "PRODUCE A SIGNAL SUITABLE FOR TRANSMISSION
3835 PRINT "OVER THE CHANNEL.
3840 PRINT "THIS INVOLVES A CODING PROCESS, AN EXAMPLE IS
3845 PRINT "A.
3850 PRINT "TELEPHONE INSTRUMENT, WHICH CHANGES SOUND
3855 PRINT "PRESSURE INTO A
3860 PRINT "PROPORTIONAL ELECTRIC CURRENT.
3865 GOSUB 1900
3870 GOSUB 2400
3875 GOSUB 1400
3880 GOSUB 1540
3885 PRINT "THE SIGNAL IS THE ENCODED OUTPUT OF THE
3890 PRINT "TRANSMITTER WHICH
3895 PRINT "IS SENT ALONG THE CHANNEL. IT MAY BE SOUND.
3900 PRINT "WAVES, ELECTRICAL.
3905 PRINT "IMPULSES, THE DOTS AND DASHES OF MORSE CODE,
3910 PRINT "ETC.
3915 GOSUB 1900
3920 GOSUB 2400
3925 CLS: GOSUB 1030
3930 GOSUB 1400
3935 GOSUB 1420
4210 GOSUB 1580
4215 PRINT" THE CHANNEL IS MERELY THE MEDIUM USED TO
TRANSMIT THE
4217 FOR N=1 TO DY(1):NEXT N
4220 PRINT:" SIGNAL FROM TRANSMITTER TO RECEIVER. IT MAY BE
A PAIR OF WIRES;
4225 PRINT:" A COAXIAL CABLE, A RADIO FREQUENCY, A BEAM OF
LIGHT, ETC.
4227 GOSUB 1900
4230 GOSUB 2400
4235 GOSUB 1600
4240 PRINT@512,
4245 PRINT:" THE RECEIVER IS AN INVERSE TRANSMITTER,
IT DECODES THE
4250 PRINT:" SIGNAL, CHANGING IT BACK INTO A MESSAGE AND
HANDING IT ON TO
4255 PRINT:" THE DESTINATION.
4257: GOSUB 1900
4260 GOSUB 2400
4265 GOSUB 1620
4270 PRINT@768,
4275 PRINT": THE DESTINATION IS THE PERSON OR THING
FOR WHICH THE
4280 PRINT:" MESSAGE IS INTENDED.
4285 GOSUB 1900
4290 GOSUB 2400
4300 CLS:PRINT:PRINT:PRINT:PROBLEM:"":PRINT
4305 PRINT": IN READING, THE SOURCE IS THE MIND OF THE
AUTHOR; THE
4310 PRINT:" DESTINATION THAT OF THE READER.
4315 PRINT:PRINT" WHICH OF THE FOLLOWING IS THE
TRANSMITTER?
4320 GOSUB 2000
4322 GOSUB 1900
4325 GOSUB 2450
4330 CLS:IF R<>B GOTO 4340
4333 GOSUB 2480
4336 GOTO 4350
4340 GOSUB 2470
4343 PRINT": THE CORRECT ANSWER IS 13. IN READING, THE
PRINTED PAGE
4346 PRINT:IS THE TRANSMITTER.
4349 GOSUB 1900
4350 GOSUB 2400
4355 CLS:PRINT:PRINT:PRINT:PROBLEM:"":PRINT
4360 PRINT" ALSO IN READING, WHICH IS THE CHANNEL?
4365 GOSUB 2000
4366 GOSUB 1900
4367 GOSUB 2450
4368 CLS
4370 FOR N=1 TO DY(2):NEXT N
4372 IF R<>2 GOTO 4380
4373 GOSUB 2480
4376 GOTO 4390
4380  GOSUB 2470
4383  PRINT"  THE CORRECT ANSWER IS #1. IN READING,
LIGHT ACTS AS THE
4386  PRINT"CHANNEL,
4388  GOSUB 1900
4390  GOSUB 2400
4400  CLS
4405  PRINT:PRINT
4410  PRINT"IN READING:"PRINT
4420  PRINT"SOURCE",CHR$(149);" THE MIND OF THE AUTHOR
4425  PRINT"MESSAGE",CHR$(149);" THOUGHT
4430  PRINT"TRANSMITTER",CHR$(149);" PRINTED PAGE
4435  PRINT"SIGNAL",CHR$(149);" WORD
4440  PRINT"CHANNEL",CHR$(149);" LIGHT
4445  PRINT"RECEIVER",CHR$(149);" EYE
4450  PRINT"DESTINATION",CHR$(149);" THE MIND OF THE
READER
4460  GOSUB 1900
4490  GOSUB 2400
4500  CLS:GOSUB 1030
4505  PRINT$320",".
4610  PRINT$" IT IS UNFORTUNATELY CHARACTERISTIC OF
COMMUNICATIONS
4620  PRINT$"SYSTEMS THAT CERTAIN THINGS MAY BE ADDED TO
THE SIGNAL BETWEEN
4625  PRINT$"TRANSMISSION AND RECEPTION THAT WERE NOT
INTENDED BY THE
4630  PRINT$"INFORMATION SOURCE,
4635  GOSUB 1900
4639  GOSUB 2400
4640  GOSUB 1300
4645  PRINT$" ANY SUCH CHANGE IN THE TRANSMITTED SIGNAL
IS CALLED
4650  PRINT$"NOISE".
4660  GOSUB 1900
4670  GOSUB 2400
4680  CLS:GOSUB 1030
4685  GOSUB 1300
4690  GOSUB 1640
4695  PRINT$324"," NOISE MAY BE DEFINED AS ANY OUTSIDE
FORCE WHICH ACTS ON
4720  PRINT$"THE TRANSMITTED SIGNAL TO VARY IT FROM THE
ORIGINAL.
4725  GOSUB 1900
4730  GOSUB 2400
4735  PRINT$312"," EXAMPLES ARE DISTORTIONS OF SOUND (EG, IN
RECORDING),
4750  PRINT$"STATIC (IN RADIO), DISTORTIONS IN SHAPE,
SHADING, OR COLOUR
4755  PRINT$"TELEVISION), OR ERRORS IN TRANSMISSION
(EG, IN TELEGRAPHY).
4760  GOSUB 1900

