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

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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.

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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 CAI.

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 (Wager, 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 reasons 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 (Matisoo, 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-1, 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

(Williams, 1983).

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. Sassenrath 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 flavourable 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 TICCIT CAI 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 factors point of view." 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 computers' 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 undertaken by investigators in other disciplines.

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 ergonometric 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. <u>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.</u>

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. <u>There is no significant difference in attitude toward CAI between male and female students.</u>

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. <u>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.</u>

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 made 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 48 K (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 Wager'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 V.1

Research Design

R	X_1	O
R	X_2	O
R		O

Although a posttest-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 nor 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 have 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 V.2

Hypotheses, statistical measures used

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.	Two way analyses of variance (attitude score totals, both weighted and unweighted, by group and sex). One way analyses of variance (individual item scores by group).
2. There is no significant difference in student attitude towards CAI between male and female students.	Two way analyses of variance (as above). One way analyses of variance (individual item scores by sex).
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.	One way analysis of variance (achievement scores by group).

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 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.

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 questionnaire, by group.

	Group 1 (Control)		Group 2 (8 sec delay)		Group 3 (16 sec delay)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Evaluative	32.22	6.27	33.78	3.51	32.31	5.04
Potency	5.94	1.08	5.32	0.72	5.84	0.88
Activity	9.06	2.05	9.07	1.48	8.15	2.08
Total unweighted	57.83	11.11	59.94	5.35	56.89	8.71

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

Source of variation	df	Sums of squares	Mean squares	F	Signif. of F
Main Effects	3	31.71	10.57	0.39	0.76
Group	2	27.67	13.83	0.51	0.60
Sex	1	4.06	4.06	0.15	0.70
Interaction	2	12.2	6.10	0.25	0.80

TABLE VI.3

Summary of analysis of variance results on Potency factor totals

Source of variation	df	Sums of squares	Mean squares	F	Signif. of F
Main Effects	3	3.23	1.08	1.29	0.29
Group	2	2.52	1.26	1.51	0.23
Sex	1	0.93	0.93	1.12	0.30
Interaction	2	0.92	0.46	0.55	0.58

TABLE VI.4

Summary of analysis of variance results on Activity factor totals

Source of variation	df	Sums of squares	Mean squares	F	Signif. of F
Main Effects	3	11.79	3.92	1.05	0.38
Group	2	7.66	3.83	1.03	0.37
Sex	1	1.80	1.79	0.48	0.49
Interaction	2	2.17	1.09	0.29	0.75

TABLE VI.5

Summary of analysis of variance results on Unweighted response totals

Source of variation	df	Sums of squares	Mean squares	F	Signif. of F
Main Effects	3	98.85	31.95	0.4[illegible]	0.75
Group	2	92.22	46.11	0.58	0.57
Sex	1	7.[illegible]4	7.74	0.09	0.76
Interaction	2	40.76	20.38	0.26	0.78

As can be seen from the above tables, none of these tests produced results which were signficant 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

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

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

	Sum of Squares		Mean Squares			
	Between Groups	Within Groups	Between Groups	Within Groups	F Ratio	F Prob.
good/bad	4.70	65.44	2.35	1.28	1.83	0.17
strong/weak	2.48	52.11	1.24	1.02	1.21	0.31
val./worthless	2.11	60.72	1.06	1.19	0.89	0.42
pleasant/unpleas.	0.11	113.9	0.56	2.23	0.03	0.98
relaxed/tense	2.81	126.83	1.41	2.49	0.57	0.57
short/long	1.81	67.67	0.91	1.33	0.68	0.51
clear/hazy	2.81	120.83	1.41	2.37	0.58	0.56
nice/awful	1.37	62.10	0.69	1.22	0.56	0.57
active/passive	3.37	110.50	1.69	2.17	0.78	0.46
fast/slow	1.81	88.7	0.91	1.74	0.52	0.60
fair/unfair	6.70	57.0	3.35	1.12	2.99	0.06

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 VI.8

Mean weighted and unweighted total scores of subjects on semantic differential questionnaire, by sex

	Females (n = 27)		Males (n = 27)	
	Mean	S.D.	Mean	S.D.
Evaluative	32.50	5.90	33.04	4.05
Potency	5.92	1.12	6.15	0.65
Activity	9.03	2.20	8.48	1.55
Unweighted Total	57.96	10.50	58.48	6.49

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 VI.9

Mean responses of subjects on items of semantic differential questionnnaire, by sex

	Females		Males	
	Mean	S.D.	Mean	S.D.
good/bad	5.93	1.04	5.70	1.27
strong/weak	5.22	1.15	5.52	0.85
valuable/worthless	5.63	1.21	5.82	0.96
pleasant/unpleasant	5.48	1.60	5.85	1.32
relaxed/tense	4.26	1.61	5.11	1.42
short/long	4.52	1.12	4.52	1.19
clear/hazy	5.81	1.62	5.56	1.45
nice/awful	5.52	1.31	5.56	0.85
active/passive	5.41	1.73	5.07	1.14
fast/slow	4.07	1.41	3.74	1.19
fair/unfair	6.11	1.31	6.04	0.85

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

	Sum of Squares		Mean Squares			
	Between Groups	Within Groups	Between Groups	Within Groups	F Ratio	F Prob.
good/bad	0.67	69.48	0.67	1.34	0.499	0.48
strong/weak	1.19	53.41	1.19	1.03	1.15	0.29
val./worthless	0.46	62.37	0.46	1.20	0.386	0.54
pleasant/unpleas.	1.85	112.14	1.85	2.16	0.859	0.36
relaxed/tense	9.80	119.9	9.80	2.30	4.25	0.044
short/long	0.0	69.48	0.0	69.48	0.0	1.00
clear/hazy	0.91	122.74	0.91	2.36	0.384	0.54
nice/awful	0.02	63.41	0.02	1.22	0.015	0.90
active/passive	1.50	122.37	1.50	2.16	0.69	0.41
fast/slow	1.50	89.04	1.50	1.71	0.87	0.35
fair/unfair	0.07	67.63	0.07	1.22	0.061	0.81

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

SCORE	:	NO DELAY	GROUP 8 SEC	16 SEC	:	TOTAL	PERCENT
5	:	0	0	1	:	1	1.9
6	:	3	4	2	:	9	16.7
7	:	6	5	2	:	13	24.1
8	:	6	3	7	:	16	29.6
9	:	2	5	5	:	12	22.2
10	:	1	1	1	:	3	5.6
MEAN	:	7.556	7.667	7.889	:		

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

Group	Mean	S.D.	Standard Error	df	t value	1-tailed probability
1 (CAI)	7.704	1.207	0.164			
				97	4.80	0.000
2 (non-CAI)	6.600	1.053	0.157			

This statistic indicated a highly significant ($\alpha < 0.0005$) 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

Results of one way analysis of variance achievement scores by group

Source	df	Sum of Squares	Mean Squares	F ratio	F probability
Between groups	2	1.037	0.5185	0.347	0.709
Within groups	51	76.222	1.4946		
Total	53	77.259			

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 statistical procedures.

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.

Chapter VII

CONCLUSIONS AND RECOMMENDATIONS

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 CAI LESSON ON INFORMATION THEORY
20 '  VERSION #1
30 '  MEAN DELAY = 0 SECONDS
40
'------------------------------------------------------------
--------------
200 '     DELAY CONSTANTS (SECONDS * 339)
210 DIM DY(10)
220 FOR N=1 TO 10:DY(N)=0:NEXT N
240
'------------------------------------------------------------
------------
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"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$(A);:NEXT N
940 FOR N=1 TO DY(8):NEXT N
960 FOR N=169 TO 255
970 READ A:PRINT CHR$(A);:NEXT N
980 RESTORE
990 RETURN
1000 ' MAIN GRAPHIC SUBROUTINE
1030 FOR N=0 TO 255
1040 READ A:PRINT CHR$(A);:NEXT N
1100 DATA
156,140,140,140,140,140,140,140,140,172,128,128,128,128,12
8,128
1110 DATA
```

```
128,156,140,140,140,140,140,140,140,140,172,128,128,128,12
8,128
1120 DATA
128,128,128,128,128,156,140,140,140,140,140,140,140,140,17
2,128
1130 DATA
128,128,128,128,128,128,156,140,140,140,140,140,140,140,14
0,172
1150 DATA
149,128,83,79,85,82,67,69,128,170,176,176,176,176,176,178
1160 DATA
164,149,128,84,82,65,78,83,45,128,170,176,176,176,176,176
1170 DATA
176,176,176,178,164,149,82,69,67,69,73,86,69,82,170,176
1180 DATA
176,176,176,176,178,164,149,128,68,69,83,84,73,45,128,170
1200 DATA
149,128,128,128,128,128,128,128,128,170,128,128,128,128,12
8,136
1210 DATA
129,149,128,77,73,84,84,69,82,128,170,128,128,128,128,128
1220 DATA
128,128,128,136,129,149,128,128,128,128,128,128,128,128,17
0,128
1230 DATA
128,128,128,128,136,129,149,128,78,65,84,73,79,78,128,170
1250 DATA
131,131,131,131,131,131,131,131,131,131,128,128,128,128,12
8,128
1260 DATA
128,131,131,131,131,131,131,131,131,131,131,128,128,128,12
8,128
1270 DATA
128,128,128,128,128,131,131,131,131,131,131,131,131,131,13
1,128
1280 DATA
128,128,128,128,128,128,131,131,131,131,131,131,131,131,13
1,131
1285 RESTORE
1290 RETURN
1300 PRINT@95,CHR$(156);CHR$(172);
1305 PRINT@158,CHR$(152);CHR$(171);CHR$(151);CHR$(164);
1310 PRINT@
220,CHR$(156);CHR$(140);CHR$(140);CHR$(142);CHR$(141);CHR$
(140);CHR$(140);CHR$(172);
1315 PRINT@284,CHR$(149);"NOISE ";CHR$(170);
1320
PRINT@348,CHR$(141);CHR$(140);CHR$(140);CHR$(140);CHR$(140
);CHR$(140);CHR$(140);CHR$(142);
1340 RETURN
1400 PRINT @ 10,"MESSAGE";:PRINT @ 29,"SIGNAL";:PRINT @
47,"MESSAGE";
1410 RETURN
1420 PRINT @ 156,"CHANNEL";
```

