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AN EVALUATION OF MICROCOMPUTER ASSISTED INSTRUCTION FOR TEACHING WORD RECOGNITION TO MENTALLY RETARDED ADULTS

by

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Abstract

This study compared the utility of computer assisted instruction with more conventional interpersonal tuition for teaching word recognition skills to mentally retarded adults. A second aspect of the research was to evaluate acquisition, retention, and transfer of learning using two common methods of instruction; these were errorless discrimination (word-focus only) and paired associate learning (picture-word focus). Recognition of words was selected as the experimental task on the basis that this was a practical academic area that traditionally involves large amounts of teaching time, primarily within the realm of drill and practice procedures.

The sample comprised 52 subjects who were drawn from three special education facilities in Palmerston North, New Zealand (a Special School, and two Vocational Training Centres). Subjects were screened initially on tests of visual perception and letter discrimination to ensure that they possessed requisite skills to benefit from participation in training. Pre-testing was carried out to determine whether subjects were able to recall or recognize any of the words to be taught. All subjects entering the experiment knew two or less of 16 words selected for inclusion in the training programmes.

Subjects were randomly assigned to computer assisted instruction or individual tuition groups with 26 persons placed in each group. Within each group, subjects were again randomly allocated to receive errorless discrimination or paired associate modes of instruction. This 2 X 2 classification resulted in 13 subjects being placed in each subgroup. Two modules each containing eight words were used for training. Both the individual instruction and computer groups were given a total of 10 training sessions, or five sessions for each of the two modules.

A modified microcomputer was interfaced with a sound-on-slide projector to provide both audio and visual instruction. Parallel teaching programmes were developed for administration by computer or individual tuition. The first programme (errorless discrimination) required subjects to select target words from a series of increasingly complex word discriminations with no picture cues provided. A second teaching method (paired associate learning) involved the pairing of pictures and words. Subjects were instructed to select target words from a list of printed items that matched referent photographs. Thirteen senior special education students (Teachers College Graduates) carried out the individual training while

the experimenter supervised the computer based programmes.

Progress in training was assessed by comparing pre- and post-test performance on Word Recognition (verbal labelling), Word Identification (pointing on cue), and Picture-Word Matching. Transfer of learning was evaluated using situational tests requiring that subjects match printed words with real life objects. Tests of retention were conducted four weeks after completion of training. A repeated measures design was used with counterbalancing to control for possible confounding effects of list order (Modules).

The findings revealed that both computer assisted instruction and interpersonal tuition resulted in very similar learning outcomes with regard to acquisition, retention, and transfer of learning. No reliable differences were found between the two groups or modes of instruction in terms of training method. It was advanced that some common features of programmed instruction (e.g. active participation, self-pacing, over-learning, and immediate feedback) may have accounted for these equal gains in performance.

In respect to the question of the potential utility of micro-processor technology in special education, this research points to the efficacy of computer assisted instruction for drill and tutorial practice. Specifically, the computer provides a highly structured learning experience that has the potential to assist retarded learners in organising input materials. Evidence from this study suggests that computer related learning environments give the adult learner considerably more control of the teaching situation, and provide consistent reinforcement that is not so readily administered through conventional forms of instruction. Finally, it was proposed that the relatively impersonal, though highly interactive, nature of the computer may avoid the triggering of perceptions of failure that can impede performance of handicapped learners.

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CHAPTER I

INTRODUCTION AND OVERVIEW

Over the past two decades a great deal of attention in special education has been directed at programmed instruction and methods of individualised teaching with handicapped persons. It has long been recognised that due to the wide range of intrapersonal and interpersonal variations found amongst mentally retarded people, training should be tailored to meet individual needs. In some countries, notably the United States of America, legislation has been enacted to help ensure that individual programme planning is used to identify relevant educational objectives and levels of instruction for each child (PL94/142).

It has generally been accepted that many mentally retarded persons are capable of maintaining themselves independently in the community following adequate social and vocational preparation (Goldstein, 1964; Brown, 1975). But this will depend to a large extent on the range of educational opportunities available to this population, particularly with regard to academic instruction in practical areas such as handling money, telling time, community awareness, self expression, recognition and understanding of important written symbols. Training of these skills requires a thoroughly structured and planned programme over an extended period. Despite evidence that suggests mentally retarded people can experience significant growths in behaviour and learning during late adolescence and early adulthood (Brown, 1975; Clarke and Clarke, 1973), there is a serious absence of continuing education for this population.