1920' PRINT "IN THIS SITU ATION • . WHICH OF THE F OL. LDWING FIT S THE DEFINITION
1930:PRINT'PRINT' PRINT 1. JOLTS AND VIBRATION CAUSED BY THE BUMPY ROAD
1940 PRINT' 2. FLICKERING LIGHT CAUSED BY THE TREES AND OTHER CARS
1950 PRINT' 3. FAINT OR DISJOINTED TYPE CAUSED BY A FAULTY PRINTING PRESS
1960 PRINT' 4. ALL OF THE ABOVE
1970 GOSUB 1900.
1980 GOSUB/2450
5000 CLS
5005 IF R>16 GOTO 5050 .
5010 GOSUB 2480
5040 GOTO 5090
5050 GOSUB 2470
5060 PRINT ' THE CORRECT ANSWER IS 4 , ALL OF THE ABOVE . THE
5070 PRINT ' UNSTEADINESS OF THE BOOK, THE UNCERTAIN LIGHT.
5080 PRINT' TYPE ARE ALL OUTSIDE FORCES WHICH DEGRADE THE SIGNAL AND ARE
5090 PRINT'THEREFORE NOISE.
5090 GOSUB 5090.
5100 CLS:PRINT192."
5105 PRINT' THERE ARE A NUMBER OF WAYS IN WHICH NOISE IN
5110 PRINT' COMMUNICATIONS MAY BE OVERCOME. THESE INCLUDE:
5115 PRINT' - THE USE OF REDUNDANCY IN THE MESSAGE
5116 PRINT' - INCREASING THE POWER OF THE TRANSMITTER
5117 PRINT' - DUPLICATING THE MESSAGE IN OTHER SIGNALS, CHANNELS
5121 PRINT' - CAREFUL BEAMING OF THE SIGNAL
5125 GOSUB 1900
5130 GOSUB 2400
5135 CLS
5140 PRINT' EXAMPLE: THE MESSAGE 'HELP'
5145 FOR N=1 TO 27:PRINT CHR$ (131);:NEXT N:PRINT
5150 PRINT' 'USE OF REDUNDANCY: '
5155 FOR N=1 TO 10:PRINT "HELP ";:NEXT N
5156 GOSUB 1900
5157 GOSUB 2400
5160 PRINT0384, ' "INCREASING TRANSMITTER POWER"'
5165 PRINT@468,CHR$(191):CHR$(195):CHR$(191):CHR$(193):CHR$(191)
PRINT@532,CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131)
5167 PRINT@532,CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131)
5168 FOR N=1 TO DYN; NEXT N
5170 PRINT@596,CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131)
5171 GOSUB 1900
5172 GOSUB 2400
5175 PRINT@704,"DUPLICATION ON OTHER CHANNELS";
5180 PRINT"HELP:";LPRT="HELP"
5185 FOR N=1 TO 5;LPRT=CHR$(138);NEXT N
5187 GOSUB 1900
5190 GOSUB 2400
5200 CLS;PRINT"PROBLEM!";PRINT
5205 PRINT"YOU AND A FRIEND ARE AMONG A BOISTEROUS CROWD WATCHING A CHAMPIONSHIP BASKETBALL GAME IN A HIGH SCHOOL GYMNASIUM. TO OVERCOME THE DIN, YOUR FRIEND LEANS OVER AND SPEAKS DIRECTLY INTO YOUR EAR."
5225 PRINT;GOSUB 2050
5227 GOSUB 1900
5230 GOSUB 2450
5235 IF R<>16 GOTO 5250
5240 GOSUB 2480
5245 GOTO 5290
5250 GOSUB 2470
5260 PRINT"THE CORRECT ANSWER IS #4. BY LEANING OVER TO SPEAK DIRECTLY INTO YOUR EAR, YOUR FRIEND HAS CAREFULLY BEANING HIS VOCAL SIGNAL. IN SUCH A CASE YOUR FRIEND MIGHT ALSO SHOUT, THUS INCREASING THE POWER OF THE TRANSMITTER."
5270 PRINT"INCREASING THE POWER OF THE TRANSMITTER."
5280 GOSUB 1900
5290 GOSUB 2400
5300 CLS;PRINT"PROBLEM!";PRINT
5305 PRINT"AT THE SAME BASKETBALL GAME, YOUR FRIEND CATCHES YOUR ATTENTION BY SAYING 'HEY' WHILE JABBING YOU IN THE RIBS WITH AN ELBOW."
5310 PRINT;GOSUB 2050
5320 GOSUB 1900
5330 GOSUB 2450
5335 IF R<>8 GOTO 5350
5340 GOSUB 2480
5345 GOTO 5390
5350 GOSUB 2470
5360 PRINT "THE CORRECT ANSWER IS #3. BY JABBING YOUR
RIBS WHILE
5365 PRINT "SPEAKING TO ATTRACT YOUR ATTENTION, YOUR
FRIEND HAS
5370 PRINT "DUPLICATING THE MESSAGE IN ANOTHER CHANNEL.
5380 GOSUB 1900
5390 GOSUB 2400
5400 CLS
5410 PRINT "THE LANGUAGES WHICH WE WRITE AND SPEAK
HAVE EXTRA
5415 PRINT "FRAMEWORK TO HELP ENSURE THAT OUR MESSAGES GET
THROUGH IN
5420 PRINT "SPITE OF ANY DISTORTION. THIS IS AN EXAMPLE OF
 THE USE OF
5425 PRINT "REDUNDANCY TO COMBAT THE EFFECTS OF NOISE IN
THE COMMUNICATIONS.
5430 PRINT "CHANNEL:
5433 FOR I TO DY(4): NEXT N
5435 PRINT CHR$(23);
5440 PRINT$332,"THE ENGLISH LANGUAGE,
5442 PRINT$408,"IS ABOUT
5444 PRINT$462,"ONE-HALF REDUNDANT
5446 GOSUB 1900
5450 PRINT CHR$(26): GOSUB 2400
5455 PRINT$462,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
CHR$(191);CHR$(191)
5457 GOSUB 1670
5460 PRINT$414,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
CHR$(191);CHR$(191);CHR$(191);CHR$(191)
5462 GOSUB 1670
5465 PRINT$332,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
CHR$(191)
5467 GOSUB 1670
5470 PRINT$356,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
5475 GOSUB 1670
5480 PRINT$576,"THE MEANING IS STILL CLEAR AFTER
HALF OF THE WORDS HAVE
5485 PRINT "BEEN DELETED.
5487 GOSUB 1900
5490 GOSUB 2400
5700 CLS: PRINT "A-SIMPLIFIED EXAMPLE!"
5710 PRINT "SOURCE:" "MONTREAL STOCKBROKER'S OFFICE
5715 PRINT "DESTINATION:" "ST. JOHN'S STOCKBROKER'S OFFICE
5720 PRINT "AT THE INFORMATION SOURCE THERE ARE TWO
POSSIBLE MESSAGES!"
5725 PRINT "BUY", "SELL"
5730 PRINT "SELL" IS SELECTED, CODED BY THE TELEX MACHINE (THE.
5735 PRINT "TRANSMITTER"), AND SENT OVER THE CHANNEL AS
5740 PRINT "THERE IS ELECTRICAL INTERFERENCE (NOISE) ON
5745 PRINT "MACHINE IN ST. JOHN'S (RECEIVER) PRINTS OUT
5750 PRINT "BUY", "SELF"
5755 PRINT "BUY", "SELL"
5760 PRINT "BUY", "SELF"
5770 PRINT "SELF", "SELL"
5775 PRINT "AS, THERE ARE ONLY TWO POSSIBLE MESSAGES,
5780 PRINT "SUFFICIENT REDUNDANCY IN THE SPELLING OF THE
5785 PRINT "WORD 'SELF', THE
5790 PRINT "MEANING IS CLEAR.
5795 GOSUB 1900
5800 GOSUB 2400
5805 CLS
5810 PRINT "ON THE MAIN ROAD, THE OUTSKIRTS OF YOUR
5815 PRINT "CITY IS MARKED BY
5820 PRINT "A CLUTTER OF FAST FOOD TAKEOUTS, RESTAURANTS,
5825 PRINT "CAR DEALERS, AND SERVICE STATIONS, EACH
5830 PRINT "DISPLAYS ONE OR MORE
5835 PRINT "SIGNS WHICH COMPETE WITH THE TRAFFIC SIGNS AND
5840 PRINT "SIGNS FOR THE
5845 PRINT "ATTENTION OF PASSING MOTORISTS.
5850 PRINT "HAVING TAKEN OVER A RESTAURANT IN
5855 PRINT "THIS AREA, YOU DECIDE
5860 PRINT "TO GET YOUR MESSAGE ACROSS TO THE MOTORISTS BY
5865 PRINT "INSTALLING THE
5870 PRINT "LARGEST, BRIGHTEST SIGN ON THE STRIP.
5875 PRINT "GOSUB 2050
5880 GOSUB 1900
5885 GOSUB 2450
5890 CLS: IF R<4 GOTO 5950
5895 GOSUB 2480
5900 GOTO 5990
5905 GOSUB 2470
5910 PRINT "THE CORRECT ANSWER IS #2, BY USING A
5915 PRINT "LARGER, BRIGHTER
5920 PRINT "SIGN, YOU ARE INCREASING THE POWER OF YOUR
5925 PRINT "TRANSMITTER.
5930 GOSUB 1900
5935 GOSUB 2400
5940 CLS
5950 GOSUB 2470
5955 CLS: IF R<4 GOTO 5950
5960 PRINT "THERE ARE OTHER FACTORS (BESIDES NOISE)
5965 PRINT "WHICH CAN KEEP A
5970 PRINT "MESSAGE FROM REACHING ITS DESTINATION INTACT.
5975 PRINT "THE BACKGROUND AND CONDITION OF THE
5980 PRINT "RECEIVING APPARATUS.
MAY DIFFER FROM THAT OF THE TRANSMITTER TO THE
EXTENT THAT THE
PRINT 'RECEIVER' MAY, NOT BE ABLE TO PICK UP THE
SIGNS WITHOUT
PRINT 'DISTORTION', IN ANY SYSTEM, THE RECEIVER MUST
BE ABLE TO DECODE
PRINT 'SOMETHING OF WHAT THE TRANSMITTER ENCODED OR
NO INFORMATION AT
PRINT 'AL Certification TO THE DESTINATION.
PRINT 'IF ONE PERSON SPEAKS CHINESE TO
ANOTHER, THE SECOND MUST
PRINT 'ALSO KNOW CHINESE IN ORDER TO UNDERSTAND THE
WORDS, HOWEVER
PRINT THEY STILL MIGHT BE ABLE TO COMMUNICATE
THROUGH COMMON NON-
PRINT 'VERBAL CODES IN OTHER CHANNELS: SMILES, ETC.
PRINT 'FOR N = 1 TO D Y (5); NEXT N
PRINT 1900
PRINT 2400
CLS: PRINT: PRINT: PRINT
PRINT 'IN INFORMATION THEORY, THE WORD
'INFORMATION', IS USED IN
PRINT 'A VERY SPECIAL SENSE THAT MUST NOT BE CONFUSED
WITH ITS
PRINT 'ORDINARY USAGE. IN PARTICULAR, 'INFORMATION'
MUST NOT BE
PRINT 'CONFUSED WITH MEANING.
PRINT 'THE TEST OF THE SAME TWO MESSAGES, ONE HEAVILY LOADED
WITH MEANING AND THE
PRINT 'OTHER PURE NONSENSE, CAN BE EXACTLY EQUIVALENT
AS REGARDS
PRINT 'INFORMATION.
PRINT 1900
PRINT 2400
CLS
PRINT 'THE WORD 'INFORMATION' DOES NOT RELATE AS
MUCH TO WHAT YOU
PRINT 'DO SAY AS MUCH AS TO WHAT YOU COULD SAY. THE
AMOUNT OF
PRINT 'INFORMATION INCREASES AS THE LOGARITHM OF THE
NUMBER OF
PRINT 'CHOICES.
PRINT
PRINT 'THE SMALLEST UNIT OF INFORMATION
REPRESENTS THE CHOICE
PRINT 'BETWEEN TWO MESSAGES, AS THESE SIMPLE
ALTERNATIVES CAN BE
PRINT 'REPRESENTED BY THE BINARY DIGITS '0' AND '1'.
THIS UNIT IS
PRINT 'REFERRED TO AS A 'BIT' FOR 'BINARY DIGIT'.
PRINT$ "CHR$(131);CHR$(131);" "CHR$(131);CHR$(131);
PRINT 1900
PRINT 2400
In our earlier example, the message 'SELL' contains one bit of information because it was a choice of only two possible messages, 'BUY' and 'SELL'.

For N = 1 to 6: Next N

Which of the following messages contains the most information?

1. The selection of either the novel 'War and Peace' or 'The Rise and Fall of the Third Reich'.
2. 'SELL!' (from our earlier example).
3. An answer to 'TO BE OR NOT TO BE'.
4. The response which you are about to type into this computer.

The correct number is 4. All the other answers represented a single choice between only two alternatives. The choices between the four numbers thus contain the most information.

Number of bits possible messages

Number of possible combinations of three binary digits.

Representing eight possible messages.

000
001
002
003
004
005
006
007

010
011
012
013

100
101
102
103

110
111

0 is 2 to the third power.