```
1425 PRINT @,256," ":RETURN
1430 PRINT@156,"          ";
1435 RETURN
1500 FOR N=1 TO 10:PRINT@65,"          ";
1503 FOR C=1 TO 30:NEXT C
1505 PRINT@65," SOURCE";:FOR C=1 TO 60:NEXT C:NEXT N
1510 PRINT@256," ":RETURN
1520 FOR N=1 TO 10:PRINT@10,"          ";:PRINT@47,"
";
1522 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,"          ";:PRINT@146,"
";
1542 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,"          ";
1563 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,"          ";
1583 FOR C=1 TO 80: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,"          ";
1603 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,"          ";:PRINT@183,"
";
1623 FOR C=1 TO 30:NEXT C
1625 PRINT@119," DESTI-";:PRINT@183," NATION";:FOR C=1 TO
30:NEXT C
1630 NEXT N:RETURN
1640 FOR N=1 TO 10:PRINT@285,"     ";
1643 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
1900 FOR C=1 TO 100:NEXT C:RETURN
2000 PRINT:PRINT" 1. LIGHT
2005 PRINT" 2. WORD
2010 PRINT" 3. PRINTED PAGE
2015 PRINT" 4. EYE
2020 RETURN
2050 PRINT"      THIS IS AN EXAMPLE OF WHICH METHOD OF
COMBATING NOISE?
2055 PRINT" 1. USE OF REDUNDANCY
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2060 PRINT" 2. INCREASED TRANSMITTER POWER
2065 PRINT" 3. MESSAGE DUPLICATED IN OTHER CHANNELS
2070 PRINT" 4. CAREFUL BEAMING OF THE SIGNAL
2075 RETURN
2100 FOR N=129 TO 833 STEP 64:PRINT@N,CHR$(253);:NEXT N
2110 RETURN
2120
'-----------------------------------------------------------------
----------
2140 '              STUDENT RESPONSE INPUT SUBROUTINES
2150 T$=INKEY$:PRINT@960,"                 * PRESS T (TRUE)
OR F (FALSE) *";
2160 R$=INKEY$
2165 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$(23):PRINT@408,"WRONG!":PRINT
CHR$(28):PRINT@448," "
2475 RETURN
2480 PRINT CHR$(23):PRINT@472,"CORRECT!":PRINT CHR$(28)
2490 RETURN
2493
'-----------------------------------------------------------------
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2495 '              MAIN TEXT STARTS HERE
2500 PRINT"     IN THE LATE 1940S, A SMALL NUMBER OF
AMERICAN
2505 PRINT"MATHEMATICIANS AND SCIENTISTS FOUNDED A NEW
AREA OF
2510 PRINT"THEORETICAL SCIENCE, THAT OF INFORMATION
THEORY. NORBERT
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
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2550 PRINT"LANGUAGE VALUABLE TO MANY FIELDS OF ENDEAVOUR. EDUCATIONAL
2555 PRINT"MEDIA IS AN OBVIOUS EXAMPLE.
2570 GOSUB 1900
2590 GOSUB 2400
2800 CLS
2805 PRINT"     IN ITS BROADEST SENSE, COMMUNICATION CAN BE DEFINED AS ANY
2810 PRINT"INFORMATION-SHARING ACTIVITY. IT INCLUDES ALL FORMS OF THE
2815 PRINT"TRANSMISSION OF MESSAGES FROM ELECTRICAL IMPULSES TO HUMAN
2820 PRINT"LANGUAGES.
2825 PRINT
2830 PRINT"     IT IS A DYNAMIC PROCESS IN WHICH A MESSAGE SENDER
2835 PRINT"CONCIOUSLY OR UNCONCIOUSLY AFFECTS A RECEIVER THROUGH
2840 PRINT"MATERIALS OR AGENCIES USED IN SYMBOLIC WAYS. THE CONTENT OF
2845 PRINT"WHAT IS EXCHANGED IS CALLED 'INFORMATION'. AT ITS SIMPLEST,
2850 PRINT"THIS PROCESS CAN BE REPRESENTED BY THIS DIAGRAM:
2860 PRINT
2870 GOSUB 1030
2880 GOSUB 1900
2890 GOSUB 2400
3100 CLS:GOSUB 1030
3105 GOSUB 1400
3106 GOSUB 1420
3110 PRINT"     THE SOURCE ORIGINATES A MESSAGE. THE TRANSMITTER CHANGES
3115 PRINT"THIS MESSAGE TO A SIGNAL WHICH IS THEN SENT THROUGH THE
3120 PRINT"COMMUNICATIONS CHANNEL TO A RECEIVER. THE RECEIVER CHANGES THE
3125 PRINT"SIGNAL BACK INTO THE MESSAGE BEFORE IT REACHES THE DESTINATION.
3127 GOSUB 1900
3130 GOSUB 2400
3135 PRINT @ 640,"     AS AN EXAMPLE, IN HUMAN SPEECH:
3140 PRINT"SOURCE -","BRAIN",CHR$(149);" CHANNEL -","AIR"
3145 PRINT"MESSAGE -","THOUGHT",CHR$(149);" RECEIVER -","LISTENER'S EAR"
3150 PRINT"TRANSMITTER -","VOCAL MECHANISM",CHR$(149);" DESTINATION -","BRAIN"
3155 PRINT"SIGNAL -","SOUND",CHR$(149)
3170 GOSUB 1900
3190 GOSUB 2400
3400 CLS:GOSUB 1030
3405 GOSUB 1500
3410 PRINT"     THE FUNCTION OF THE INFORMATION SOURCE IS TO SELECT A
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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
3490 GOSUB 2400
3700 CLS:GOSUB 1030
3705 GOSUB 1400
3706 GOSUB 1420
3710 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,
PICTURES, MUSIC,
3725 PRINT"ETC. IT MAY BE VERY SIMPLE OR VERY COMPLEX.
3730 PRINT
3735 PRINT"      THE MESSAGE PROVIDES THE CONTENT OF THE
COMMUNICATIONS.
3750 GOSUB 1900
3790 GOSUB 2400
4000 CLS:GOSUB 1080
4005 GOSUB 1400
4006 GOSUB 1420
4010 GOSUB 1540
4015 PRINT"      THE TRANSMITTER OPERATES ON THE MESSAGE
IN SOME WAY TO
4020 PRINT"PRODUCE A SIGNAL SUITABLE FOR TRANSMISSION
OVER THE CHANNEL.
4025 PRINT"THIS INVOLVES A CODING PROCESS. AN EXAMPLE IS
A
4030 PRINT"TELEPHONE INSTRUMENT, WHICH CHANGES SOUND
PRESSURE INTO A
4035 PRINT"PROPORTIONAL ELECTRIC CURRENT.
4037 GOSUB 1900
4040 GOSUB 2400
4045 GOSUB 1560
4050 PRINT@640," "
4060 PRINT"      THE SIGNAL IS THE ENCODED OUTPUT OF THE
TRANSMITTER WHICH
4065 PRINT"IS SENT ALONG THE CHANNEL. IT MAY BE SOUND
WAVES, ELECTRICAL
4070 PRINT"IMPULSES, THE DOTS AND DASHES OF MORSE CODE,
ETC.
4080 GOSUB 1900
4090 GOSUB 2400
4200 CLS:GOSUB 1030
4205 GOSUB 1400
4206 GOSUB 1420
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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<>8 GOTO 4340
4333 GOSUB 2480
4336 GOTO 4350
4340 GOSUB 2470
4343 PRINT"      THE CORRECT ANSWER IS #3. IN READING, THE
PRINTED PAGE
4346 PRINT"IS THE TRANSMITTER.
4348 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
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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
4600 CLS:GOSUB 1030
4605 PRINT @320,' '
4610 PRINT'      IT IS UNFORTUNATELY CHARACTERISTIC OF
COMMUNICATIONS
4615 PRINT'SYSTEMS THAT CERTAIN THINGS MAY BE ADDED TO
THE SIGNAL BETWEEN
4620 PRINT'TRANSMISSION AND RECEPTION THAT WERE NOT
INTENDED BY THE
4625 PRINT'INFORMATION SOURCE.
4627 GOSUB 1900
4630 GOSUB 2400
4635 GOSUB 1300
4640 PRINT@ 640,' '
4645 PRINT'      ANY SUCH CHANGE IN THE TRANSMITTED SIGNAL
IS CALLED
4650 PRINT''NOISE'.
4660 GOSUB 1900
4690 GOSUB 2400
4800 CLS:GOSUB 1030
4805 GOSUB 1300
4810 GOSUB 1640
4815 PRINT@384,'      NOISE MAY BE DEFINED AS ANY OUTSIDE
FORCE WHICH ACTS ON
4820 PRINT'THE TRANSMITTED SIGNAL TO VARY IT FROM THE
ORIGINAL.
4825 GOSUB 1900
4830 GOSUB 2400
4835 PRINT@512,' '
4850 PRINT'      EXAMPLES ARE DISTORTIONS OF SOUND (EG. IN
RECORDING),
4855 PRINT'STATIC (IN RADIO), DISTORTIONS IN SHAPE,
SHADING, OR COLOUR
4860 PRINT'(IN TELEVISION), OR ERRORS IN TRANSMISSION
(EG. IN TELEGRAPHY).
4870 GOSUB 1900
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4890 GOSUB 2400
4900 CLS:PRINT"PROBLEM:":PRINT
4910 PRINT"     YOU ARE A PASSENGER IN A CAR WHIH IS
BEING DRIVEN RAPIDLY
4915 PRINT"ALONG A SMALL COUNTRY ROAD. YOU ARE ATTEMPTING
TO READ A BOOK.
4920 PRINT"IN THIS SITUATION, WHICH OF THE FOLLOWING FITS
THE DEFINITION
4925 PRINT"OF NOISE?
4930 PRINT:PRINT" 1. JOLTS AND VIBRATION CAUSED BY THE
BUMPY ROAD
4935 PRINT" 2. FLICKERING LIGHT CAUSED BY THE TREES AND
OTHER CARS
4940 PRINT" 3. FAINT OR DISJOINTED TYPE CAUSED BY A
FAULTY PRINTING PRESS
4945 PRINT" 4. ALL OF THE ABOVE
4970 GOSUB 1900
4990 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
5065 PRINT"UNSTEADINESS OF THE BOOK, THE UNCERTAIN LIGHT,
AND THE POOR
5070 PRINT"TYPE ARE ALL OUTSIDE FORCES WHICH DEGRADE THE
SIGNAL, AND ARE
5075 PRINT"THEREFORE NOISE.
5080 GOSUB 1900
5090 GOSUB 2400
5100 CLS:PRINT@192,""
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
5117 PRINT"     - INCREASING THE POWER OF THE TRANSMITTER
5119 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:PRINT"USE OF REDUNDANCY:"
5155 FOR N=1 TO 10:PRINT "HELP   ";:NEXT N
5156 GOSUB 1900
5157 GOSUB 2400
5160 PRINT@384, "INCREASING TRANSMITTER POWER:"
5165
PRINT@468,CHR$(191);CHR$(195);CHR$(191);CHR$(193);CHR$(191
);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$(1
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91);CHR$(197);CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$
(189);
5167
PRINT@532,CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(191
);CHR$(193);CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(1
94);CHR$(191);CHR$(197);CHR$(191);CHR$(131);CHR$(131);CHR$
(131);CHR$(129);
5168 FOR N=1 TO DY(3):NEXT N
5170
PRINT@596,CHR$(131);CHR$(195);CHR$(131);CHR$(193);CHR$(131
);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$(1
31);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$
(131)
5171 GOSUB 1900
5172 GOSUB 2400
5175 PRINT@704,"DUPLICATION ON OTHER CHANNELS:
5180 PRINT"      HELP":LPRINT,,"HELP"
5185 FOR N=1 TO 5:LPRINT CHR$(138):NEXT N
5187 GOSUB 1900
5190 GOSUB 2400
5200 CLS:PRINT"PROBLEM:":PRINT
5205 PRINT"      YOU AND A FRIEND ARE AMONG A BOISTEROUS
CROWD WATCHING A
5210 PRINT"CHAMPIONSHIP BASKETBALL GAME IN A HIGH SCHOOL
GYMNASIUM. TO
5215 PRINT"OVERCOME THE DIN, YOUR FRIEND LEANS OVER AND
SPEAKS DIRECTLY
5220 PRINT"INTO YOUR EAR.
5225 PRINT:GOSUB 2050
5227 GOSUB 1900
5230 GOSUB 2450
5235 CLS:IF R<>16 GOTO 5250
5240 GOSUB 2480
5245 GOTO 5290
5250 GOSUB 2470
5260 PRINT"      THE CORRECT ANSWER IS #4. BY LEANING OVER
TO SPEAK
5265 PRINT"DIRECTLY INTO YOUR EAR, YOUR FRIEND WAS
CAREFULLY BEAMING HIS
5270 PRINT"VOCAL SIGNAL. IN SUCH A CASE YOUR FRIEND MIGHT
ALSO SHOUT, THUS
5275 PRINT"INCREASING THE POWER OF THE TRANSMITTER.
5280 GOSUB 1900
5290 GOSUB 2400
5300 CLS:PRINT"PROBLEM:":PRINT
5305 PRINT"      AT THE SAME BASKETBALL GAME, YOUR FRIEND
CATCHES YOUR
5310 PRINT"ATTENTION BY SAYING 'HEY' WHILE JABBING YOU IN
THE RIBS WITH
5315 PRINT"AN ELBOW.
5325 PRINT:GOSUB 2050
5327 GOSUB 1900
5330 GOSUB 2450
5335 CLS:IF R<>8 GOTO 5350
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5340 GOSUB 2480
5345 GOTO 5390
5350 GOSUB 2470
5360 PRINT"      THE CORRECT ANSWER IS #3. BY JABBING YOUR
RIBS WHILE
5365 PRINT"SPEAKING TO ATTRACT YOUR ATTENTION, YOUR
FRIEND WAS
5370 PRINT"DUPLICATING THE MESSAGE IN ANOTHER CHANNEL.
5380 GOSUB 1900
5390 GOSUB 2400
5400 CLS
5410 PRINT"      THE LANGUAGES WHICH WE WRITE AND SPEAK
HAVE EXTRA
5415 PRINT"FRAMEWORK TO HELP ENSURE THAT OUR MESSAGES GET
THROUGH IN
5420 PRINT"SPITE OF ANY DISTORTION. THIS IS AN EXAMPLE OF
THE USE OF
5425 PRINT"REDUNDANCY TO COMBAT THE EFFECTS OF NOISE IN
THE COMMUNICATIONS
5430 PRINT"CHANNEL.
5433 FOR N=1 TO DY(4):NEXT N
5435 PRINT CHR$(23);
5440 PRINT@332,"THE ENGLISH LANGUAGE
5442 PRINT@408,"IS ABOUT
5444 PRINT@462,"ONE-HALF REDUNDANT
5446 GOSUB 1900
5450 PRINT CHR$(28);:GOSUB 2400
5455
PRINT@462,CHR$(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
);
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);CHR$(1
91);CHR$(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:
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5725 PRINT,"BUY","SELL"
5730 PRINT"     'SELL' IS SELECTED, CODED BY THE TELEX
MACHINE (THE
5735 PRINT"TRANSMITTER), AND SENT OVER THE CHANNEL AS
ELECTRICAL IMPULSES.
5740 PRINT"THERE IS ELECTRICAL INTERFERENCE (NOISE) ON
THE CHANNEL. THE
5745 PRINT"MACHINE IN ST. JOHN'S (RECEIVER) PRINTS OUT
THE WORD 'SELF'.
5750 PRINT,"BUY","SELF"
5755 PRINT,"BUI","SEL"
5760 PRINT,"BUIY","PELL"
5775 PRINT"     AS THERE ARE ONLY TWO POSSIBLE MESSAGES,
THERE IS
5780 PRINT"SUFFICIENT REDUNDANCY IN THE SPELLING OF THE
WORDS THAT, EVEN
5785 PRINT"WITH THE RECEPTION OF THE WORD 'SELF', THE
MEANING IS CLEAR.
5787 GOSUB 1900
5790 GOSUB 2400
5800 CLS
5805 PRINT"     ON THE MAIN ROAD, THE OUTSKIRTS OF YOUR
CITY IS MARKED BY
5810 PRINT"A CLUTTER OF FAST FOOD TAKEOUTS, RESTAURANTS,
STORES, MOTELS,
5815 PRINT"CAR DEALERS, AND SERVICE STATIONS. EACH
DISPLAYS ONE OR MORE
5820 PRINT"SIGNS WHICH COMPETE WITH THE TRAFFIC SIGNS AND
SIGNALS FOR THE
5825 PRINT"ATTENTION OF PASSING MOTORISTS.
5830 PRINT:PRINT"     HAVING TAKEN OVER A RESTAURANT IN
THIS AREA, YOU DECIDE
5835 PRINT"TO GET YOUR MESSAGE ACROSS TO THE MOTORISTS BY
INSTALLING THE
5840 PRINT"LARGEST, BRIGHTEST SIGN ON THE STRIP.
5850 PRINT:GOSUB 2050
5855 GOSUB 1900
5860 GOSUB 2450
5900 CLS:IF R<>4 GOTO 5950
5910 GOSUB 2480
5920 GOTO 5990
5950 GOSUB 2470
5960 PRINT"     THE CORRECT ANSWER IS #2. BY USING A
LARGER, BRIGHTER
5965 PRINT"SIGN, YOU ARE INCREASING THE POWER OF YOUR
TRANSMITTER.
5980 GOSUB 1900
5990 GOSUB 2400
6000 CLS
6010 PRINT"     THERE ARE OTHER FACTORS (BESIDES NOISE)
WHICH CAN KEEP A
6015 PRINT"MESSAGE FROM REACHING ITS DESTINATION INTACT."
6020 PRINT:PRINT"     THE BACKGROUND AND CONDITION OF THE
RECEIVING APPARATUS
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6025 PRINT'MAY DIFFER FROM THAT OF THE TRANSMITTER TO THE
EXTENT THAT THE
6030 PRINT'RECEIVER MAY NOT BE ABLE TO PICK UP THE
SIGNALS WITHOUT
6040 PRINT'DISTORTION. IN ANY SYSTEM, THE RECEIVER MUST
BE ABLE TO DECODE
6045 PRINT'SOMETHING OF WHAT THE TRANSMITTER ENCODED OR
NO INFORMATION AT
6050 PRINT'ALL GETS TO THE DESTINATION.
6055 PRINT:PRINT'     IF ONE PERSON SPEAKS CHINESE TO
ANOTHER, THE SECOND MUST
6060 PRINT'ALSO KNOW CHINESE IN ORDER TO UNDERSTAND THE
WORDS. HOWEVER
6065 PRINT'THEY STILL MIGHT BE ABLE TO COMMUNICATE
THROUGH COMMON NON-
6070 PRINT'VERBAL CODES IN OTHER CHANNELS: SMILES, ETC.
6080 FOR N=1 TO DY(5):NEXT N
6085 GOSUB 1900
6090 GOSUB 2400
6300 CLS:PRINT:PRINT:PRINT
6305 PRINT'     IN INFORMATION THEORY, THE WORD
'INFORMATION' IS USED IN
6310 PRINT'A VERY SPECIAL SENSE THAT MUST NOT BE CONFUSED
WITH ITS
6315 PRINT'ORDINARY USAGE. IN PARTICULAR, 'INFORMATION'
MUST NOT BE
6320 PRINT'CONFUSED WITH MEANING.
6325 PRINT:PRINT'     TWO MESSAGES, ONE HEAVILY LOADED
WITH MEANING AND THE
6330 PRINT'OTHER PURE NONSENSE, CAN BE EXACTLY EQUIVALENT
AS REGARDS
6335 PRINT'INFORMATION.
6350 GOSUB 1900
6390 GOSUB 2400
6400 CLS
6410 PRINT'     THE WORD 'INFORMATION' DOES NOT RELATE AS
MUCH TO WHAT YOU
6415 PRINT'DO SAY AS MUCH AS TO WHAT YOU COULD SAY. THE
AMOUNT OF
6420 PRINT'INFORMATION INCREASES AS THE LOGARITHM OF THE
NUMBER OF
6425 PRINT'CHOICES.
6430 PRINT
6435 PRINT'     THE SMALLEST UNIT OF INFORMATION
REPRESENTS THE CHOICE
6440 PRINT'BETWEEN TWO MESSAGES. AS THESE SIMPLE
ALTERNATIVES CAN BE
6445 PRINT'REPRESENTED BY THE BINARY DIGITS '0' AND '1',
THIS UNIT IS
6450 PRINT'REFERED TO AS A 'BIT' FOR 'BINARY DIGIT'.
6455 PRINT@603,CHR$(181);CHR$(131);"
";CHR$(131);CHR$(131);
6457 GOSUB 1900
6460 GOSUB 2400
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6465 PRINT@640,'     IN OUR EARLIER EXAMPLE, THE MESSAGE
'SELL' CONTAINS ONE .
6470 PRINT'BIT OF INFORMATION BECAUSE IT WAS A CHOICE OF
ONLY TWO POSSIBLE
6475 PRINT'MESSAGES, 'BUY' AND 'SELL'.
6480 GOSUB 1900
6490 GOSUB 2400
6495 FOR N=1 TO DY(6):NEXT N
6500 CLS:PRINT'PROBLEM!':PRINT
6505 PRINT'     WHICH OF THE FOLLOWING MESSAGES CONTAINS
THE MOST
6510 PRINT'INFORMATION?
6515 PRINT:PRINT' 1. THE SELECTION OF EITHER THE NOVEL
'WAR AND PEACE' OR
6520 PRINT'    'THE RISE AND FALL OF THE THIRD REICH'
6525 PRINT' 2. 'SELL' (FROM OUR EARLIER EXAMPLE)
6530 PRINT' 3. AN ANSWER TO 'TO BE OR NOT TO BE'
6535 PRINT' 4. THE RESPONSE WHICH YOU ARE ABOUT TO TYPE
IN TO THIS
6540 PRINT'    COMPUTER.
6550 GOSUB 1900
6590 GOSUB 2450
6600 CLS
6610 IF R<>16 GOTO 6650
6620 GOSUB 2480
6640 GOTO 6690
6650 GOSUB 2470
6660 PRINT'     THE CORRECT NUMBER IS #4. ALL THE OTHER
ANSWERS
6665 PRINT'REPRESENTED A SINGLE CHOICE BETWEEN ONLY TWO
ALTERNATIVES. THE
6670 PRINT'CHOICES BETWEEN THE FOUR NUMBERS THUS CONTAIN
THE MOST
6675 PRINT'INFORMATION.
6680 GOSUB 1900
6690 GOSUB 2400
6700 CLS
6710 PRINT'          NUMBER OF BITS          NUMBER OF
POSSIBLE MESSAGES
6720 PRINT,'1",,'2'
6722 PRINT,'2",,'4'
6724 PRINT,'3",,'8'
6726 PRINT,'4",,'16"
6728 PRINT,'5",,'32"
6740 PRINT'EXAMPLE:
6745 PRINT'THERE ARE EIGHT POSSIBLE COMBINATIONS OF THREE
BINARY DIGITS,
6750 PRINT'REPRESENTING EIGHT POSSIBLE MESSAGES.
6755 PRINT,'000','100
6760 PRINT,'001','101
6765 PRINT,'010','110
6770 PRINT,'011','111
6780 PRINT' 8 IS 2 TO THE THIRD POWER
6785 PRINT'32 IS 2 TO THE FIFTH POWER
```