In New Zealand, mentally retarded persons considered unable to benefit from instruction in a regular or special class, are placed in special schools located in all major centres. The New Zealand Education Act (1964) includes a general provision to ensure that all such children receive an "appropriate" form of instruction within special education facilities until the age of 16 years. Following this, many of these children enter workshops or training centres operated for the most part by voluntary agencies such as the New Zealand Society for the Intellectually Handicapped. But it is most often the case that these adult training facilities take the form of occupational centres that primarily focus upon development of vocational skills with little or no emphasis on social education involving academic preparation for skills of living. More recently, attention has been directed to some ways in which assessment and training can be extended to cover a full range of life skills required to gain greater independence in society (Ryba and McDonald, 1979a, 1979b). The training situation itself may be self defeating when individuals are not progressively prepared to assume responsibilities and roles which must inevitably be met on discharge to the community.

The concept of normalisation (Nirje, 1969; Wolfensberger, 1972) has encouraged the view that mentally retarded persons should be provided with a full measure of human and legal rights. The focus has been on making available the kinds of opportunities, experiences, and conditions which occur in everyday life and are consistent with behavioural norms for the mainstream of society. In this sense, normalisation refers to a humanitarian rather than a psychological principle. Reservation has been expressed by some writers about the manner in which the principle has been implemented. Gunzburg (1972) has argued that normalising concepts tend to overlook actual deficits in the mentally handicapped where these exist. He expresses concern that important problems of social and personal adjustment can persist even though the individual has been integrated into new, more independent, but also more demanding living conditions. Education of mentally retarded persons needs to be considered in terms different from a traditional academic syllabus designed for the younger normal child. The purpose of education should be to provide an all-round knowledge which will help in adult life. Many aspects of the normal school curriculum represent non-useful acquisitions for this group and their learning requires far too much time (e.g. grammar, arithmetic rules) when the immediate task is to pave the way to developing practical skills of community living.

Another concept which has exerted a powerful influence upon habilitation programmes for the mentally retarded is the principle of adaptive behaviour. This stresses potential for changes in learning and behaviour, thus removing the use of static descriptors of intelligence such as the IQ and MA. The principle of adaptive behaviour was first adopted by the American Association on Mental Deficiency (AAMD) who defined mental retardation as:

> "referring to subaverage general intellectual functioning which originates during the developmental period and is associated with impairment in one or more of the following areas: (1) maturation, (2) learning and (3) social adjustment."
>
> (Heber, 1961).

'Subaverage' is here understood to refer to a performance that extends more than one standard deviation below the population mean, and 'general intellectual function' as it is measured by one or more standardised intelligence tests. The developmental period is primarily regarded as the period from the time of birth to about 16 years of age (Sattler, 1974).

Widespread use of the adaptive behaviour criterion is exemplified through habilitation assessment instruments like the Adaptive Functioning Index (Marlett, 1973), the Adaptive Behaviour Scale (Nihara, Foster, Shellhaas, and Leland, 1969) and the Progress Assessment Charts (Gunzburg, 1974). All of these stress the measurement of progress in training within the major areas of social, vocational, residential, and practical academic skills.

The science of habilitation methods with moderately and severely retarded persons is of relatively recent origin and can be dated to the early work of O'Connor and Tizard (1951) and Clarke and Clarke (1954) who demonstrated the social and vocational capabilities of mentally retarded persons who were given specialised training in institutions and hospitals. It has generally been accepted since that time that mentally retarded persons tend to underfunction when denied opportunities to develop their personal capabilities. Considerable recognition is now given to the importance of community-based training facilities that provide continuing education in all areas of life skills development.

Programmed learning which with its focus on the individual learner has received extensive attention over the past years, offered much promise in the field of education with moderately and severely retarded persons. Training features of programmed instruction (e.g. small steps, active participation, immediate feedback, selfpacing and testing) have been well documented in the literature (Gagne, 1970; Brown, 1975; Clarke and Clarke, 1974). These learning principles have encouraged practitioners to examine both their goals and methods of instruction and have led to detailed evaluation of the progress of individuals in learning various types of material (Beasely, 1974). On the surface at least it would seem that this application of principles of learning theory in the form of programmed instruction should have given a significant boost to the education of mentally retarded persons. Several detailed reviews on programmed instruction in special education have been provided by Stolurow, (1963); Greene, (1966); Malpass, (1968);and Haskell, (1966). The general conclusion arising from all of these reviews seems to underline the fact that while programmed instruction is an effective means of teaching the mentally retarded, there is little evidence to support the contention that this approach is more beneficial than other conventional methods (Blackman and Capobianco, 1965). Several reasons may be advanced for this finding - lack of trained personnel, inconsistent application of methods and materials, large variation in type and content of teaching programmes. Limitations of this sort may have prevented the principles of learning from being given a true test (Beasely, 1974). It is particularly notable that many of the studies to date have been carried out with educable mentally retarded persons while there is a paucity of research concerning the application of programmed learning with the more severely handicapped. Educational programmes that teach word recognition (Holz, 1976), number skills (Strain, 1974) and budgeting and banking (Sandals, 1973) have been successfully taught to mentally retarded persons by means of programmed learning and computer assisted instruction.