32 is 2 to the fifth power.
LIBRARY PRINT HOW MANY POSSIBLE MESSAGES CAN BE
CONTAINED IN SIX BITS

PRINT "OF INFORMATION?"
PRINT 1, 6
PRINT 2, 4
PRINT 3, 12
PRINT 4, 16
GOSUB 1900
GOSUB 2450
CLS: IF R<>4 GOTO 6850
GOSUB 2480
GOTO 6890
GOSUB 2470.
PRINT "THE CORRECT ANSWER IS #2. SIX BITS OF
INFORMATION CAN
PRINT "REPRESENT ANY OF UP TO SIXTY-FOUR POSSIBLE
MESSAGES.
PRINT "64 IS 2 TO THE SIXTH POWER
PRINT "THE BASE 2 LOGARITHM OF 64 IS 6
GOSUB 1900
GOSUB 2400
CLS: PRINT: PRINT
PRINT "FOUR ELECTRICAL SWITCHES (OR BINARY
DIGITS) CAN
PRINT "COMMUNICATE UP TO HOW MANY MESSAGES?
PRINT 1, 16
PRINT 2, 4
PRINT 3, 12
PRINT 4, 8
GOSUB 1900
GOSUB 2450
CLS: IF R<>2 GOTO 6950
GOSUB 2480
GOTO 6990
GOSUB 2470.
PRINT "THE CORRECT ANSWER IS #1. FOUR BITS OF
INFORMATION CAN
PRINT "REPRESENT ANY OF UP TO SIXTEEN POSSIBLE
MESSAGES.
PRINT "16 IS 2 TO THE FOURTH POWER
GOSUB 1900
GOSUB 2400
CLS: PRINT: PRINT: PRINT
PRINT "BECAUSE EACH BIT IS LIMITED TO ONE OF
ONLY TWO
PRINT "POSSIBILITIES, IT MAY APPEAR THAT THE USE OF
BINARY CODING
PRINT "WILL GREATLY RESTRICT THE COMPLEXITY OF THE
MESSAGES THAT MAY BE
PRINT "COMMUNICATED. HOWEVER, BINARY DATA IS NOT AT
ALL RESTRICTING IF
7025 PRINT *ENOUGH CHOICES, DECISIONS ARE MADE. BINARY, OR
'DIGITAL'.
7030 PRINT *CODING IS THE STANDARD METHOD OF DATA
MANIPULATION AND STORAGE.
7035 PRINT *FOR BUSINESS MACHINES AND COMPUTERS AND IS
RAPIDLY BECOMING
7040 PRINT *STANDARD FOR ALL TYPES OF TIMING, PROCESS
CONTROL, AND
7045 PRINT *ELECTRONIC COMMUNICATIONS MEDIA.
7050 GOSUB 1900
7060 GOSUB 2400
7070 CLS:PRINT:PRINT
7080 PRINT * TO DISPLAY THIS SCREEN OF CHARACTERS, THE
CENTRAL
7090 PRINT *PROCESSING UNIT OF THIS COMPUTER SENDS 8192
BITS OF INFORMATION
7100 PRINT *TO THE VIDEO DISPLAY CIRCUITRY.
7110 PRINT *INCLUDING ITS TWO DISK DRIVES, THIS
COMPUTER CAN STORE
7120 PRINT *OVER 1,300,000 BITS OF INFORMATION. DATA IS
TRANSFERRED TO AND
7130 PRINT *FROM THE DISKS AT OVER 100,000 BITS PER
SECOND.
7140 PRINT *A LARGE IBM TYPE COMPUTER CAN STORE
A BILLION BITS ON A
7150 PRINT *SINGLE DISK, AND ITS DATA TRANSFER RATES ARE
CORRESPONDINGLY
7160 PRINT *GREATER.
7170 GOSUB 1900
7180 GOSUB 2400
7190 CLS:PRINT
7200 FOR N=1 TO DY(7); NEXT N
7210 PRINT *WHenever added factors or dimensions
(SUCH AS COLOUR,
7220 PRINT *MOTION, HIGH FIDELITY, ETC.) ARE ADDED TO A
MESSAGE. THE
7230 PRINT *NUMBER OF DECISIONS NECESSARY GROWS BY GREAT
LEAPS.
7240 PRINT *A NEWSPAPER PHOTOGRAPH IS COMPOSED
OF MANY TINY BLACK
7250 PRINT *AND WHITE DOTS. A TYPICAL PICTURE REPRESENTS
PERHAPS 150,000.
7260 PRINT *BITS OF INFORMATION. THE SAME PICTURE, PRINTED
IN COLOUR,
7270 PRINT *WOULD REQUIRE APPROXIMATELY 600,000 BITS.
7280 PRINT *DIGITAL COMMUNICATION AND STORAGE
OF COLOUR TELEVISION
7290 PRINT *REQUIRES AROUND 14,000,000 BITS PER SECOND. AT
THAT RATE, A ONE-
7300 PRINT *HOUR PROGRAM REQUIRES 50,000,000,000 BITS.
7310 GOSUB 1900
7320 GOSUB 2400
7330 CLS:PRINT:PRINT:PRINT.
7605 PRINT* SOME TYPES OF COMMUNICATIONS EXIST ON A HIGHER LEVEL OF COMPLEXITY. WAVES ON A BEACH MAY APPEAR RANDOM AND MEANINGLESS.
7610 PRINT*HOWEVER, IF ONE KNOWS THE CODE, THEY CAN CONVEY KNOWLEDGE OF EVENTS FAR OUT AT SEA: WINDS, STORMS, THEIR DISTANCE AND INTENSITY, AS WELL AS THE LOCATIONS OF REEFS AND ISLANDS.
7635 PRINT* SIMILARLY, DIFFERENT TYPES OF RADIATION EMANATING FROM THE SUN ARE STILL BEING DISCOVERED AND GRADUALLY DECODED.
7640 PRINT* STARS ARE STILL BEING DISCOVERED AND GRADUALLY DECODED.
7650 GOSUB 1900
7690 GOSUB 2400
10000 CLS
10010 PRINT@401,*AND NOW, A SHORT REVIEW -- --
10020 GOSUB 1900
10090 GOSUB 2400
10100 CLS
10110 GOSUB 910
10120 GOSUB 1400
10130 GOSUB 1420
10140 PRINT@384,* THIS SIMPLIFIED DIAGRAM REPRESENTS THE BASIS OF INFORMATION THEORY, A MATHEMATICAL MODEL OF THE COMMUNICATIONS SYSTEM.
10150 PRINT*PROCESS WHICH IS APPLICABLE TO ALL FORMS OF COMMUNICATION.
10160 GOSUB 1900
10190 GOSUB 2400
10200 PRINT@384,* THE INFORMATION SOURCE SELECTS A MESSAGE OUT OF A SET OF POSSIBLE MESSAGES. THIS MESSAGE, WHETHER SIMPLE OR COMPLEX,
10210 PRINT*PROVIDES THE CONTENT OF THE COMMUNICATIONS, THE TRANSMITTER.
10215 PRINT*ENCODES THE MESSAGE, CHANGING IT INTO A SIGNAL WHICH IS SENT THROUGH THE COMMUNICATIONS MEDIUM, THE CHANNEL.
10220 PRINT*THE RECEIVER DECODES THE SIGNAL BACK INTO A MESSAGE AND HANDS IT ON TO THE INTENDED DESTINATION.
10225 PRINT@384,* ANY UNDESIRED CHANGE WHICH TAKES PLACE IN THE SIGNAL BETWEEN THE TRANSMITTER AND THE RECEIVER IS CALLED NOISE. WHEN
10230 PRINT*THE NOISE CANNOT BE ELIMINATED, THERE ARE
FOUR METHODS OF OVERCOMING ITS EFFECTS:
10325 PRINT "THE AMOUNT OF INFORMATION TRANSMITTED DEPENDS UPON THE NUMBER OF CHOICES MADE. THE NUMBER OF POSSIBLE MESSAGES IN THE MESSAGE SET. ONE BIT CAN ONLY TRANSMIT A SIMPLE CHOICE BETWEEN TWO ALTERNATIVES.
10425 PRINT "TWO BINARY DIGITS CAN REPRESENT ANY OF FOUR MESSAGES.
10430 PRINT "THREE ANY OF EIGHT, FOUR ANY OF SIXTEEN, AND SO ON. THE NUMBER OF BITS REQUIRED IS THE NATURAL OR BASE 2 LOGARITHM OF THE NUMBER OF POSSIBLE MESSAGES.
10440 PRINT "NUMBER OF POSSIBLE MESSAGES.
10450 GOSUB 1900
10490 GOSUB 2400
10495

---

QUIZ

10497
11000 CLS
11010 FOR N=15424 TO 15487:POKE N:176:NEXT N
11020 FOR N=15551 TO 16255 STEP 4:POKE N,191:NEXT N
11030 FOR N=16319 TO 16256 STEP -1:POKE N,131:NEXT N
11040 FOR N=16192 TO 15488 STEP -64:POKE N,191:NEXT N
11100 PRINT@130,1.