```
6787 GOSUB 1900
6790 GOSUB 2400
6800 CLS
6805 PRINT@192,"PROBLEM:"
6810 PRINT:PRINT"      HOW MANY POSSIBLE MESSAGES CAN BE
CONTAINED IN SIX BITS
6815 PRINT"OF INFORMATION?
6820 PRINT:PRINT" 1. 6
6822 PRINT" 2. 64
6824 PRINT" 3. 12
6826 PRINT" 4. 16
6828 GOSUB 1900
6830 GOSUB 2450
6835 CLS:IF R<>4 GOTO 6850
6840 GOSUB 2480
6845 GOTO 6890
6850 GOSUB 2470
6855 PRINT"      THE CORRECT ANSWER IS #2. SIX BITS OF
INFORMATION CAN
6860 PRINT"REPRESENT ANY OF UP TO SIXTY-FOUR POSSIBLE
MESSAGES.
6865 PRINT"64 IS 2 TO THE SIXTH POWER
6870 PRINT"THE BASE 2 LOGARITHM OF 64 IS 6
6880 GOSUB 1900
6890 GOSUB 2400
6900 CLS:PRINT:PRINT
6905 PRINT"      FOUR ELECTRICAL SWITCHES (OR BINARY
DIGITS) CAN
6910 PRINT"COMMUNICATE UP TO HOW MANY MESSAGES?
6915 PRINT:PRINT" 1. 16
6920 PRINT" 2. 4
6925 PRINT" 3. 12
6930 PRINT" 4. 8
6932 GOSUB 1900
6935 GOSUB 2450
6940 CLS:IF R<>2 GOTO 6950
6943 GOSUB 2480
6946 GOTO 6990
6950 GOSUB 2470
6960 PRINT"      THE CORRECT ANSWER IS #1. FOUR BITS OF
INFORMATION CAN
6965 PRINT"REPRESENT ANY OF UP TO SIXTEEN POSSIBLE
MESSAGES.
6970 PRINT:PRINT"      16 IS 2 TO THE FOURTH POWER
6980 GOSUB 1900
6990 GOSUB 2400
7000 CLS:PRINT:PRINT:PRINT
7005 PRINT"      BECAUSE EACH BIT IS LIMITED TO ONE OF
ONLY TWO
7010 PRINT"POSSIBILITIES, IT MAY APPEAR THAT THE USE OF
BINARY CODING
7015 PRINT"WILL GREATLY RESTRICT THE COMPEXITY OF THE
MESSAGES THAT MAY BE
7020 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.
7060 GOSUB 1900
7090 GOSUB 2400
7300 CLS:PRINT:PRINT
7305 PRINT'      TO DISPLAY THIS SCREEN OF CHARACTERS, THE CENTRAL
7310 PRINT'PROCESSING UNIT OF THIS COMPUTER SENDS 8192 BITS OF INFORMATION
7315 PRINT'TO THE VIDEO DISPLAY CIRCUITRY.
7320 PRINT:PRINT'      INCLUDING ITS TWO DISK DRIVES, THIS COMPUTER CAN STORE
7325 PRINT'OVER 1,300,000 BITS OF INFORMATION. DATA IS TRANSFERRED TO AND
7330 PRINT'FROM THE DISKS AT OVER 100,000 BITS PER SECOND.
7340 PRINT:PRINT'      A LARGE IBM TYPE COMPUTER CAN STORE A BILLION BITS ON A
7345 PRINT'SINGLE DISK, AND ITS DATA TRANSFER RATES ARE CORRESPONDINGLY
7350 PRINT'GREATER
7360 GOSUB 1900
7390 GOSUB 2400
7500 CLS:PRINT
7502 FOR N=1 TO DY(7):NEXT N
7505 PRINT'      WHENEVER ADDED FACTORS OR DIMENSIONS (SUCH AS COLOUR,
7510 PRINT'MOTION, HIGH FIDELITY, ETC.) ARE ADDED TO A MESSAGE, THE
7515 PRINT'NUMBER OF DECISIONS NECESSARY GROWS BY GREAT LEAPS.
7520 PRINT:PRINT'      A NEWSPAPER PHOTOGRAPH IS COMPOSED OF MANY TINY BLACK
7525 PRINT'AND WHITE DOTS. A TYPICAL PICTURE REPRESENTS PERHAPS 150,000
7530 PRINT'BITS OF INFORMATION. THE SAME PICTURE, PRINTED IN COLOUR,
7535 PRINT'WOULD REQUIRE APPROXIMATELY 600,000 BITS.
7540 PRINT:PRINT'      DIGITAL COMMUNICATION AND STORAGE OF COLOUR TELEVISION
7545 PRINT'REQUIRES AROUND 14,000,000 BITS PER SCOND. AT THAT RATE, A ONE-
7550 PRINT'HOUR PROGRAM REQUIRES 50,000,000,000 BITS.
7560 GOSUB 1900
7590 GOSUB 2400
7600 CLS:PRINT:PRINT:PRINT
```

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7605 PRINT"     SOME TYPES OF COMMUNICATIONS EXIST ON A
HIGHER LEVEL OF
7610 PRINT"COMPLEXITY. WAVES ON A BEACH MAY APPEAR RANDOM
AND MEANINGLESS.
7615 PRINT"HOWEVER, IF ON KNOWS THE CODE, THEY CAN CONVEY
KNOWLEDGE OF
7620 PRINT"EVENTS FAR OUT AT SEA: WINDS, STORMS, THEIR
DISTANCE AND
7625 PRINT"INTENSITY, AS WELL AS THE LOCATIONS OF REEFS
AND ISLANDS.
7635 PRINT:PRINT"     SIMILARLY, DIFFERENT TYPES OF
RADIATION EMANATING FROM THE
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
10145 PRINT"INFORMATION THEORY, A MATHEMATICAL MODEL OF
THE COMMUNICATIONS
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
10205 PRINT"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
10220 PRINT"THROUGH THE COMMUNICATIONS MEDIUM, THE
CHANNEL. THE RECEIVER
10225 PRINT"DECODES THE SIGNAL BACK INTO A MESSAGE AND
HANDS IT ON TO THE
10230 PRINT"INTENDED DESTINATION.
10250 GOSUB 1900
10290 GOSUB 2400
10300 GOSUB 1430
10305 GOSUB 1300
10310 PRINT@384,"     ANY UNDESIRED CHANGE WHICH TAKES
PLACE IN THE SIGNAL
10315 PRINT"BETWEEN THE TRANSMITTER AND THE RECEIVER IS
CALLED NOISE. WHEN
10320 PRINT"THE NOISE CANNOT BE ELIMINATED, THERE ARE
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FOUR METHODS OF
10325 PRINT'OVERCOMING ITS EFFECTS!
10340 GOSUB 2055
10350 GOSUB 1900
10390 GOSUB 2400
10400 PRINT@384,'    THE AMOUNT OF INFORMATION
TRANSMITTED DEPENDS UPON THE
10405 PRINT'NUMBER OF CHOICES MADE, THE NUMBER OF
POSSIBLE MESSAGES IN THE
10410 PRINT'MESSAGE SET. ONE BIT CAN ONLY TRANSMIT A
SIMPLE CHOICE BETWEEN
10415 PRINT'TWO ALTERNATIVES.
10425 PRINT: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
10435 PRINT'OF BITS REQUIRED IS THE NATURAL OR BASE 2
LOGARITHM OF THE
10440 PRINT'NUMBER OF POSSIBLE MESSAGES.
10450 GOSUB 1900
10490 GOSUB 2400
10495
'-----------------------------------------------------------
---------
10497 '                        QUIZ
11000 CLS
11010 FOR N=15424 TO 15487:POKE N,176:NEXT N
11020 FOR N=15551 TO 16255 STEP 64: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$='F' THEN S=S+1
11400 GOSUB 2100
11405 PRINT@130,'4.';
11410 PRINT@386,'     THE FUNCTION OF THE INFORMATION
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```
SOURCE IS TO SELECT";
11420 PRINT@450,"A DESIRED MESSAGE OUT OF A SET OF
POSSIBLE MESSAGES.";
11440 GOSUB 1900
11450 GOSUB 2150
11460 IF R$="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
```

```
12105 PRINT@130,"11.";
12110 PRINT@386,"     THIS EXTRA FRAMEWORK IS AN EXAMPLE
OF OVERCOMING NOISE";
12120 PRINT@450,"BY DUPLICATING THE MESSAGE IN OTHER
CHANNELS.";
12140 GOSUB 1900
12150 GOSUB 2150
12160 IF R$="F" THEN S=S+1
12180 FOR N=1 TO DY(9):NEXT N
12200 GOSUB 2100
12205 PRINT@130,"12.";
12210 PRINT@386,"     IF THE MESSAGE IS SELECTED FROM
'BUY' OR 'SELL', IT";
12220 PRINT@450,"CONTAINS LESS INFORMATION THAN IF IT
MUST BE THE FULL";
12230 PRINT@514,"TEXT OF EITHER THE BIBLE OR THE KORAN.";
12240 GOSUB 1900
12250 GOSUB 2150
12260 IF R$="F" THEN S=S+1
12300 GOSUB 2100
12305 PRINT@130,"13.";
12310 PRINT@386,"     THREE BINARY DIGITS (OR 'BITS') CAN
BE PUT TOGETHER IN";
12320 PRINT@450,"EIGHT POSSIBLE COMBINATIONS., AND THUS
CAN BE USED TO";
12330 PRINT@514,"REPRESENT ANY OF UP TO EIGHT MESSAGES.";
12340 GOSUB 1900
12350 GOSUB 2150
12360 IF R$="T" THEN S=S+1
12400 GOSUB 2100
12405 PRINT@130,"14.";
12410 PRINT@386,"     BECAUSE EACH BIT CAN REPRESENT ONE
OF ONLY TWO";
12420 PRINT@450,"POSSIBILITIES, BINARY DATA CAN ONLY BE
USED TO COMMUNICATE";
12430 PRINT@514,"VERY SIMPLE MESSAGES.";
12440 GOSUB 1900
12450 GOSUB 2150
12460 IF R$="F" THEN S=S+1
12500 GOSUB 2100
12505 PRINT@130,"15.";
12510 PRINT@386,"     AS THE COMPLEXITY OF THE MESSAGE
INCREASES, THE NUMBER";
12515 FOR N=1 TO DY(10):NEXT N
12520 PRINT@450,"OF BITS NECESSARY TO TRANSMIT THE SIGNAL
INCREASES.";
12540 GOSUB 1900
12550 GOSUB 2150
12560 IF R$="T" THEN S=S+1
13000 CLS:PRINT
13010 IF S>12 THEN PRINT "      EXCELLENT.";:GOTO 13100
13020 IF S>9 THEN PRINT "      VERY GOOD.";:GOTO 13100
13030 IF S>7 THEN PRINT "      GOOD.";:GOTO 13100
13040 IF S>5 THEN PRINT "      POOR.";:GOTO 13100
```

```
13050 PRINT"      VERY POOR.";
13100 PRINT" YOU GOT";S;"OUT OF 15 CORRECT
OR";INT(S/15*100);"PERCENT."
13110 PRINT
14000 PRINT"     THIS SHORT LESSON HAS BARELY SCRATCHED
THE SURFACE OF"
14010 PRINT"INFORMATION THEORY. MANY BASIC CONCEPTS SUCH
AS SYMBOLS AND
14020 PRINT"ENTROPY HAVE NOT BEEN TOUCHED. CONTINUOUS (AS
OPPOSED TO
14030 PRINT"DISCRETE) MESSAGES HAVE NOT BEEN MENTIONED.
MATHEMATICS AND
14040 PRINT"THE ENGINEERING VARIABLES TO WHICH THE THEORY
IS APPLIED HAVE
14050 PRINT"ALL BEEN IGNORED."
14060 PRINT
14100 PRINT"      TO LEARN MORE 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 QUESTIONAIRE FROM
THE LAB
14355 PRINT"ASSISTANT, FILL IT IN, AND RETURN IT."
14360 PRINT:PRINT"     THANK YOU."
14365 GOSUB 1900
14370
'-----------------------------------------------------------
---------
14380 '                QUIZ RESULTS FILED ON DISK AND EXIT
14390 T$=INKEY$
14400 PRINT@960,"                 * 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)=S:GOTO 15300
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    '   EXPERIMENTAL CAI LESSON ON INFORMATION THEORY
20    '   VERSION #2
30    '   MEAN DELAY = 12 SECONDS
40    '-----------------------------------------------------
200   '     DELAY CONSTANTS (SECONDS X 339)
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 339)
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)