The application of principles of programmed instruction with more severely retarded persons has often made use of automated machines rather than conventional materials (e.g. Hively, 1964; Haskell, 1971). This tendency is attributable to the fact that special purpose machines can be constructed in such a manner as to elicit a restricted stimulus-response relationship for persons of low cognitive ability. But difficulties in designing machines that are reliable and capable of being used by handicapped persons and not prohibitive in cost has restricted the development of these automated teaching aids. A later section of this thesis will consider the problems associated with the development of this educational technology.

A considerable amount of work has been carried out on the application of automated procedures for teaching word recognition and understanding of written symbols (e.g. Holz, 1976; Beasely, 1974;

Vergason, 1968). With advances in technology this research has progressively made use of mechanical teaching machines, large, time-shared computer systems, and more recently, microprocessor based computers. The rationale for all of these approaches has been based upon the principles of programmed instruction. Yet this fascination with auto-instructional techniques has at best provided fragments of evidence to support the contention that programmed learning is more effective than traditional teacher based instruction. Technology-oriented researchers have tended to put most efforts into validation of the hardware (e.g. Hallworth and Brebner, 1976; Eaton, 1975) while overlooking some of the basic theoretical propositions that have guided the development of learning programmes.

Researchers such as Dorry and Zeaman, (1975), Walsh and Lamberts, (1979), and Vergason (1964, 1968), to name just a few, have shed a great deal of light on some of the basic premises and theoretical issues that underlay the teaching of word recognition and comprehension with handicapped persons. Yet despite this considerable body of knowledge, much of the research on auto-instruction has failed to consider the wide range of research findings already available in this area. Moreover, many studies have attempted to validate their findings on groups receiving supplementary auto-instruction (e.g. Holz, 1976; Atkinson, 1974) without comparing these innovative approaches to more conventional teaching methods. Even though it can reasonably be argued that each subject provides his own baseline in a pre- versus post-programme design, the absence of comparison groups makes it difficult to gauge the ecological validity of these automated procedures. Additionally there is an absence of information on retention and transfer of learning that may result from these experimental approaches.

Widespread public interest is now being shown in ways in which microcomputers might transform world society at all levels, particularly with regard to education. Whereas the age of teaching machines ran a reasonably silent course, being largely confined to highly specialised areas of research, the general availability of home computers has ushered in a new era of almost universal awareness that microcomputers will play a significant role in human learning and modification of behaviour.

Purpose of the Study

With these recent technological advances in mind, the purpose of this study was two-fold, firstly, to evaluate the utility of two contrasting approaches for teaching word recognition to moderately and severely retarded adults. The second purpose was to explore the effectiveness of computer assisted instruction as a teaching aid in comparison to more traditional forms of teacher based instruction. Two well known methods for teaching word recognition to mentally retarded persons were selected for evaluation; these were errorless discrimination (e.g. Edmark, 1972) and paired associate learning (e.g. Vergason, 1964).

Word recognition was chosen as the experimental task on the basis that this was a practical academic area that traditionally requires large amounts of teaching time, primarily involving drill and practice procedures. The task readily lends itself to programmed instruction using either automated or prescriptive teaching methods. It was felt that word recognition represents a functional skill that is central to independence and decision making in community life. Since few reliable tests have been developed for use in assessing word recognition of mentally retarded persons, a set of instruments was devised by the experimenter to measure any changes in learning that might have occurred following participation in training. Another aspect of the present study was to examine the extent to which subjects could transfer their learning to other real life situations and retain information for a period of time after completion of the training sessions.

Because of the very rapid technological changes occurring in the field of electronics engineering, particularly with regard to microprocessing, it was felt necessary to deal with some of the practical problems and issues that are likely to arise as this educational technology gains prominence in special education. This concerns both the advantages and limitations of microcomputer systems as well as some of the social and psychological issues to be faced in the near future.

Attention is also given in this study to research findings on cognitive development of mentally retarded persons, for it is recognised that the manner in which information is processed by a person (i.e. underlying cognitive processes) will ultimately account for the amount and type of learning that occurs. There are many problems and shortcomings to this and other related research that must be considered when interpreting the results of the investigation. An attempt has been made to alert the reader to some of these issues in the following chapter.