11105 PRINT@450,"ANY INFORMATION-SHARING ACTIVITY IS A FORM OF COMMUNICATION.
11140 GOSUB 1900
11150 GOSUB 2150
11160 IF R="T" THEN S=S+1
11200 GOSUB 2100
11205 PRINT@130,2.
11210 PRINT@450,"INFORMATION IS THE CONTENT OF THE COMMUNICATIONS PROCESS.
11240 GOSUB 1900
11250 GOSUB 2150
11260 IF R="T" THEN S=S+1
11300 GOSUB 2100
11305 PRINT@130,3.
11310 PRINT@386,"IN HUMAN SPEECH, THE SIGNAL IS SOUND. THE INFORMATION"
11320 PRINT@450,"CHANNEL IS THE LISTENER'S EAR.
11340 GOSUB 1900
11350 GOSUB 2150
11360 IF R="F" THEN S=S+1
11400 GOSUB 2100
11405 PRINT@130,4.
11410 PRINT@386,"THE FUNCTION OF THE INFORMATION
SOURCE IS TO SELECT:
11420 PRINT 450, "A DESIRED MESSAGE OUT OF A SET OF
POSSIBLE MESSAGES."
11440 GOSUB 1900
11450 GOSUB 2150
11460 IF R*="T" THEN S=S+1
11500 GOSUB 2100
11505 PRINT 130, "5."
11510 PRINT 460, "THE MESSAGE MUST BE VERY SIMPLE."
11540 GOSUB 1900
11550 GOSUB 2150
11560 IF R*="F" THEN S=S+1
11600 GOSUB 2100
11605 PRINT 130, "6."
11610 PRINT 455, "THE DESTINATION DECODES THE TRANSMITTED
SIGNAL."
11640 GOSUB 1900
11650 GOSUB 2150
11660 IF R*="F" THEN S=S+1
11700 GOSUB 2100
11705 PRINT 130, "7."
11710 PRINT 386, "INCREASING THE POWER OF THE
TRANSMITTER IS A METHOD OF."
11720 PRINT 450, "OVERCOMING REDUNDANCY."
11740 GOSUB 1900
11750 GOSUB 2150
11760 IF R*="F" THEN S=S+1
11800 GOSUB 2100
11805 PRINT 130, "8."
11810 PRINT 386, "ANY OUTSIDE FORCE WHICH ACTS ON THE
SIGNAL TO VARY IT."
11820 PRINT 450, "FROM THE ORIGINAL IS KNOWN AS 'NOISE'."
11840 GOSUB 1900
11850 GOSUB 2150
11860 IF R*="T" THEN S=S+1
11900 GOSUB 2100
11905 PRINT 130, "9."
11910 PRINT 386, "CAREFUL BEAMING OF THE SIGNAL IS ONE
METHOD OF:"
11920 PRINT 450, "OVERCOMING NOISE."
11940 GOSUB 1900
11950 GOSUB 2150
11960 IF R*="T" THEN S=S+1
12000 GOSUB 2100
12005 PRINT 130, "10."
12010 PRINT 386, "THE ENGLISH LANGUAGE HAS EXTRA
STRUCTURE WHICH HELPS."
12020 PRINT 450, "TO ENSURE THAT OUR MESSAGES GET THROUGH
IN SPITE OF ANY"
12030 PRINT 514, "DISTORTION."
12040 GOSUB 1900
12050 GOSUB 2150
12060 IF R*="T" THEN S=S+1
12100 GOSUB 2100
EXCELLENT.

GOOD.

POOR.
TO LEARN ABOUT THIS IMPORTANT AREA OF SCIENCE.

14110 PRINT "EXPLORE THE 'Q 360' SECTION OF THE LIBRARY AND VIEW THE FILM"

14120 PRINT "A COMMUNICATIONS PRIMER IN CAVE."

14150 GOSUB 1900

14190 GOSUB 2400

14300 CLS

14310 PRINT@192, "YOU HAVE NOW COMPLETED THIS COMPUTED-ASSISTED LESSON ON"

14320 PRINT "INFORMATION THEORY."

14330 PRINT

14350 PRINT "PLEASE OBTAIN THE SHORT QUESTIONNAIRE FROM THE LAB"

14355 PRINT "ASSISTANT, FILL IT IN AND RETURN IT."

14360 PRINT "THANK YOU."

14365 GOSUB 1900

14370

14380 'QUIZ RESULTS FILED ON DISK AND EXIT

14390 'PRESS THE SPACE BAR TO EXIT *";

14410 IF PEEK(14400)<128 THEN 14400

14490 CLS

15000 DIM R(50)

15100 OPEN "I",2,"RESULTS.TXT"

15200 FOR N=1 TO 50

15210 INPUT #2,R

15215 R(N)=R

15230 NEXT N

15240 CLOSE 2

15250 FOR N=1 TO 50

15255 IF R(N)=0 THEN R(N)=615300

15270 NEXT N

15300 OPEN "O",2,"RESULTS.TXT"

15310 FOR N=1 TO 50
15315 R=R(N)
15320 PRINT #2,R
15330 NEXT N
15390 CLOSE 2
19000 CLS
19999 END
II. Original version (12 second delays)

Lines 10-230 only are shown. The remainder is identical to that shown in I. above.

10 ORIGINAL VERSION #2
20 MEAN DELAY = 12 SECONDS
40______________________________________________________________________
200 DELAY CONSTANTS (SECONDS X 3.39)
210 DIM DY(10)
220 DY(1)=6246: DY(2)=2498: DY(3)=3747: DY(4)=3836: DY(5)=2319
230 DY(6)=7047: DY(7)=3301: DY(8)=5263: DY(9)=4639: DY(10)=1784

III. Original Experimental version (24 seconds delays)

Lines 10-230 only are shown. The remainder is identical to that shown in I. above.

10 EXPERIMENTAL CAI LESSON ON INFORMATION THEORY
20 VERSION #3
30 MEAN DELAY = 24 SECONDS
40______________________________________________________________________
200 DELAY CONSTANTS (SECONDS X 3.39)
210 DIM DY(10)
220 DY(1)=12492: DY(2)=4996: DY(3)=7494: DY(4)=7672: DY(5)=4638
230 DY(6)=14094: DY(7)=6602: DY(8)=10526: DY(9)=9278:
   DY(10)=3568
IV. Final Control group version (no delay)
EXPERIMENTAL CAI LESSON ON INFORMATION THEORY

VERSIO N #1

MEAN DELAY = 0 SECONDS

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DELAY CONSTANTS (SECONDS × 339)

DIM DY(7)

FOR N=1 TO 7: DY(N)=0: NEXT N

---

INTRODUCTORY TEXT

CLS: PRINT: PRINT

PRINT" WELCOME TO A COMPUTER ASSISTED INSTRUCTION UNIT ON"

PRINT" INFORMATION THEORY."

PRINT" TO ADVANCE THE LESSON, YOU MUST PRESS THE APPROPRIATE KEYS ON"

PRINT" THE COMPUTER KEYBOARD. THE ONLY KEYS REQUIRED ARE THE SPACE BAR"

PRINT" AT THE BOTTOM OF THE KEYBOARD, THE KEYS NUMERED: 1, 2, 3, AND 4."

PRINT" (EITHER AT THE TOP OR FAR RIGHT OF THE KEYBOARD), AND THE."

PRINT" LETTERS T AND F. SHOULD YOU PRESS A KEY AND NOTHING HAPPENS,"

PRINT" PRESS AGAIN - FIRMLY."

PRINT" THE CUE AS TO WHICH KEY TO PRESS WILL ALWAYS APPEAR ON"

PRINT" THE BOTTOM OF THE SCREEN, LIKE THIS:"

GOSUB 2030

GOSUB 2430

CLS: GOTO 2710

---

LINE S 910-1670 CONTAIN THE VARIOUS GRAPHICS SUBROUTINES

GRAPHIC SUBROUTINE WITH DELAY

FOR N=0 TO 168

READ A: PRINT CHR$(A);: NEXT N

FOR N=1 TO DY(3): NEXT N

FOR N=169 TO 255

READ A: PRINT CHR$(A);: NEXT N

RESTORE

RETURN

MAIN GRAPHIC SUBROUTINE

FOR N=0 TO 255

READ A: PRINT CHR$(A);: NEXT N

DATA

156, 140, 140, 140, 140, 140, 140, 140, 140, 140, 140, 140, 140, 172, 128, 128, 128, 128, 128, 128, 128, 128

DATA
128,156,140,140,140,140,140,140,140,140,140,140,140,140,140,128
770 DATA
128,128,128,128,128,128,156,140,140,140,140,140,140,140,172
2,128
790 DATA
128,128,128,128,128,128,128,128,156,140,140,140,140,140,140,140,14
0,172
810 DATA
149,128,83,79,85,82,67,69,128,170,176,176,176,176,176,176,178
830 DATA
164,149,128,84,82,65,78,83,45,128,170,176,176,176,176,176
850 DATA
176,176,176,176,176,164,149,82,69,67,69,73,86,69,82,170,176
870 DATA
176,176,176,176,176,176,164,149,128,68,69,63,84,73,95,128,170
890 DATA
8,136
910 DATA
129,149,128,77,73,84,84,69,82,128,170,128,128,128,128,128,128
930 DATA
0,128
950 DATA
128,128,128,128,136,129,149,128,78,65,84,73,79,78,128,170
970 DATA
131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,128
8,128
990 DATA
128,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131
8,128
1010 DATA
128,128,128,128,128,128,128,128,131,131,131,131,131,131,131,131
1,128
1030 DATA
128,128,128,128,128,128,128,128,131,131,131,131,131,131,131,131
1,131
1050 RESTORE
1070 RETURN
1090 PRINT@95,CHR$(156);CHR$(172);
1110 PRINT@158,CHR$(152);CHR$(171);CHR$(151);CHR$(164);
1130 PRINT@220,CHR$(156);CHR$(140);CHR$(140);CHR$(142);CHR$(141);CHR$(140);CHR$(140);CHR$(172);
1150 PRINT@284,CHR$(149);NOISE;CHR$(170);
1170 PRINT@348,CHR$(141);CHR$(140);CHR$(140);CHR$(140);CHR$(140);CHR$(140);CHR$(140);CHR$(142);
1190 RETURN
1210 PRINT@10,"MESSAGE";PRINT@29,"SIGNAL";PRINT@47,"MESSAGE";
1230 RETURN
1250 PRINT@156,"CHANNEL";
1270 PRINT @ 256,*:RETURN
1290 PRINT @ 156,*;
1310 RETURN
1330 FOR N = 1 TO 6:PRINT @ 65,*;
1350 FOR C = 1 TO 30:NEXT C
1370 PRINT @ 65,*:SOURCE:*:FOR C = 1 TO 60:NEXT C:NEXT N
1390 PRINT @ 256,*:*RETURN
1410 FOR N = 1 TO 6:PRINT @ 10,*;
1430 FOR C = 1 TO 30:NEXT C
1450 GOSUB 1210:FOR C = 1 TO 30:NEXT C
1470 NEXT N:PRINT @ 256,*:*RETURN
1490 FOR N = 1 TO 6:PRINT @ 82,*;
1510 FOR C = 1 TO 30:NEXT C
1530 PRINT @ 82,*:TRANS:*:PRINT @ 146,*:MITTER:*:FOR C = 1 TO 30:NEXT C
1550 NEXT N:PRINT @ 256,*:*RETURN
1570 FOR N = 1 TO 6:PRINT @ 27,*;
1590 FOR C = 1 TO 30:NEXT C:GOSUB 1210
1610 FOR C = 1 TO 30:NEXT C
1630 NEXT N:RETURN
1650 FOR N = 1 TO 6:PRINT @ 156,*;
1670 FOR C = 1 TO 30:NEXT C
1690 GOSUB 1250:FOR C = 1 TO 30:NEXT C
1710 NEXT N:PRINT @ 256,*:*RETURN
1730 FOR N = 1 TO 6:PRINT @ 102,*;
1750 FOR C = 1 TO 30:NEXT C
1770 PRINT @ 102,*:RECEIVER:*:FOR C = 1 TO 30:NEXT C
1790 NEXT N:RETURN
1810 FOR N = 1 TO 6:PRINT @ 119,*;
1830 FOR C = 1 TO 30:NEXT C
1850 PRINT @ 119,*:DESTI-*:PRINT @ 183,*:NATION:*:FOR C = 1 TO 30:NEXT C
1870 NEXT N:RETURN
1890 FOR N = 1 TO 6:PRINT @ 285,*;
1910 FOR C = 1 TO 30:NEXT C
1930 PRINT @ 285,*:NOISE:*:FOR C = 1 TO 30:NEXT C
1950 NEXT N:RETURN
1970 FOR C = 1 TO 400:NEXT C:RETURN
1990 **------------------------------------------**