```
10 '  EXPERIMENTAL CAI LESSON ON INFORMATION THEORY
30 '   VERSION #1
50 '   MEAN DELAY = 0 SECONDS
70
'-------------------------------------------------------------
--------------
90 '     DELAY CONSTANTS (SECONDS * 339)
110 DIM DY(7)
130 FOR N=1 TO 7:DY(N)=0:NEXT N
150
'-------------------------------------------------------------
------------
170 '              INTRODUCTORY TEXT
190 CLS:PRINT:PRINT
210 PRINT"      WELCOME TO A COMPUTER ASSISTED INSTRUCTION
UNIT ON
230 PRINT"INFORMATION THEORY."
250 PRINT:PRINT"TO ADVANCE THE LESSON, YOU MUST PRESS THE
APPROPRIATE KEYS ON
270 PRINT"THE COMPUTER KEYBOARD. THE ONLY KEYS REQUIRED
ARE THE SPACE BAR
290 PRINT"AT THE BOTTOM OF THE KEYBOARD, THE KEYS
NUMBERED 1, 2, 3, AND 4
310 PRINT"(EITHER AT THE TOP OR FAR RIGHT OF THE
KEYBOARD), AND THE
330 PRINT"LETTERS T AND F. SHOULD YOU PRESS A KEY AND
NOTHING HAPPENS,
350 PRINT"PRESS AGAIN - FIRMLY."
370 PRINT:PRINT"     THE CUE AS TO WHICH KEY TO PRESS
WILL ALWAYS APPEAR ON
390 PRINT"THE BOTTOM OF THE SCREEN, LIKE THIS:
410 GOSUB 2030
430 GOSUB 2430
450 CLS:GOTO 2710
470
'-------------------------------------------------------------
--------------
490 '   LINES 910-1670 CONTAIN THE VARIOUS GRAPHICS
SUBROUTINES
510 '   GRAPHIC SUBROUTINE WITH DELAY
530 FOR N=0 TO 168
550 READ A:PRINT CHR$(A);:NEXT N
570 FOR N=1 TO DY(3):NEXT N
590 FOR N=169 TO 255
610 READ A:PRINT CHR$(A);:NEXT N
630 RESTORE
650 RETURN
670 ' MAIN GRAPHIC SUBROUTINE
690 FOR N=0 TO 255
710 READ A:PRINT CHR$(A);:NEXT N
730 DATA
156,140,140,140,140,140,140,140,140,172,128,128,128,128,12
8,128
750 DATA
```