CHAPTER II

REVIEW OF RESEARCH ON INFORMATION PROCESSING: ACQUISITION, RETENTION, TRANSFER OF LEARNING

Introduction

The purpose of this chapter will be to present some research findings on cognitive characteristics of the mentally retarded learner. There is a considerable body of theoretical knowledge that can be drawn upon to explain the outcome of training, yet it is often the case that this theory has not been translated into practice. An attempt will be made in this section to highlight some of the procedural variations that might account for the extent to which retarded learners acquire, retain and transfer their learning.

Procedural Variations

Early work by Harlow (1949, 1950) has repeatedly demonstrated that organisms can be taught a progressive sequence of discrimination problems. The main feature of this work has been to describe learning sets which refer to transfer of training amongst several problems in a single class rather than the more common transfer between problems of disparate classes or transfer associated with relatively few problems in the same class (Kaufman and Prehm, 1966). When a broad sampling of learning is obtained within multiple problems of the same class (e.g. word recognition, picture-word association), it is more feasible to evaluate error factors and changes in problem difficulty that might affect the learning process. It seems reasonable to expect that analysis of error factors will have direct application to understanding how mentally retarded learners process information presented in the experimental teaching situation.

Learning set research with retarded persons is characterised by wide procedural variations. It is essential, therefore, to consider the range of variations and arrive at some useful frame of reference for comparing the procedures and outcomes of individual studies. Firstly, there are differences associated with problem length, both with regard to the number of problems and the number of trials within each problem. It might be the case for example that a researcher presents a large number of problems to subjects such that each problem comprises a pairing of elements for a relatively small fixed number of trials. This approach is exemplified in a study by Parmenter, Hauritz, Riches, Ward, Yates and James (1979) who presented two lists of 11 paired associate problems (tool names) to mildly retarded adolescents each day for a period of ten days or a maximum of 220 problems. Another study by Harter (1965) used 10 four-trial problems per day until students were able to reach a mastery level of 93 percent on four successive problems. Conversely, a small number of problems may be presented for many trials over a long or short time period. For instance, in a study comparing Down's Syndrome and normal children, Girardeau (1959) presented a single problem each day with a maximum of 50 trials per problem and mastery criterion of 11 successive correct responses. In general, learning set studies have tended to make use of between 5 and 10 problems (e.g. Walsh and Lamberts, 1979; Dorry and Zeaman, 1973) for teaching word recognition or comprehension. Other procedural variations involve combinations of the two extremes previously mentioned. Ellis, Girardeau and Pryer, (1962) for instance made use of a large number of trials for each problem during a pre-training phase and then switched to a large number of problems with few trials during the training phase. It is evident that variation in the length of problems will play a part in learning outcomes and should be taken into account when evaluating individual studies.

Relatively little attention has been paid to the effects of pre-training experience in research on learning set. Yet it seems likely that the amount and type of prior training will exert an important influence on learning outcomes. Often the amount of training is decided on the basis of degree of intellectual deficit in the sample being studied. Adaption to the training environment and experimental task is subject to many other situational factors including presence or absence of experimenter, type of verbal or nonverbal response, interpersonal or machine-based instruction, etc.

Occasionally subjects are given a pretraining sequence of problems that are not assessed in the main experiment (e.g. Holz, 1976). This serves as an introduction to the task with sample problems that are relatively simple for the learner to master. But it is most often the case that pretraining is incorporated into the actual teaching sessions on the assumption that a learner has the requisite skills to participate in an experiment (e.g. Parmenter, et. al., 1979; Dorry and Zeaman, 1973; Vandever, Maggart and Nasser, 1976). This is a questionable procedure as variations in the amount of pretraining might substantially account for programme differences. Indeed, there is some indirect evidence to show that mentally retarded learners do not initially know where to focus their attention when confronted with a novel learning task. But once the retarded child discovers the relevant dimensions, he learns at a rate similar to that of nonretarded children (Zeaman and House, 1967). The practical implication is that learning outcomes could reflect accommodation to the requirements of a task, which will vary for each child, or acquisition of knowledge following mastery of the appropriate operational dimensions required of the task. At the extreme, a subject might spend all of his training time learning to sort out relevant dimensions of the task, and then demonstrate rapid gains in learning toward the end of training. Thus, experimental designs may not adequately tap "process" variables with the effect that spurious estimates of content knowledge are made through assessment of the subject matter alone.

There have been very few attempts made to systematically evaluate the effects of various pretraining procedures. One important study was carried out by Bowes and Wischner (1959) who evaluated object quality problems with 60 institutionalised mentally retarded persons. Four groups were given different numbers of training problems; group one was given 60 pretraining problems, groups two and three received 12 and 3 pretraining problems, respectively, while the fourth group received no pretraining at all. It was found that there was a progressive increase in errors from group one through four for the first 60 problems. But alternation of the 12 and 3 problem pretraining for groups two and three failed to demonstrate any differences in error rate for these conditions. This suggested that the maximum 12 problem pretraining condition was no more effective in establishing a learning set than the minimum pretraining condition. More research along these lines is required to gain some knowledge of pretraining variations on task performance.