2010 ' MIS C. SUBROUTINES
2030 FOR C = 1 TO 100:NEXT C:RETURN
2050 PRINT:PRINT* 1, LIGHT
2070 PRINT* 2, WORD
2090 PRINT* 3, PRINTED PAGE
2110 PRINT* 4, EYE
2130 RETURN
2150 PRINT* THIS IS AN EXAMPLE OF WHICH METHOD OF COMEATING NOISE?
2170 PRINT* 1, USE OF REDUNDANCY
2190 PRINT* 2, INCREASED TRANSMITTER POWER
2210 PRINT 3. MESSAGE DUPLICATED IN OTHER CHANNELS
2230 PRINT 4. CAREFUL BEAMING OF THE SIGNAL
2250 RETURN
2270 FOR N=129 TO 833 STEP 64:PRINTCHR(253):NEXT N
2290 RETURN
2310
2330 ' STUDENT RESPONSE INPUT SUBROUTINES
2350 T$=INKEY$:PRINT@960," * PRESS T (TRUE)
2370 OR F (FALSE) *"
2390 IF R$<>"F" AND R$<>"T" THEN 2370
2410 RETURN
2430 T$=INKEY$:PRINT@960," * PRESS THE SPACE BAR WHEN
2450 YOU ARE READY TO PROCEED *"
2470 IF R$<>"F" THEN 2450
2490 RETURN
2510 T$=INKEY$:PRINT@960," * PRESS THE CORRECT
2530 NUMBER KEY *"
2550 IF R$<"1" GOT0 2510 ELSE IF R$>"4" GOT0 2510
2570 R$=PEEK (14352):RETURN
2590 PRINT CHR$(23):PRINT@408,"WRONG!":PRINT
2610 CHR$(28):PRINT@498,""
2630 RETURN
2650 PRINT CHR$(23):PRINT@472,"CORRECT!":PRINT CHR$(28)
2670 RETURN

2690 ' MAIN TEXT STARTS HERE
2710 CLS
2720 PRINT@254,""
2730 PRINT* IN ITS WRODEST SENSE, COMMUNICATION CAN
2750 BE DEFINED AS 'ANY
2770 PRINT* INFORMATION-SHARING ACTIVITY. IT INCLUDES ALL
2790 FORMS OF THE
2810 PRINT* TRANSMISSION OF MESSAGES FROM ELECTRICAL
2830 IMPULSES TO HUMAN.
2850 PRINT* LANGUAGES.
2870 GOSUB 2030
2880 GOSUB 2430
2900 GOSUB 126,""
2915 PRINT* ANY INFORMATION-SHARING ACTIVITY IS A FORM
2920 OF:
2925 PRINT* 1. LANGUAGE
2929 PRINT* 2. MEANING
2930 PRINT* 3. COMMUNICATION
2935 PRINT* 4. ELECTRICITY
2940 GOSUB 2030.
2944 GOSUB 2510.
2950 CLS:IF R<>B GOT0 2870
COMMUNICATION IS A DYNAMIC PROCESS IN WHICH A MESSAGE
SEARCH CONSCIOUSLY OR UNCONSCIOUSLY AFFECTS A
RECEIVER THROUGH
MATERIALS OR AGENCIES USED IN SYMBOLIC WAYS.
AT ITS SIMPLEST;
THE PROCESS CAN BE REPRESENTED BY THIS
DIAGRAM:
 WHICH OF THE FOLLOWING IS AN EXAMPLE OF
COMMUNICATION?
1. THE READING OF A BOOK
2. A TEACHER'S ANGRY GLANCE AT A MISBEHAVING
STUDENT
3. A THERMOSTAT CAUSING A HEATER TO SWITCH ON
4. ALL OF THE ABOVE
THE READING OF A BOOK, THE TEACHER'S ANGRY
GLANCE, AND
THE ACTION OF THE HEATER THERMOSTAT ARE ALL
FORMS OF
COMMUNICATION.
THE INFORMATION SOURCE SELCETS A DESIRED
MESSAGE OUT OF
A SET OF POSSIBLE MESSAGES.
THIS SET OF POSSIBLE MESSAGES MAY BE AS
LARGE AND COMPLEX.
AS ALL THE THOUGHTS AND IDEAS OF WHICH THE
HUMAN MIND IS
CAPABLE. IT MAY BE AS SIMPLE AS THE 'ON' AND
'OFF' STATES OF
AN ELECTRIC CIRCUIT.
IN HUMAN SPEECH, THE BRAIN OF THE SPEAKER IS THE INFORMATION SOURCE.

This message, which has been selected by the source, can be of many forms. It may consist of words, pictures, music.

Ideas, or electrical states, etc., it may be very simple or very complex.

In human speech, the information source is the speaker's brain. The message is a thought. Answer "1" is:

- PRINT "THE CORRECT ONE."
- PRINT "FOR N=1 TO 10 END NEXT N"

The transmitter operates on the message in some way to produce a signal suitable for transmission over the channel.

This involves a coding process. An example is a telephone.

An instrument, which changes sound pressure into a proportional electric current.

The transmitter is the speaker's vocal.
3925 PRINT "MECHANISM."
3950 GOSUB 2030
3960 GOSUB 2430
3970 CLS:GOSUB 690
3975 GOSUB 1210
3980 GOSUB 1250
3990 GOSUB 1570
4010 PRINT @320>
4030 PRINT " THE SIGNAL IS THE ENCODED OUTPUT OF THE
4050 PRINT " TRANSMITTER WHICH
4070 PRINT " IS SENT ALONG THE CHANNEL. IT MAY BE SOUND
4090 PRINT " WAVES, ELECTRICAL
4100 PRINT " IMPULSES, THE DOTS AND DASHES OF MORSE CODE,
4110 PRINT " ETC.
4120 GOSUB 2030
4130 GOSUB 2430
4140 CLS:PRINT:PRINT:PRINT
4150 PRINT " IN HUMAN SPEECH, THE SIGNAL IS:
4160 PRINT " 1. SOUND
4170 PRINT " 2. THOUGHT
4180 PRINT " 3. AIR
4190 FOR N=1 TO 2: NEXT N
4210 PRINT " 4. NONE OF THE ABOVE
4220 GOSUB 2030
4230 GOSUB 2510
4240 CLS:IF R<>2 GOTO 4150
4250 GOSUB 2630
4260 GOTO 4180
4270 GOSUB 2590
4280 PRINT " #1 IS CORRECT. IN HUMAN SPEECH, THE
4290 PRINT " SIGNAL IS VOCALIZED"
4300 PRINT "SOUND."
4310 GOSUB 2030
4320 GOSUB 2430
4330 CLS:GOSUB 690
4340 GOSUB 1210
4350 GOSUB 1250
4360 GOSUB 1650
4370 PRINT " THE CHANNEL IS MERELY THE MEDIUM USED TO
4380 PRINT " TRANSMIT THE.
4390 PRINT " SIGNAL FROM TRANSMITTER TO RECEIVER. IT MAY BE
4400 PRINT " A PAIR OF WIRES,
4410 PRINT " A COAXIAL CABLE, A RADIO FREQUENCY, A BEAM OF
4420 PRINT " LIGHT, ETC.
4430 PRINT " IN THE CASE OF SPEECH, THE
4440 PRINT " COMMUNICATIONS CHANNEL IS"
4450 PRINT " THE AIR THROUGH WHICH THE SOUND WAVES TRAVEL."
4460 GOSUB 2030
4470 GOSUB 2430
4480 CLS:GOSUB 690
4490 GOSUB 1210
4500 GOSUB 1250
4510 GOSUB 1730
4520 GOSUB 1730
THE RECEIVER IS AN INVERSE TRANSMITTER. IT DECODES THE SIGNAL, CHANGING IT BACK INTO A MESSAGE AND HANDING IT ON TO THE DESTINATION.

THE LISTENER'S EAR IS THE RECEIVER.

THE DESTINATION IS THE PERSON OR THING FOR WHICH THE MESSAGE IS INTENDED.

IN HUMAN SPEECH, THE DESTINATION IS THE BRAIN OF THE LISTENER.

IN HUMAN SPEECH, THE DESTINATION THAT OF THE READER.

WHICH OF THE FOLLOWING IS THE TRANSMITTER?