```
128,156,140,140,140,140,140,140,140,140,172,128,128,128,12
8,128
770 DATA
128,128,128,128,128,156,140,140,140,140,140,140,140,140,17
2,128
790 DATA
128,128,128,128,128,128,156,140,140,140,140,140,140,140,14
0,172
810 DATA
149,128,83,79,85,82,67,69,128,170,176,176,176,176,176,178
830 DATA
164,149,128,84,82,65,78,83,45,128,170,176,176,176,176,176
850 DATA
176,176,176,178,164,149,82,69,67,69,73,86,69,82,170,176
870 DATA
176,176,176,176,178,164,149,128,68,69,83,84,73,45,128,170
890 DATA
149,128,128,128,128,128,128,128,128,170,128,128,128,128,12
8,136
910 DATA
129,149,128,77,73,84,84,69,82,128,170,128,128,128,128,128
930 DATA
128,128,128,136,129,149,128,128,128,128,128,128,128,128,17
0,128
950 DATA
128,128,128,128,136,129,149,128,78,65,84,73,79,78,128,170
970 DATA
131,131,131,131,131,131,131,131,131,131,128,128,128,128,12
8,128
990 DATA
128,131,131,131,131,131,131,131,131,131,131,128,128,128,12
8,128
1010 DATA
128,128,128,128,128,131,131,131,131,131,131,131,131,131,13
1,128
1030 DATA
128,128,128,128,128,128,131,131,131,131,131,131,131,131,13
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,"         ";:PRINT@47,"          ";
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,"          ";:PRINT@146,"
";
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,"          ";:PRINT@183,"
";
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 '              MISC. 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
COMBATING 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:PRINT@N,CHR$(253);:NEXT N
2290 RETURN
2310
'-------------------------------------------------------------
----------
2330 '                STUDENT RESPONSE INPUT SUBROUTINES
2350 T$=INKEY$:PRINT@960,"                  * PRESS T (TRUE)
OR F (FALSE) *";
2370 R$=INKEY$
2390 IF R$<>"F" AND R$<>"T" THEN 2370
2410 RETURN
2430 T$=INKEY$:PRINT @ 960,"    * PRESS THE SPACE BAR WHEN
YOU ARE READY TO PROCEED *";
2450 R$=INKEY$
2470 IF R$<>" " THEN 2450
2490 RETURN
2510 T$=INKEY$:PRINT@960,"          * PRESS THE CORRECT
NUMBER KEY *";
2530 R$=INKEY$
2550 IF R$<"1" GOTO 2510 ELSE IF R$>"4" GOTO 2510
2570 R=PEEK (14352):RETURN
2590 PRINT CHR$(23):PRINT@408,"WRONG!":PRINT
CHR$(28):PRINT@448," "
2610 RETURN
2630 PRINT CHR$(23):PRINT@472,"CORRECT!":PRINT CHR$(28)
2650 RETURN
2670
'-------------------------------------------------------------
----------
2690 '                MAIN TEXT STARTS HERE
2710 CLS
2720 PRINT@256," "
2730 PRINT"     IN ITS BROADEST SENSE, COMMUNICATION CAN
BE DEFINED AS ANY
2750 PRINT"INFORMATION-SHARING ACTIVITY. IT INCLUDES ALL
FORMS OF THE
2770 PRINT"TRANSMISSION OF MESSAGES FROM ELECTRICAL
IMPULSES TO HUMAN
2790 PRINT"LANGUAGES.
2795 GOSUB 2030
2800 GOSUB 2430
2810 CLS:PRINT@128," "
2815 PRINT"     ANY INFORMATION-SHARING ACTIVITY IS A FORM
OF:
2820 PRINT" 1. LANGUAGE
2825 PRINT" 2. MEANING
2830 PRINT" 3. COMMUNICATION
2835 PRINT" 4. ELECTRICITY
2840 GOSUB 2030
2845 GOSUB 2510
2850 CLS:IF R<>8 GOTO 2870
```