Low motivation is a major cause of underfunctioning for handicapped persons. It is commonly accepted that incentives and rewards may enhance learning and performance. Yet there is often an absence of information on the role incentives might have played in individual studies of learning sets. Many researchers simply do not discuss whether incentives, tangible or intangible (formal/informal) might have contributed to the experimental findings. For example, in none of the studies reviewed by Kaufman and Prehm (1966) was it possible to determine if variable incentives (usually candy and food) were switched from trial to trial, problem to problem or day to day. Evidence relating to rewards is found in studies cited by Clarke and Clarke (1973). Rewards seem most likely to be effective when given frequently and over small intervals. But the incentives and rewards must be meaningful to the person concerned and may take several forms including concrete, verbal, competitive and social rewards. The extent to which these are used and the manner in which incentives are employed varies considerably amongst research studies cited in the literature. Heber (1959) found that alternating from high to low preference incentives with each subject resulted in decreased performance on motor tasks. The practical implication is that research studies must take account of possible incentive factors that might influence learning and performance on cognitive tasks.

Etiological classification has not been controlled for in most cognitive studies with the result that cultural-familial retarded persons are studied along with subjects demonstrating some genetic or organic dysfunction. The significance of etiology in learning set formation is clearly demonstrated in studies by Bowes and Wischner (1959) and Wischner, Braun and Patton (1962). In the former research, it was noted that when two diagnostic categories were used (mongoloids/ cultural familials), different pretraining schedules significantly influenced mongoloid performance but had no effect on familials. MA differences were not a factor in these etiological effects. Wischner, Braun and Patton (1962) analysed characteristics of subjects who failed to reach criterion at the end of training and noted that organic involvement was a factor. Seven out of twelve children who did not attain the criterion were known to have some form of cerebral dysfunction (e.g. microcephaly, Trisomy 23, epilepsy) whereas only three of twenty subjects who reached the criterion demonstrated similar organic involvement. Studies such as these suggest there is a need to identify etiological variation and attempt to control for organic versus non-organic classification where possible.

Error Factors

A major advantage of learning set research is that it often affords a systematic record of learning efficiency and measurement of error factors operating at any stage in training. Several error factors including perseveration, response shift, position preference and differential cues have been studied in mentally retarded persons. All of these factors have been observed in individual tuition, machine based teaching and computer assisted instruction. Stimulus perseveration denotes a tendency to repeat incorrect choices on subsequent trials of an identical problem. Research by Kaufman and Peterson (1958) found that mildly retarded children were more likely to demonstrate stimulus perseveration errors than normal children of the same CA. Holz (1976) found that some mentally retarded children would perseverate when asked to identify a target word from a fixed sequence of items on a CRT screen during computer assisted instruction. This response set was modified by randomly changing position of the words prior to each trial. Position preference refers to consistent responding to the same location on multiple choice problems (e.g. left, right, up, down). It was noted by Ellis, Girardeau and Pryer (1962) that mentally retarded persons showed a marked preference for position in comparison with normal preschool subjects; 83 percent of the severely mentally retarded group showed position preferences in contrast to only 31 percent of the preschool children.

Response shift defines a predilection for exploring or trying out both objects in a discrimination learning task. This factor has been the subject of research by Harlow (1959) and House and Zeaman (1958) who attribute these errors to curiosity on the part of a subject who is simply "trying out" both objects of a presented pair. Related to this, House and Zeaman (1963) stress that mentally retarded persons need practice in learning to attend to relevant dimensions of a task. These researchers hold to the view that a familiar stimulus should first be presented in order to gain the learner's attention and then gradually faded so that attention is directed toward an unfamiliar but associated stimulus. When teaching word recognition, for example, pictures are used to mediate a strong attention response, and then progressively removed to assure that transfer of attention is shifted to the printed words (Dorry and Zeaman, 1975). However as Walsh and Lamberts(1979) have noted, children may experience difficulties in shifting attention from a familiar stimulus (picture) to an unfamiliar stimulus (printed word). From the principle of least effort it can be argued that when given a stimulus that is readily identifiable and another which is not, the child will attend to the more familiar object (Samuels, 1970). It is evident that care must be taken in designing an experiment task to help ensure that the subject has reasonable opportunity to discover the relevant dimensions of the operation.