THE CORRECT ANSWER IS 3. IN READING, THE PRINTED PAGE IS THE TRANSMITTER.
4870 GOSUB 2430
4890 CLS:PRINT:PRINT:PRINT
4910 PRINT "ALSO IN READING, WHICH IS THE CHANNEL?
4930 GOSUB 2050
4950 GOSUB 2030
4970 GOSUB 2510
4990 CLS
5030 IF R<>2 GOTO 5090
5050 GOSUB 2630
5070 GOTO 5170:
5090 GOSUB 2590
5110 PRINT "THE CORRECT ANSWER IS #1. IN READING,
LIGHT ACTS AS THE
5130 PRINT "CHANNEL."
5150 GOSUB 2030
5170 GOSUB 2430
5190 CLS
5210 PRINT:PRINT:
5230 PRINT "IN READING:
5250 PRINT "SOURCE",CHR$(149);" THE MIND OF THE AUTHOR
5270 PRINT "MESSAGE",CHR$(149);" THOUGHT
5290 PRINT "TRANSMITTER",CHR$(149);" PRINTED PAGE
5310 PRINT "SIGNAL",CHR$(149);" WORD
5330 PRINT "CHANNEL",CHR$(149);" LIGHT
5350 PRINT "RECEIVER",CHR$(149);" EYE
5370 PRINT "DESTINATION",CHR$(149);" THE MIND OF THE READER
5390 GOSUB 2030.
5410 GOSUB 2430
5430 CLS:GOSUB 690
5450 PRINT @320,"*
5470 PRINT "IT IS UNFORTUNATELY CHARACTERISTIC OF
COMMUNICATIONS
5490 PRINT "SYSTEMS THAT CERTAIN THINGS MAY BE ADDED TO
THE SIGNAL BETWEEN
5510 PRINT "TRANSMISSION AND RECEPTION THAT WERE NOT
INTENDED BY THE
5530 FOR N=1 TO D(Y(4);NEXT N
5550 PRINT "INFORMATION SOURCE."
5560 GOSUB 2030
5570 GOSUB 2430
5590 GOSUB 1970
5610 PRINT @640,"*
5630 PRINT "ANY SUCH CHANGE IN THE TRANSMITTED SIGNAL
IS CALLED
5650 PRINT "NOISE"
5670 GOSUB 2030
5690 GOSUB 2430
5710 CLS:GOSUB 690
5720 PRINT "NOISE MAY BE DEFINED AS ANY OUTSIDE
FORCE WHICH ACTS ON
5740 PRINT "THE TRANSMITTED SIGNAL TO VARY IT FROM THE
ORIGINAL.
5810 GOSUB 2030
5830 GOSUB 2430
5850 PRINT$(512)
5870 PRINT*131 EXAMPLES ARE DISTORTIONS OF SOUND (E.G. IN
RECORDING):
5890 PRINT*STATIC (IN RADIO), DISTORTIONS IN SHAPE,
SHADING, OR COLOUR
5910 PRINT*IN TELEVISION), OR ERRORS IN TRANSMISSION
(E.G. IN TELEGRAPHY).
5930 GOSUB 2030
5950 GOSUB 2430.
5970 CLS:PRINT:PRINT
5990 PRINT* YOU ARE A PASSENGER IN A CAR WHICH IS
BEING-DRIVEN RAPIDLY
6010 PRINT*LONG A SMALL COUNTRY ROAD YOU ARE ATTEMPTING
TO READ A BOOK.
6030 PRINT*IN THIS SITUATION WHICH OF THE FOLLOWING FITS
THE DEFINITION
6050 PRINT*OF NOISE?
6070 PRINT*PRINT 1. JOLTS AND VIBRATION CAUSED BY THE
BUMPY ROAD
6090 PRINT*2. FLICKERING LIGHT CAUSED BY THE TREES AND
OTHER CARS
6110 PRINT*3. FAINT OR DISJOINTED TYPE CAUSED BY A
FAULTY PRINTING PRESS
6130 PRINT*4. ALL OF THE ABOVE
6150 GOSUB 2030
6160 FOR N=1 TO D$(5):NEXT N
6170 GOSUB 2510
6190 CLS
6210 IF R$>16 GOTO 6270
6230 GOSUB 2630'
6250 GOTO 6390
6270 GOSUB 2590
6290 -PRINT* THE CORRECT ANSWER IS 4. ALL OF THE
ABOVE. THE
6310 PRINT*UNSTEADINESS OF THE BOOK, THE UNCERTAIN LIGHT,
AND THE POOR
6330 PRINT*TYPE ARE ALL OUTSIDE FORCES WHICH DEGRADE THE
SIGNAL, AND ARE
6350 PRINT*THEREFORE NOISE.
6370 GOSUB 2030
6390 GOSUB 2430
6410 CLS:PRINT$(92)
6430 PRINT* THERE ARE A NUMBER OF WAYS IN WHICH NOISE IN
6450 PRINT*COMMUNICATIONS MAY BE OVERCOME. THESE INCLUDE:
6470 PRINT* - THE USE OF REDUNDANCY IN THE MESSAGE
6490 PRINT* - INCREASING THE POWER OF THE TRANSMITTER
6510 PRINT* - DUPLICATING THE MESSAGE IN OTHER
SIGNALS, CHANNELS
6530 PRINT* - CAREFUL BEAMING OF THE SIGNAL
6550 GOSUB 2030

...
132

6570 GOSUB 2430
6590 CLS
6610 PRINT "EXAMPLE: THE MESSAGE 'HELP'
6630 FOR N=1 TO 27:PRINT CHR$(131);:NEXT N:PRINT
6650 PRINT "USE OF REDUNDANCY:"
6670 FOR N=1 TO 10:PRINT "HELP":NEXT N
6690 GOSUB 2030
6710 GOSUB 2430
6730 PRINT "INCREASING TRANSMITTER POWER:"
6750 PRINT 468,CHR$(191);CHR$(195);CHR$(191);CHR$(193);CHR$(191)
   CHR$(131);CHR$(131);CHR$(193);CHR$(191);CHR$(197);CHR$(191)
   CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(131)
6770 PRINT 532,CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(191)
   CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(131)
6790 FOR N=1 TO 3:PRINT "HELP":NEXT N
6810 PRINT 396,CHR$(131);CHR$(195);CHR$(191);CHR$(193);CHR$(131)
   CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(131)
6830 GOSUB 2030
6850 GOSUB 2430
6870 PRINT 701, "DUPLICATION ON OTHER CHANNELS:
6890 PRINT "HELP":PRINT,"HELP"
6910 FOR N=1 TO 5:PRINT CHR$(139);:NEXT N
6930 GOSUB 2030
6950 GOSUB 2430
6970 CLS:PRINT:PRINT:PRINT
6990 PRINT "YOU AND A FRIEND ARE AMONG A BOISTEROUS
   CROWD WATCHING A
7010 PRINT "CHAMPIONSHIP BASKETBALL GAME IN A HIGH SCHOOL
   GYMNASIUM. TO"
7030 PRINT "OVERCOME THE DIN, YOUR FRIEND LEANS OVER AND
   SPEAKS DIRECTLY"
7050 PRINT "INTO YOUR EAR."
7070 PRINT:GOSUB 2150
7090 GOSUB 2030
7110 GOSUB 2510
7130 CLS:IF R<16 GOTO 7190
7150 GOSUB 2630
7170 GOTO 7310
7190 GOSUB 2590
7210 PRINT "THE CORRECT ANSWER IS 14. BY LEANING OVER TO SPEAK"
7230 PRINT "DIRECTLY INTO YOUR EAR, YOUR FRIEND WAS
   CAREFULLY BEATING HIS"
7250 PRINT "VOCAI SIGNAL. IN SUCH A CASE YOUR FRIEND MIGHT
   ALSO SHOUT, THUS"
7270 PRINT "INCREASING THE POWER OF THE TRANSMITTER."
7290 GOSUB 2030
7310 GOSUB 2430
7330 CLS:PRINT:PRINT:PRINT
7350 PRINT* AT THE SAME BASKETBALL GAME, YOUR FRIEND
CATCHES YOUR
7370 PRINT ATTNENTION BY SAYING 'HEY' WHILE JABBING YOU IN
THE RIBS WITH
7390 PRINT AN ELBOW.
7410 PRINT:GOSUB 2150
7430 GOSUB 2030
7450 GOSUB 2510
7470 CLS:IF R<26 GOTO 7530
7490 GOSUB 2630
7510 GOTO 7630
7530 GOSUB 2590
7550 PRINT** THE CORRECT ANSWER IS $3. BY JABBING YOUR
RIBS WHILE
7570 PRINT SPEAKING TO ATTRACT YOUR ATTENTION, YOUR
FRIEND WAS
7590 PRINT DUPLICATING THE MESSAGE IN ANOTHER CHANNEL.
7610 GOSUB 2030
7630 GOSUB 2430
7650 CLS.
7670 PRINT THE LANGUAGES WHICH WE WRITE AND SPEAK
HAVE EXTRA
7690 PRINT FRAMEWORK TO HELP ENSURE THAT OUR MESSAGES GET
THROUGH IN
7710 PRINT SPITE OF ANY DISTORTION, THIS IS AN EXAMPLE OF
THE USE OF
7730 PRINT REDUNDANCY TO COMBAT THE EFFECTS OF NOISE IN
THE COMMUNICATIONS.
7750 PRINT CHANNEL.
7790 PRINT CHR$(23):
7810 PRINT0332,'THE ENGLISH LANGUAGE
7830 PRINT0408,'IS ABOUT
7850 PRINT0462,'ONE-HALF REDUNDANT
7870 GOSUB 2030
7890 PRINT CHR$(19) ; GOSUB 2430
7900 PRINT CHR$(253) ;
7910 PRINT0462,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
;CHR$(191);CHR$(191);
7930 GOSUB 1970
7950 PRINT0414,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
;CHR$(191);CHR$(191);CHR$(191);CHR$(191);
7960 FOR N=1 TO DY(6) NEXT N
7970 GOSUB 1970
7990 PRINT0332,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)
;
8010 GOSUB 1970
8030.
PRINT0356,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191)}
THE MEANING IS STILL CLEAR AFTER HALF OF THE WORDS HAVE BEEN DELETED.