```
2855 GOSUB 2630
2860 GOTO 2890
2870 GOSUB 2590
2875 PRINT" TRY AGAIN":GOSUB 2030
2880 GOSUB 2430
2885 GOTO 2810
2890 GOSUB 2030
2895 GOSUB 2430
2900 CLS:PRINT:PRINT
2905 PRINT"     COMMUNICATION IS A DYNAMIC PROCESS IN
WHICH A MESSAGE"
2910 PRINT"SENDER CONCIOUSLY OR UNCONCIOUSLY AFFECTS A
RECEIVER THROUGH"
2915 PRINT"MATERIALS OR AGENCIES USED IN SYMBOLIC WAYS.
AT ITS SIMPEST,"
2920 PRINT"THE PROCESS CAN BE REPRESENTED BY THIS
DIAGRAM:"
2925 PRINT:GOSUB 690
2930 GOSUB 2030
2935 GOSUB 2430
2940 CLS:PRINT:PRINT
2945 PRINT"     WHICH OF THE FOLLOWING IS AN EXAMPLE OF
COMMUNICATION?"
2950 PRINT" 1. THE READING OF A BOOK
2955 PRINT" 2. A TEACHER'S ANGRY GLANCE AT A MISBEHAVING
STUDENT
2960 PRINT" 3. A THERMOSTAT CAUSING A HEATER TO SWITCH ON
2965 PRINT" 4. ALL OF THE ABOVE
2970 GOSUB 2030
2975 GOSUB 2510
2980 CLS:IF R<>16 GOTO 2990
2983 GOSUB 2630
2987 GOTO 3000
2990 GOSUB 2590
2993 PRINT"     THE READING OF A BOOK, THE TEACHER'S ANGRY
GLANCE, AND
2995 PRINT"THE ACTION OF THE HEATER THERMOSTAT ARE ALL
FORMS OF
2997 PRINT"COMMUNICATION."
3000 GOSUB 2030
3005 GOSUB 2430
3330 CLS:GOSUB 690
3350 GOSUB 1330
3370 PRINT"      THE INFORMATION SOURCE SELECTS A DESIRED
MESSAGE OUT OF"
3390 PRINT"A SET OF POSSIBLE MESSAGES."
3410 PRINT
3430 PRINT"      THIS SET OF POSSIBLE MESSAGES MAY BE AS
LARGE AND COMPLEX
3450 PRINT"AS ALL THE THOUGHTS AND IDEAS OF WHICH THE
HUMAN MIND IS
3470 PRINT"CAPABLE. IT MAY BE AS SIMPLE AS THE 'ON' AND
'OFF' STATES OF
3490 PRINT"AN ELECTRIC CIRCUIT.
```