Multiple choice discriminations involve simultaneously rewarding a response to a stimulus object as well as position of the object. Differential cue errors refer to the frequency of errors that occur on trials in which the object remains in the same position versus errors made when the correct stimulus object is located in a new position from the previous trial. While there is evidence to suggest that retarded subjects do not differ from normal persons with regard to differential cue errors (House and Zeaman, 1958; Kaufman, 1955), it is important during pretraining to provide practice in dealing with variations of stimulus placement on the experimental task.

Retention of Learning

In order to be really beneficial, learning must be recalled at a later time. Obviously the most important factor is amount of recall of original learning. Vergason (1968) clearly demonstrated the difficulties children have in retaining new information when he asked teachers of retarded children to retest words from previous spelling tests. The error rate was about 75 percent for the children even though they all had perfect papers at the time of first testing. This is a rather salient example of the extent to which previously learned material can be forgotten in the absence of opportunities for overlearning.

It has generally been accepted that the learning of retarded persons can be accelerated when they are given practice in identifying relevant cues of a task. Zeaman and House (1963) have demonstrated that the higher the mental age of subjects, the greater the number of important cues which they are likely to observe and respond to correctly. Conversely, severely retarded persons are less able to identify pertinent dimensions of a given task. Zeaman and House contend that distraction is linked to inability to ignore irrelevant dimensions and suggest that those stimuli which have little usefulness in guiding the subject's performance on a task should be discarded.

Vergason (1968) provides a comprehensive review of research in learning and attention that is aimed at identifying some practices that teachers might employ to improve attention and ability of retarded children to retain information. Following the Zeaman and House (1963) theoretical lines, Vergason advocates the use of teaching aids that enhance attention to the learning task; audio visual equipment, some teaching machines, and television are examples. The distinctiveness of stimulus cues is also likely to influence the rate and amount of learning. Attention to a relevant dimension should be very strongly affected when the distinctiveness of relevant dimensions is enhanced; not only in original learning but transfer as well. A detailed study by Switzky (1973) confirms that when the physical differences between the cues were large, problems were learned quickly. Conversely when the physical differences between the cues was small, problems were learned at a much slower rate. There is also evidence from the work of Gold (1972) to support the importance of teaching relevant task dimensions to multiple handicapped persons. Working with a group of 64 moderately and severely retarded individuals, it was found that subjects who were given colour and position cues on a complex assembly task (15-piece bicycle brake) learned the procedure at a significantly faster rate than groups who worked on the parts as they came from the factory. The results suggest that difficult tasks which utilize more than a single relevant dimension are within the capabilities of retarded persons. For example, complex tasks such as electronic circuit board assemblies could be taught using colour coded parts and by putting the parts in a particular place on the board. Gold found highly significant retention effects one year after training and attributes this to the use of rigid criteria during original learning.

There are a number of studies which indicate that certain mediation processes facilitate learning amongst retarded people. Early work by Hermelin and O'Connor (1958) found that trainable mentally retarded persons were more able to learn a set of paired associate drawings when given a verbal label, compared to a control group given the same amount of training using rote memory only. More recent work by Brown and Hughson (1972) also suggests that the manner in which verbal instructions are given is highly relevant to the learning of tasks. Decibel level of information, the speed at which instruction is given, together with the amount of relevant elements of language are factors that can influence learning. Experimentation revealed that a speed of about 95 words per minute is the maximum severely retarded persons can retain in learning new tasks. Doubling of the speed of verbal information was shown to result in a ten-fold decrease in performance. Moreover, the amount of relevant information is a significant factor; that is, when plain and simple instructions are presented, more effective learning occurs. This is contrary to the tendency of many teachers who increase decibel level, speed up language, and elaborate on verbal information with subjects not able to understand instructions (Brown, 1975). These findings are also consistent with the work of McLeod (1972) who recorded social workers' interviews with trainees. The results demonstrated that retarded adults experience considerable difficulty in retaining interview information as measured by recall thirty minutes later. It was found that subjects remember more of their own statements than those of the counsellor. An analysis of interview content confirmed that shorter (i.e. less than twelve minutes), simpler interviews (less verbal elaboration) resulted in greater levels of retention. Practical recommendations arising from the study were that repetition of information along with trainees verbalising the content appear to increase the effectiveness of interviews.

Language appears to be a key feature of mediation with retarded persons. Clarke and Cookson (1962) suggest that overt verbal commentaries by trainees on the work they are doing may aid performance. Support for this assumption is also obtained from studies by Luria (1961) who found that language can facilitate appropriate motor activity in younger children. Similarly, Wolff (1967) found that concept attainment was facilitated through overt verbalisation. His contention is that overt verbalisation increases the salience and discriminability of verbal cues necessary for concept attainment.