ANY INFORMATION-SHARING ACTIVITY IS A FORM OF COMMUNICATION.

IN HUMAN SPEECH, THE SIGNAL IS SOUND. THE INFORMATION CHANNEL IS THE LISTENER’S EAR.

THE FUNCTION OF THE INFORMATION SOURCE IS TO SELECT A DESIRED MESSAGE OUT OF A SET OF POSSIBLE MESSAGES.

THE MESSAGE MUST BE VERY SIMPLE.

13960 GOSUB 2270
13970 PRINT@130,"6.");
13980 PRINT@455,"THE DESTINATION DECODES THE TRANSMITTED SIGNAL.");
13990 GOSUB 2030,
14000 GOSUB 2350
14010 IF R$="F" THEN S=S+1
14020 GOSUB 2270
14030 PRINT@130,"7.");
14040 PRINT@386,"INCREASING THE POWER OF THE TRANSMITTER IS A METHOD OF"
14050 PRINT@450,"OVERCOMING REDUNDANCY.");
14060 GOSUB 2030
14070 GOSUB 2350
14080 IF R$="T" THEN S=S+1
14090 GOSUB 2270
14100 PRINT@130,"9.");
14110 PRINT@386,"ANY OUTSIDE FORCE WHICH ACTS ON THE SIGNAL TO VARY IT"
14120 PRINT@450,"FROM THE ORIGINAL IS KNOWN AS 'NOISE'.");
14130 GOSUB 2030
14140 GOSUB 2350
14150 IF R$="T" THEN S=S+1
14160 GOSUB 2270
14170 PRINT@130,"9.");
14180 PRINT@386,"CAREFUL BEAMING OF THE SIGNAL IS ONE METHOD OF"
14190 PRINT@450,"OVERCOMING NOISE.");
14200 GOSUB 2030
14210 GOSUB 2350
14220 IF R$="T" THEN S=S+1
14230 GOSUB 2270
14240 PRINT@130,"10.");
14250 PRINT@386,"THE ENGLISH LANGUAGE HAS EXTRA STRUCTURE WHICH HELPS"
14260 PRINT@450,"TO ENSURE THAT OUR MESSAGES GET THROUGH IN SPITE OF ANY"
14270 PRINT@514,"DISTORTION.");
14280 GOSUB 2030
14290 GOSUB 2350
14300 IF R$="T" THEN S=S+1
14310 PRINT@386,"THE LANGUAGE HAS A STRUCTURE WHICH HELPS"
14320 PRINT@450,"TO ENSURE THAT OUR MESSAGES GET THROUGH IN SPITE OF ANY"
14330 PRINT@514,"DISTORTION.");
14340 GOSUB 2030
14350 GOSUB 2350
14360 IF R$="T" THEN S=S+1
14370 PRINT@386,"EXCELLENT");
14380 PRINT@450,"VERY GOOD.");
14390 PRINT@514,"GOOD.");
14400 PRINT@386,"POOR");
14410 PRINT@514,"YOU GOT"/S/"OUT OF 10 CORRECT.
14420 PRINT@514,"THE SURFACE OF"
14430 PRINT@514,"THIS SHORT LESSON HAS BARELY SCRATCHED"
14440 PRINT@514,"THE SURFACE OF"
14450 PRINT@514,"INFORMATION THEORY.
14460 PRINT@514,"TO LEARN MORE ABOUT THIS SUBJECT, VIEW THE FILM"
15730 PRINT "A COMMUNICATIONS PRIMER IN CAVE."
15850 PRINT
15870 PRINT "PLEASE OBTAIN THE SHORT QUESTIONNAIRE FROM"
15890 PRINT "THE LAB"
15910 PRINT "ASSISTANT, FILL IT IN, AND RETURN IT."
15930 PRINT "THANK YOU."
15950

15970 \----- QUIZ RESULTS FILED ON DISK AND EXIT
15990 T$=INKEY$ * PRESS THE SPACE BAR TO
16010 PRINT$960,"\" variable EXIT *;
16030 IF PEEK(14400)<128 THEN 16010
16050 CLS
16070 DIM R(50)
16090 OPEN "I",2,"RESULTS.TXT"
16110 FOR N=1 TO 50
16130 INPUT#2,R
16150 R(N)=R
16170 NEXT N
16190 CLOSE 2
16210 FOR N=1 TO 50
16230 IF R(N)<>0 THEN R(N)="S":GOTO 16270
16250 NEXT N
16270 OPEN "O",2,"RESULTS.TXT"
16290 FOR N=1 TO 50
16310 R=R(N)
16330 PRINT#2,R
16350 NEXT N
16370 CLOSE 2
16390 CLS
16410 END.
V. Final Experimental version (8 second mean delays)

Lines 10-130 only are shown. The remainder is identical to that shown in IV. above.

```
10    EXPERIMENTAL CAI LESSON ON INFORMATION THEORY
30   VERSION #2
50   MEAN DELAY = 8 SECONDS
70.----------------------------------------------
90   DELAY CONSTANTS (SECONDS X 339)
110  DIM DY(7)
130  DY(1)=51: DY(2)=4783: DY(3)=3434: DY(4)=2444: DY(5)=1092:
     DY(6)=3017: DY(7)=1559
```

VI. Final Experimental version (16 second mean delays)

Lines 10-130 only are shown. The remainder is identical to that shown in IV. above.

```
10    EXPERIMENTAL CAI LESSON ON INFORMATION THEORY
30   VERSION #3
50   MEAN DELAY = 16 SECONDS
70.----------------------------------------------
90   DELAY CONSTANTS (SECONDS X 339)
110  DIM DY(7)
130  DY(1)=5302: DY(2)=9567: DY(3)=6868: DY(4)=4888: DY(5)=2183:
     DY(6)=6034: DY(7)=3119
```
APPENDIX C

CAI module frame printouts

The following pages show the individual instructional frames of the CAI unit. Two frames are presented per page. The introductory, feedback, quiz and end frames have been omitted.

Each frame shown is a typewriter approximation of what was seen on the CRT display of the computer. All graphics characters are represented by periods. Many of the frames included dynamic elements such as building in steps, flashing and simple animation. All such elements have had to be eliminated.

Only the screen display is represented. One of the frames utilized the system printer as an example of the duplication of a message in a different channel.
IN ITS BROADEST SENSE, COMMUNICATION CAN BE DEFINED AS ANY INFORMATION-SHARING ACTIVITY. IT INCLUDES ALL FORMS OF THE TRANSMISSION OF MESSAGES FROM ELECTRICAL IMPULSES TO HUMAN LANGUAGES.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *

ANY INFORMATION-SHARING ACTIVITY IS A FORM OF:
1. LANGUAGE
2. MEANING
3. COMMUNICATION
4. ELECTRICITY

* PRESS THE CORRECT NUMBER KEY *
COMMUNICATION IS A DYNAMIC PROCESS IN WHICH A MESSAGE SENT CONSCIOUSLY OR UNCONSCIOUSLY AFFECTS A RECEIVER THROUGH MATERIALS OR AGENCIES USED IN SYMBOLIC WAYS. AT ITS SIMPLEST, THE PROCESS CAN BE REPRESENTED BY THIS DIAGRAM:

SOURCE ........ TRANS-MITTER ........ RECEIVER ........ DESTINATION

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *

WHICH OF THE FOLLOWING IS AN EXAMPLE OF COMMUNICATION?

1. THE READING OF A BOOK
2. A TEACHER'S ANGRY GLANCE AT A MISBEHAVING STUDENT
3. A THERMOSTAT CAUSING A HEATER TO SWITCH ON
4. ALL OF THE ABOVE

* PRESS THE CORRECTION NUMBER KEY *
THE INFORMATION SOURCE SELECTS A DESIRED MESSAGE OUT OF A SET OF POSSIBLE MESSAGES.

THIS SET OF POSSIBLE MESSAGES MAY BE AS LARGE AND COMPLEX AS ALL THE THOUGHTS AND IDEAS OF WHICH THE HUMAN MIND IS CAPABLE. IT MAY BE AS SIMPLE AS THE 'ON' AND 'OFF' STATES OF AN ELECTRIC CIRCUIT.

IN HUMAN SPEECH, THE BRAIN OF THE SPEAKER IS THE INFORMATION SOURCE.

PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED.

THIS MESSAGE, WHICH HAS BEEN SELECTED BY THE SOURCE, CAN BE OF MANY FORMS. IT MAY CONSIST OF WORDS, PICTURES, MUSIC, IDEAS, OR ELECTRICAL STATES, ETC. IT MAY BE VERY SIMPLE OR VERY COMPLEX.

PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED.
IN HUMAN SPEECH, THE INFORMATION SOURCE IS THE SPEAKER'S BRAIN. THE MESSAGE IS:

1. A WORD
2. A THOUGHT
3. 'ON' OR 'OFF'
4. AN ELECTRICAL IMPULSE

* PRESS THE CORRECT NUMBER KEY *


THE TRANSMITTER OPERATES ON THE MESSAGE IN SOME WAY TO PRODUCE A SIGNAL SUITABLE FOR TRANSMISSION OVER THE CHANNEL. THIS INVOLVES A CODING PROCESS. AN EXAMPLE IS A TELEPHONE INSTRUMENT, WHICH CHANGES SOUND PRESSURE INTO A PROPORTIONAL ELECTRIC CURRENT.

IN HUMAN SPEECH, THE TRANSMITTER IS THE SPEAKER'S VOCAL MECHANISM.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *
THE SIGNAL IS THE ENCODED OUTPUT OF THE TRANSMITTER WHICH IS SENT ALONG THE CHANNEL. IT MAY BE SOUND WAVES, ELECTRICAL IMPULSES, THE DOTS AND DASHES OF MORSE CODE, ETC.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *

IN HUMAN SPEECH, THE SIGNAL IS:

1. SOUND
2. THOUGHT
3. AIR
4. NONE OF THE ABOVE

* PRESS THE CORRECT NUMBER KEY *
THE CHANNEL IS MERELY THE MEDIUM USED TO TRANSMIT THE SIGNAL FROM TRANSMITTER TO RECEIVER. IT MAY BE A PAIR OF WIRES, A COAXIAL CABLE, A RADIO FREQUENCY, A BEAM OF LIGHT, ETC.