```
3495 PRINT:PRINT"     IN HUMAN SPEECH, THE BRAIN OF THE
SPEAKER IS THE "
3500 PRINT"INFORMATION SOURCE."
3510 GOSUB 2030
3530 GOSUB 2430
3550 CLS:GOSUB 690
3570 GOSUB 1210
3590 GOSUB 1250
3610 GOSUB 1410
3630 PRINT"     THIS MESSAGE, WHICH HAS BEEN SELECTED BY
THE SOURCE, CAN
3650 PRINT"BE OF MANY FORMS. IT MAY CONSIST OF WORDS,
PICTURES, MUSIC,
3670 PRINT"IDEAS, OR ELECTRICAL STATES, ETC. IT MAY BE
VERY SIMPLE OR"
3675 PRINT"VERY COMPLEX."
3680 GOSUB 2030
3685 GOSUB 2430
3700 CLS:PRINT:PRINT:PRINT
3705 PRINT"     IN HUMAN SPEECH, THE INFORMATION SOURCE
IS THE SPEAKER'S"
3710 PRINT"BRAIN. THE MESSAGE IS:"
3715 PRINT:PRINT" 1. A WORD
3720 PRINT" 2. A THOUGHT
3725 PRINT" 3. 'ON' OR 'OFF'
3730 PRINT" 4. AN ELECTRICAL IMPULSE
3735 GOSUB 2030
3740 GOSUB 2510
3750 CLS:IF R<>4 GOTO 3770
3755 GOSUB 2630
3760 GOTO 3790
3770 GOSUB 2590
3775 PRINT"     IN HUMAN SPEECH, THE MESSAGE IS A
THOUGHT. ANSWER #2 IS"
3780 PRINT"THE CORRECT ONE."
3790 GOSUB 2030
3792 FOR N=1 TO DY(1):NEXT N
3795 GOSUB 2430
3830 CLS:GOSUB 690
3835 GOSUB 1210
3840 GOSUB 1250
3845 GOSUB 1490
3847 PRINT
3850 PRINT"     THE TRANSMITTER OPERATES ON THE MESSAGE
IN SOME WAY TO
3870 PRINT"PRODUCE A SIGNAL SUITABLE FOR TRANSMISSION
OVER THE CHANNEL.
3890 PRINT"THIS INVOLVES A CODING PROCESS. AN EXAMPLE IS
A TELEPHONE
3910 PRINT"INSTRUMENT, WHICH CHANGES SOUND PRESSURE INTO
A PROPORTIONAL
3915 PRINT"ELECTRIC CURRENT."
3920 PRINT:PRINT"     IN HUMAN SPEECH, 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
TRANSMITTER WHICH
4050 PRINT"IS SENT ALONG THE CHANNEL. IT MAY BE SOUND
WAVES, ELECTRICAL
4070 PRINT"IMPULSES, THE DOTS AND DASHES OF MORSE CODE,
ETC.
4075 GOSUB 2030
4080 GOSUB 2430
4085 CLS:PRINT:PRINT:PRINT
4090 PRINT"       IN HUMAN SPEECH, THE SIGNAL IS:"
4095 PRINT:PRINT" 1. SOUND
4100 PRINT" 2. THOUGHT
4105 PRINT" 3. AIR
4107 FOR N=1 TO DY(2):NEXT N
4110 PRINT" 4. NONE OF THE ABOVE
4115 GOSUB 2030
4120 GOSUB 2510
4125 CLS:IF R<>2 GOTO 4150
4130 GOSUB 2630
4135 GOTO 4180
4150 GOSUB 2590
4155 PRINT"      #1 IS CORRECT. IN HUMAN SPEECH, THE
SIGNAL IS VOCALIZED"
4160 PRINT"SOUND."
4180 GOSUB 2030
4185 GOSUB 2430
4190 CLS:GOSUB 690
4195 GOSUB 1210
4200 GOSUB 1250
4205 GOSUB 1650
4210 PRINT"       THE CHANNEL IS MERELY THE MEDIUM USED TO
TRANSMIT THE
4250 PRINT"SIGNAL FROM TRANSMITTER TO RECEIVER. IT MAY BE
A PAIR OF WIRES,
4270 PRINT"A COAXIAL CABLE, A RADIO FREQUENCY, A BEAM OF
LIGHT, ETC.
4275 PRINT:PRINT"       IN THE CASE OF SPEECH, THE
COMMUNICATIONS CHANNEL IS"
4280 PRINT"THE AIR THROUGH WHICH THE SOUND WAVES TRAVEL."
4285 GOSUB 2030
4290 GOSUB 2430
4300 CLS:GOSUB 690
4305 GOSUB 1210
4310 GOSUB 1250
4315 GOSUB 1730
4330 GOSUB 1730
```

```
4350 PRINT@320," "
4370 PRINT"     THE RECEIVER IS AN INVERSE TRANSMITTER.
IT DECODES THE
4390 PRINT"SIGNAL, CHANGING IT BACK INTO A MESSAGE AND
HANDING IT ON TO
4395 PRINT"THE DESTINATION."
4400 GOSUB 2030
4405 GOSUB 2430
4410 CLS:PRINT:PRINT:PRINT
4415 PRINT"     IN HUMAN SPEECH, WHICH IS THE RECEIVER?"
4420 PRINT:PRINT" 1. SOUND WAVES"
4425 PRINT" 2. THE LISTENER'S EAR
4430 PRINT" 3. THE LISTENER'S BRAIN
4435 PRINT" 4. THE SET OF POSSIBLE MESSAGES
4440 GOSUB 2030
4445 GOSUB 2510
4450 CLS:IF R<>4 GOTO 4470
4455 GOSUB 2630
4460 GOTO 4490
4470 GOSUB 2590
4475 PRINT"     #2 IS CORRECT. THE LISTENER'S EAR IS THE
RECEIVER."
4490 GOSUB 2030
4495 GOSUB 2430
4500 CLS:GOSUB 530
4505 GOSUB 1210
4510 GOSUB 1250
4515 GOSUB 1810
4520 PRINT@320," "
4525 PRINT"     THE DESTINATION IS THE PERSON OR THING
FOR WHICH THE"
4530 PRINT"MESSAGE IS INTENDED.
4535 PRINT:PRINT"     IN HUMAN SPEECH, THE DESTINATION IS
THE BRAIN OF THE"
4540 PRINT"LISTENER."
4550 GOSUB 2030
4570 GOSUB 2430
4590 CLS:PRINT:PRINT:PRINT"PROBLEM:":PRINT
4610 PRINT"     IN READING, THE SOURCE IS THE MIND OF THE
AUTHOR, THE
4630 PRINT"DESTINATION THAT OF THE READER.
4650 PRINT:PRINT"     WHICH OF THE FOLLOWING IS THE
TRANSMITTER?
4670 GOSUB 2050
4690 GOSUB 2030
4710 GOSUB 2510
4730 CLS:IF R<>8 GOTO 4790
4750 GOSUB 2630
4770 GOTO 4870
4790 GOSUB 2590
4810 PRINT"     THE CORRECT ANSWER IS #3. IN READING, THE
PRINTED PAGE
4830 PRINT"IS THE TRANSMITTER.
4850 GOSUB 2030
```

```
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:":PRINT
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
5520 FOR N=1 TO DY(4):NEXT N
5530 PRINT"INFORMATION SOURCE.
5550 GOSUB 2030
5570 GOSUB 2430
5590 GOSUB 1890
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
5730 GOSUB 1090
5750 GOSUB 1890
5770 PRINT@384,"     NOISE MAY BE DEFINED AS ANY OUTSIDE
FORCE WHICH ACTS ON
5790 PRINT"THE TRANSMITTED SIGNAL TO VARY IT FROM THE
```