The practical suggestion of the above research is that teachers can assist mediation of learning by helping retarded individuals to see similarities and differences of new material in relation to what they already know. Instruction should be tied to familiar elements that serve as a basis for learning relevant dimensions of new tasks. Yet despite these research findings, relatively little attention is given in practice to procedures that are likely to mediate task acquisition and retention amongst mentally retarded persons. Most cognitive studies have failed to attend to factors that might influence mediation of learning and provide little or no detailed account of the manner in which information was presented to the learner. As mentioned earlier, there are large differences in the amount and type of pretraining used in experimental work. It seems reasonable to suggest that a major emphasis during the pretraining phase should be to assist the learner with developing mediation strategies that will help ensure attention to relevant operations required in the performance of a new task.

It is commonly believed that mentally retarded persons learn at a slower rate and retain less information than intellectually normal people (e.g. Underwood, 1954). More recent research, however, suggests that retarded and normal subjects may learn certain materials at the same rate (Vergason, 1968; Zeaman, 1973). This is especially the case with meaningful material though differences in performance are apparent as the level of abstractness and complexity increases (Heber, Prehm, Nandi and Sampson, 1962). There is a growing body of evidence to believe that assumed deficits in short and long term memory are less evident where overlearning is practiced. Thus repetition of the task after attainment of a minimum criterion is likely to lead to better retention over time (Brown, 1975; Parmenter, Hauritz, Riches, Ward, Yates and James, 1979). This is essential because when a handicapped person is transferred to a new environment, overlearning helps to minimize effects of stress and fatigue that might otherwise result in decrements of performance. At a more intuitive level, one is left to ponder why retarded individuals are able to recall a name or certain types of information over a period of years. Practitioners are aware, for example, that persons need little formal instruction to learn certain slang expressions and their correct connotations. From a slightly different perspective, there is evidence to indicate that once a retarded person has learned something, this bit of knowledge becomes very permanent indeed. Research on perseveration, position habits and resistance to extinction uphold the fact that it is extremely difficult to modify behaviour and learning of mentally retarded people (Brown, 1975; Lipman and Spitz, 1961; Stevenson and Knight, 1961). In Skinnerian (1961) terms, the basic tenet of programming is to minimise errors in learning. But errors can occur even with simple motor skills like handling tools, using a telephone, or holding a pencil. This means that these behaviours need to be unlearned and because modification is very slow with handicapped persons, it is important that these errors do not occur in the first place.

Vergason (1964) provides some very convincing evidence regarding the role of overlearning in acquisition and retention. Using an automatic advance slide projector he individually trained 64 normal and 64 mentally retarded male adolescents on a paired associate (picture/word) learning task composed of thirteen items. In order to determine the extent to which retention was a function of the amount of original learning, half of the subjects were trained to a minimum criterion while the remainder received additional overlearning trials. Analyses of the original trials revealed that intellectually normal subjects were superior to the retarded group on performance of a minimum task at one and twenty days after training. However, no differences on retention of an overlearned task were found after thirty days. The implication is clearly that retarded persons can benefit from programmes that emphasise overlearning in acquisition. Also using an auto-instructional procedure, Parmenter et al., (1979) studied the effects of incidental learning in comparison to a more structured paired associate task. Mildly mentally retarded adolescents, were first given training on a conventional paired associate task (tool names) presented by means of an automatic slide projector. Under this condition each subject worked individually and was instructed to attempt to read the work presented prior to the exposure of each picture. Following this, subjects completed a second training sequence on an equivalent word list as above, but in pairs. One of the pair operated the projector and attempted to name each tool prior to receiving recorded correct or incorrect responses by placing a tick or cross opposite words that were numbered in the same order as the slides appeared. The results revealed that after ten training sessions, post-test scores had significantly improved from the respective pre-test scores for each treatment. But there was no significant difference between treatments in terms of acquisition or retention of words. Retention tests at intervals of one, four, twelve and twenty-four weeks after training indicated a high level of retention over the six month follow-up period. In general, it would seem that both incidental and formal instruction were used successfully for teaching word recognition. The fact that both conditions resulted in significant retention of information over time is encouraging. But as the authors note, the incidental condition may in fact be another form of paired associate learning as the peer checking responses was first exposed to a photographic slide followed by a peer attempting to say the name of each tool.

In summary, there is a convincing amount of evidence that mentally retarded people can retain information over a period of time. However, some caution should be exercised in applying this general description to more severely handicapped persons as most of the supportive research has been derived from samples of mildly retarded subjects. Overlearning appears to be a key feature in retention and is acknowledged as one of the more important learning principles in the habilitation field. For practical reasons such as time and resource limitations, there is a paucity of information on retention of word recognition amongst more severely retarded groups.