IN THE CASE OF SPEECH, THE COMMUNICATIONS CHANNEL IS THE AIR THROUGH WHICH THE SOUND WAVES TRAVEL.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *

THE RECEIVER IS AN INVERSE TRANSMITTER. IT DECODES THE SIGNAL, CHANGING IT BACK INTO A MESSAGE AND HANDING IT ON TO THE DESTINATION.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *
IN HUMAN SPEECH, WHICH IS THE RECEIVER?

1. SOUND WAVES
2. THE LISTENER'S EAR
3. THE LISTENER'S BRAIN.
4. THE SET OF POSSIBLE MESSAGES

* PRESS THE CORRECT NUMBER KEY *

MESSAGE SIGNAL MESSAGE
SOURCE TRANS- RECEIVER DESTI-
MITTER CHANNEL NATION

THE DESTINATION IS THE PERSON OR THING FOR WHICH THE MESSAGE IS INTENDED.

IN HUMAN SPEECH, THE DESTINATION IS THE BRAIN OF THE LISTENER.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *
PROBLEM:

In reading, the source is the mind (of the author), the destination that of the reader.

Which of the following is the transmitter?

1. Light
2. Word
3. Printed Page
4. Eye

* Press the correct number key *

Also in reading, which is the channel?

1. Light
2. Word
3. Printed Page
4. Eye

* Press the correct number key *
IN READING:

SOURCE
MESSAGE
TRANSMITTER
SIGNAL
CHANNEL
RECEIVER
DESTINATION

THE MIND OF THE AUTHOR
THOUGHT
PRINTED PAGE
WORD
LIGHT
EYE
THE MIND OF THE READER

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *

IT IS UNFORTUNATELY CHARACTERISTIC OF COMMUNICATIONS SYSTEMS THAT CERTAIN THINGS MAY BE ADDED TO THE SIGNAL BETWEEN TRANSMISSION AND RECEPTION THAT WERE NOT INTENDED BY THE INFORMATION SOURCE.

ANY SUCH CHANGE IN THE TRANSMITTED SIGNAL IS CALLED 'NOISE'.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *
Noise may be defined as any outside force which acts on the transmitted signal to vary it from the original.

Examples are distortions of sound (eg. in recording), static (in radio), distortions in shape, shading, or colour (in television), or errors in transmission (eg. in telegraphy).

* Press the space bar when you are ready to proceed *

You are a passenger in a car which is being driven rapidly along a small country road. You are attempting to read a book. In this situation, which of the following fits the definition of noise?

1. Jolts and vibration caused by the bumpy road
2. Flickering light caused by the trees and other cars
3. Faint or disjointed type caused by a faulty printing press
4. All of the above

* Press the correct number key *
THERE ARE A NUMBER OF WAYS IN WHICH NOISE IN
COMMUNICATIONS MAY BE OVERCOME, THESE INCLUDE:
- THE USE OF REDUNDANCY IN THE MESSAGE
- INCREASING THE POWER OF THE TRANSMITTER
- DUPLICATING THE MESSAGE IN OTHER SIGNALS, CHANNELS
- CAREFUL BEAMING OF THE SIGNAL

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *

EXAMPLE: THE MESSAGE 'HELP!':

USE OF REDUNDANCY:
HELP HELP HELP HELP HELP HELP HELP HELP HELP

INCREASING TRANSMITTER POWER:

DUPLICATION ON OTHER CHANNELS:
HELP

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *
YOU AND A FRIEND ARE AMONG A BOISTEROUS CROWD WATCHING A CHAMPIONSHIP BASKETBALL GAME IN A HIGH SCHOOL GYMNASIUM. TO OVERCOME THE DIN, YOUR FRIEND LEANS OVER AND SPEAKS DIRECTLY INTO YOUR EAR.

THIS IS AN EXAMPLE OF WHICH METHOD OF COMBATING NOISE?
1. USE OF REDUNDANCY
2. INCREASED TRANSMITTER POWER
3. MESSAGE DUPLICATED IN OTHER CHANNELS
4. CAREFUL BEAMING OF THE SIGNAL

* PRESS THE CORRECT NUMBER KEY *

AT THE SAME BASKETBALL GAME, YOUR FRIEND CATCHES YOUR ATTENTION BY SAYING 'HEY' WHILE JABBING YOU IN THE RIBS WITH AN ELBOW.

THIS IS AN EXAMPLE OF WHICH METHOD OF COMBATING NOISE?
1. USE OF REDUNDANCY
2. INCREASED TRANSMITTER POWER
3. MESSAGE DUPLICATED IN OTHER CHANNELS
4. CAREFUL BEAMING OF THE SIGNAL

* PRESS THE CORRECT NUMBER KEY *

THE LANGUAGES WHICH WE WRITE AND SPEAK HAVE EXTRA FRAMEWORK TO HELP ENSURE THAT OUR MESSAGES GET THROUGH IN SPITE OF ANY DISTORTION. THIS IS AN EXAMPLE OF THE USE OF REDUNDANCY TO COMBAT THE EFFECTS OF NOISE IN THE COMMUNICATIONS CHANNEL.

ENGLISH

IS

HALF REDUNDANT

THE MEANING IS STILL CLEAR AFTER HALF OF THE WORDS HAVE BEEN DELETED.

* PRESS THE SPACE BAR WHEN YOU ARE READY TO PROCEED *
Semantic differential attitude questionnaire

Sex: M   F

Below are eleven pairs of adjectives which may be applied to the computer interaction which you have just experienced. Between each pair are seven blanks. Place an "X" in the blank which best represents your feelings about the experience.

| good       | bad          |
| weak       | strong       |
| worthless  | valuable     |
| pleasant   | unpleasant   |
| tense      | relaxed      |
| long       | short        |
| clear      | hairy        |
| awful      | nice         |
| active     | passive      |
| fast       | slow         |
| unfair     | fair         |
APPENDIX E

Achievement test items

The correct answer for each is shown in parentheses.

1. Any information-sharing activity is a form of communication. (true)

2. Information is the content of the communications process. (true)

3. In human speech, the signal is sound. The information channel is the listener's ear. (false)

4. The function of the information source is to select a desired message out of a set of possible messages. (true)

5. The message must be very simple (false)

6. The destination decodes the transmitted signal. (false)

7. Increasing the power of the transmitter is a method of overcoming redundancy. (false)
8. Any outside force which acts on the signal to vary it from the original is known as 'noise'. (true)

9. Careful beaming of the signal is one method of overcoming noise. (true)

10. The English language has extra structure which helps to ensure that our messages get through in spite of any distortion. (true)
APPENDIX P

Semantic differential item factor loadings

The following are the evaluative, potency, and activity factor loadings for each of the items used in the final version of the semantic differential attitude questionnaire (Osgood and Suci, 1955).

<table>
<thead>
<tr>
<th>Item</th>
<th>Evaluative</th>
<th>Potency</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>good/bad</td>
<td>.88</td>
<td>.05</td>
<td>-.09</td>
</tr>
<tr>
<td>strong/weak</td>
<td>-.19</td>
<td>.62</td>
<td>.20</td>
</tr>
<tr>
<td>valuable/worthless</td>
<td>.79</td>
<td>.04</td>
<td>.13</td>
</tr>
<tr>
<td>pleasant/unpleasant</td>
<td>.82</td>
<td>-.05</td>
<td>.28</td>
</tr>
<tr>
<td>relaxed/tense</td>
<td>.55</td>
<td>.12</td>
<td>-.37</td>
</tr>
<tr>
<td>short/long</td>
<td>.20</td>
<td>.34</td>
<td>.13</td>
</tr>
<tr>
<td>clear/hazy</td>
<td>.59</td>
<td>.03</td>
<td>.10</td>
</tr>
<tr>
<td>nice/awful</td>
<td>.87</td>
<td>-.08</td>
<td>.19</td>
</tr>
<tr>
<td>active/passive</td>
<td>.14</td>
<td>.04</td>
<td>.59</td>
</tr>
<tr>
<td>fast/slow</td>
<td>.01</td>
<td>.00</td>
<td>.70</td>
</tr>
<tr>
<td>fair/unfair</td>
<td>.83</td>
<td>.08</td>
<td>-.07</td>
</tr>
</tbody>
</table>
Ancillary program listings

Both these BASIC programs dealt with the floppy disk file "RESULTS/TXT" in which the results of the achievement test were stored by the computer. A version of that file and a copy of each of these two programs resided alongside the CAI lesson on each of the three floppy diskettes used for the experiment.

I. File creation program

10 PROGRAM TO CREATE RESULTS FILE AND FILL WITH ZEROS.
100 PRINT "DO YOU REALLY WANT TO ERASE ALL DATA?"
110 INPUT Y$.
120 IF Y$="Y" THEN 999
150 R=0.
200 OPEN "O", 2, "RESULTS/TXT"
210 FOR N=1 TO 50
220 PRINT #2, R
230 NEXT N
290 CLOSE 2
999 END

II. Data retrieval program

10 PROGRAM TO PRINT OUT SCORES FROM RESULTS FILE
50 DIM R(50)
100 OPEN "I", 2, "RESULTS/TXT"
110 FOR N=1 TO 50
120 INPUT #2, R
125 R(N)=R
150 NEXT N
190 CLOSE 2
195 FOR N=1 TO 51: LPRINT CHR$(138): NEXT N
200 LPRINT "ACHIEVEMENT QUIZ SCORES (MAX.10):"
210 FOR N=1 TO 50
220 IF R(N)=0 GOTO 300
230 LPRINT R(N)
250 NEXT N
300 FOR N=1 TO 51: LPRINT CHR$(139): NEXT N
999 END