```
ORIGINAL.
5810 GOSUB 2030
5830 GOSUB 2430
5850 PRINT@512," "
5870 PRINT"      EXAMPLES ARE DISTORTIONS OF SOUND (EG. IN
RECORDING),
5890 PRINT"STATIC (IN RADIO), DISTORTIONS IN SHAPE,
SHADING, OR COLOUR
5910 PRINT"(IN TELEVISION), OR ERRORS IN TRANSMISSION
(EG. IN TELEGRAPHY).
5930 GOSUB 2030
5950 GOSUB 2430
5970 CLS:PRINT:PRINT
5990 PRINT"      YOU ARE A PASSENGER IN A CAR WHIH IS
BEING DRIVEN RAPIDLY
6010 PRINT"ALONG 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 DY(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@192," "
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
```

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6570 GOSUB 2430
6590 CLS
6610 PRINT'EXAMPLE: THE MESSAGE 'HELP'
6630 FOR N=1 TO 27:PRINT CHR$(131);:NEXT N:PRINT
6650 PRINT:PRINT'USE OF REDUNDANCY:'
6670 FOR N=1 TO 10:PRINT 'HELP  ';:NEXT N
6690 GOSUB 2030
6710 GOSUB 2430
6730 PRINT@384, 'INCREASING TRANSMITTER POWER:'
6750
PRINT@468,CHR$(191);CHR$(195);CHR$(191);CHR$(193);CHR$(191
);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$(1
91);CHR$(197);CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$
(189);
6770
PRINT@532,CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(191
);CHR$(193);CHR$(191);CHR$(131);CHR$(131);CHR$(131);CHR$(1
94);CHR$(191);CHR$(197);CHR$(191);CHR$(131);CHR$(131);CHR$
(131);CHR$(129);
6790 FOR N=1 TO DY(3):NEXT N
6810
PRINT@596,CHR$(131);CHR$(195);CHR$(131);CHR$(193);CHR$(131
);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$(1
31);CHR$(131);CHR$(131);CHR$(131);CHR$(131);CHR$(193);CHR$
(131)
6830 GOSUB 2030
6850 GOSUB 2430
6870 PRINT@704,'DUPLICATION ON OTHER CHANNELS:
6890 PRINT'         HELP':LPRINT,'HELP'
6910 FOR N=1 TO 5:LPRINT CHR$(138):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 #4. BY LEANING OVER
TO SPEAK
7230 PRINT'DIRECTLY INTO YOUR E[illegible] YOUR FRIEND WAS
CAREFULLY BEAMING HIS
7250 PRINT'VOCAL 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'ATTENTION 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<>B 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$(23);
7810 PRINT@332,'THE ENGLISH LANGUAGE
7830 PRINT@408,'IS ABOUT
7850 PRINT@462,'ONE-HALF REDUNDANT
7870 GOSUB 2030
7890 PRINT CHR$(28);:GOSUB 2430
7900 PRINT@960,CHR$(253);
7910
PRINT@462,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191
);CHR$(191);CHR$(191);
7930 GOSUB 1970
7950
PRINT@414,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191
);CHR$(191);CHR$(191);CHR$(191);CHR$(191);
7960 FOR N=1 TO DY(6):NEXT N
7970 GOSUB 1970
7990
PRINT@332,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191
);
8010 GOSUB 1970
8030
PRINT@356,CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191
```

```
);CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(191);CHR$(1
91);CHR$(191);CHR$(191);CHR$(191);CHR$(191);
8050 GOSUB 1970
8070 PRINT@576,"     THE MEANING IS STILL CLEAR AFTER
HALF OF THE WORDS HAVE
8090 PRINT"BEEN DELETED.
8110 GOSUB 2030
8130 GOSUB 2430
13130
'-------------------------------------------------------------------
---------
13150 '                          QUIZ
13170 CLS
13190 FOR N=15424 TO 15487:POKE N,176:NEXT N
13210 FOR N=15551 TO 16255 STEP 64:POKE N,191:NEXT N
13230 FOR N=16319 TO 16256 STEP -1:POKE N,131:NEXT N
13250 FOR N=16192 TO 15488 STEP -64:POKE N,191:NEXT N
13270 PRINT@130,"1.";
13290 PRINT@450,"ANY INFORMATION-SHARING ACTIVITY IS A
FORM OF COMMUNICATION.";
13310 GOSUB 2030
13330 GOSUB 2350
13350 IF R$="T" THEN S=S+1
13370 GOSUB 2270
13390 PRINT@130,"2.";
13410 PRINT@450,"INFORMATION IS THE CONTENT OF THE
COMMUNICATIONS PROCESS.";
13430 GOSUB 2030
13450 GOSUB 2350
13470 IF R$="T" THEN S=S+1
13490 GOSUB 2270
13510 PRINT@130,"3.";
13520 FOR N=1 TO DY(7):NEXT N
13530 PRINT@386,"     IN HUMAN SPEECH, THE SIGNAL IS
SOUND, THE INFORMATION";
13550 PRINT@450,"CHANNEL IS THE LISTENER'S EAR.";
13570 GOSUB 2030
13590 GOSUB 2350
13610 IF R$="F" THEN S=S+1
13630 GOSUB 2270
13650 PRINT@130,"4.";
13670 PRINT@386,"     THE FUNCTION OF THE INFORMATION
SOURCE IS TO SELECT";
13690 PRINT@450,"A DESIRED MESSAGE OUT OF A SET OF
POSSIBLE MESSAGES.";
13710 GOSUB 2030
13730 GOSUB 2350
13750 IF R$="T" THEN S=S+1
13770 GOSUB 2270
13790 PRINT@130,"5.";
13810 PRINT@460,"THE MESSAGE MUST BE VERY SIMPLE.";
13830 GOSUB 2030
13850 GOSUB 2350
13870 IF R$="F" THEN S=S+1
```

```
13890 GOSUB 2270
13910 PRINT@130,"6.";
13930 PRINT@455,"THE DESTINATION DECODES THE TRANSMITTED SIGNAL.";
13950 GOSUB 2030
13970 GOSUB 2350
13990 IF R$="F" THEN S=S+1
14010 GOSUB 2270
14030 PRINT@130,"7.";
14050 PRINT@386,"     INCREASING THE POWER OF THE TRANSMITTER IS A METHOD OF";
14070 PRINT@450,"OVERCOMING REDUNDANCY.";
14090 GOSUB 2030
14110 GOSUB 2350
14130 IF R$="F" THEN S=S+1
14150 GOSUB 2270
14170 PRINT@130,"8.";
14190 PRINT@386,"     ANY OUTSIDE FORCE WHICH ACTS ON THE SIGNAL TO VARY IT";
14210 PRINT@450,"FROM THE ORIGINAL IS KNOWN AS 'NOISE'.";
14230 GOSUB 2030
14250 GOSUB 2350
14270 IF R$="T" THEN S=S+1
14290 GOSUB 2270
14310 PRINT@130,"9.";
14330 PRINT@386,"     CAREFUL BEAMING OF THE SIGNAL IS ONE METHOD OF";
14350 PRINT@450,"OVERCOMING NOISE.";
14370 GOSUB 2030
14390 GOSUB 2350
14410 IF R$="T" THEN S=S+1
14430 GOSUB 2270
14450 PRINT@130,"10.";
14470 PRINT@386,"     THE ENGLISH LANGUAGE HAS EXTRA STRUCTURE WHICH HELPS";
14490 PRINT@450,"TO ENSURE THAT OUR MESSAGES GET THROUGH IN SPITE OF ANY";
14510 PRINT@514,"DISTORTION.";
14530 GOSUB 2030
14550 GOSUB 2350
14570 IF R$="T" THEN S=S+1
15390 CLS:PRINT
15410 IF S>8 THEN PRINT "        EXCELLENT.";:GOTO 15510
15430 IF S>7 THEN PRINT "        VERY GOOD.";:GOTO 15510
15450 IF S>5 THEN PRINT "        GOOD.";:GOTO 15510
15490 PRINT"      POOR.";
15510 PRINT" YOU GOT";S;"OUT OF 10 CORRECT."
15530 PRINT
15550 PRINT"     THIS SHORT LESSON HAS BARELY SCRATCHED THE SURFACE OF"
15570 PRINT"INFORMATION THEORY."
15670 PRINT
15690 PRINT"     TO LEARN MORE ABOUT THIS SUBJECT, VIEW THE FILM
```

```
15730 PRINT''A COMMUNICATIONS PRIMER' IN CAVE.'
15850 PRINT
15870 PRINT'     PLEASE OBTAIN THE SHORT QUESTIONAIRE FROM
THE LAB
15890 PRINT'ASSISTANT, FILL IT IN, AND RETURN IT.'
15910 PRINT:PRINT'      THANK YOU.'
15930 GOSUB 2030
15950
'------------------------------------------------------------
---------
15970 '                 QUIZ RESULTS FILED ON DISK AND EXIT
15990 T$=INKEY$
16010 PRINT@960,'                  * PRESS THE SPACE BAR TO
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)=2[illegible]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 SENDER 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-  ............... RECEIVER.......... DESTI- .
.        .           . MITTER .               .        .          . NATION .
..........           ..........               ..........          ..........
```

* 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 *

```
..........       ..........            ..........          ..........
. SOURCE ......... TRANS- .............RECEIVER......... DESTI- .
.        .       . MITTER .            .        .        . NATION .
..........       ..........            ..........          ..........
```

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 *

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

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 *

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

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 *

SOURCE	MESSAGE	TRANS-MITTER	SIGNAL	CHANNEL

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

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 *

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

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 *

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

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	. THE MIND OF THE AUTHOR
MESSAGE	. THOUGHT
TRANSMITTER	. PRINTED PAGE
SIGNAL	. WORD
CHANNEL	. LIGHT
RECEIVER	. EYE
DESTINATION	. THE MIND OF THE READER

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

```
..........       .........                  .........         .........
. SOURCE ........ TRANS- ............ RECEIVER.......... DESTI- .
.        .       . MITTER .      .      .                 . NATION .
..........       .........       .      .........         .........
                             .........
                             . NOISE .
                             .........
```

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 *

```
..........        ..........                  ..........         ..........
. SOURCE ......... . TRANS-  ............. .RECEIVER. ........ . DESTI- .
.        .        . MITTER  .             .        .          . NATION .
..........        ..........                ..........        ..........
                          .........
                          . NOISE .
                          .........
```

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 RADIDLY 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:

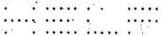
- THE USE OF REDUNDANCY IN THE MESSAGE
- INCREASING THE POWER OF THE TRANSMITTER
- DUPLICATING THE MESSAGE IN OTHER SIGNALS, CHANNELS
- CAREFUL BEAMING OF THE SIGNAL

* 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.

..... E N G L I S H ....
I S ....
.... H A L F   R E D U N D A N T

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

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

APPENDIX D

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	___	___	___	___	___	___	___	hazy
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 F

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).

	Evaluative	Potency	Activity
good/bad	.88	.05	-.09
strong/weak	.19	.62	.20
valuable/worthless	.79	.04	.13
pleasant/unpleasant	.82	-.05	.28
relaxed/tense	.55	.12	-.37
short/long	.20	.34	.13
clear/hazy	.59	.03	.10
nice/awful	.87	-.08	.19
active/passice	.14	.04	.59
fast/slow	.01	.00	.70
fair/unfair	.83	.08	-.07

APPENDIX G

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 5:LPRINT CHR$(138):NEXT N
200 LPRINT "ACHIEVEMENT QUIZ SCORES (MAX.10):"
210 FOR N=1 TO 50
220 IF R(N)=0 GOTO 300
230 LPRINT R(N)
250 NEXT N
300 FOR N=1 TO 5:LPRINT CHR$(139):NEXT N
999 END
```