Transfer of Learning

Whatever the nature of a learning task, generalisation of training to other similar, though not identical, situations is an essential criterion for determining the efficacy of particular teaching methods. Yet despite the obvious importance of transfer of training for gauging the success of educational and rehabilitative efforts, there have been only limited attempts to investigate the extent to which mentally retarded people can generalise new learning (Kaufman and Prehm, 1966). Moreover, relatively few studies have attempted to isolate conditions under which transfer of training is likely to occur. Considerable procedural variations in training, population sampling, use of incentives, and etiological classification make it difficult to define any general trends from the body of available evidence. Thus, an attempt will be made in this section to bring together some of the more pertinent findings that have arisen from previous research which might have practical importance for future work on the transfer phenomenom.

There is no unitary body of knowledge concerning transfer of learning with mentally retarded persons and so an attempt must be made to identify relevant information from a variety of sources including social psychological research, educational psychology, and rehabilitation studies. Information on problems with the transfer of social learning is available from Rosen, Floor and Zisfein (1974). These researchers have extensively investigated the tendency of mentally retarded persons to be overly compliant and vulnerable to exploitation by other people. The underlying assumption is that acquiescence is a conditioned and pervasive personality dimension associated with sheltered life styles either within a protective home or institutional environment. The results of this social psychological research showed that handicapped residential students had a greater tendency toward acquiescence and behavioural compliance than a group of normal subjects matched for mental age. Group differences on potentially aversive or harmful items that involved requests for a subject to take a pill (candy placebo) or submit to an electrical shocking device (innocuous electrical buzzer) were used to highlight the vulnerability of retarded people.

Zisfein and Rosen (1974) carried out a followup study to evaluate the effectiveness of a personal adjustment training programme designed to decondition acquiescent behaviour. This investigation revealed that mentally retarded persons had extreme difficulties transferring their learning from formal group sessions to less structured problem situations posed in day-to-day life. For example, even though subjects appeared to understand the dangers of indiscriminately signing a legal form in the group training sessions, they unhesitatingly signed a petition without explanation when asked to do so by a confederate. In a study that explored situational determinants of acquiescence, Rosen, Floor, and Zisfein (1975) found that alteration of the physical setting, sex and apparent identity of the person making the request, amount of social coercion and perceived fear, were important variables that influenced acquiescent behaviour.

Paralleling this research, Ryba (1976) demonstrated that mentally retarded persons were unable to transfer coping strategies learned through behavioural rehearsal and role playing, to handle similar problems in more common real life events. The practical importance of these findings is that training should be sufficiently varied to ensure that subjects can respond appropriately to very similar though not identical stimulus dimensions. Training needs to stress both attention to and reasonable variation of relevant task characteristics.

Research on teaching severely mentally retarded persons to perform complex vocational tasks such as assembling bicycle brakes and electronic circuit boards has been undertaken by Gold (1972, 1973, 1974). Results of this work showed that subjects have little difficulty in transferring their learning from one psychomotor task to another, even when additional stimulus dimensions (e.g. colour coding) that were provided during original training are removed from the transfer task.

On the basis of these results, Gold contended that the use of colour, as a cue redundancy with form, does not inhibit transfer to a form-only task so long as overlearning is provided on the original training sequence. Thus, an additional cue such as colour could be employed for training purposes and then made redundant once a criterion has been reached. However, this is somewhat contrary to the theoretical proposition of Zeaman and House (1973) who predict that where the dimension which was relevant in original learning is made irrelevant, and the previously irrelevant dimension is made relevant (extradimensional shift - ED), a negative transfer effect will occur. Whereas, intradimensional shifts (ID) will arrange for positive transfer of the attention response since the same stimulus dimension is relevant in both original learning and transfer.

Further confirmation on the Zeaman and House (1963) and Zeaman (1973) theory is available from a study by Switzky (1973) who investigated cue distinctiveness in learning and transfer of a visual discrimination task. This research supported the view that ID shifts are learned at a significantly faster rate than ED shifts when subjects were trained on relevant dimensions of low distinctiveness in original learning. But when trained on highly distinctive cues (colour, shape), it was found that subjects learned ID and ED shifts at the same rate. The results also suggested that when subjects are trained in original learning on problems where the relevant dimension is of low distinctiveness, they appear to learn a dimensional mediator which assists with transfer to a new task. Conversely, the use of high distinctive cues to highlight relevant dimensions during original learning seems to impede transfer. One explanation for this affect was that given highly distinctive stimuli, subjects learned to solve problems by responding to the obvious cues but failed to learn any dimensional mediators. On the basis of these results, it appears important to diminish progressively the distinctiveness of cues during training to help ensure that the learner is able to learn some dimensional mediators which transfer to shift conditions.

Discussions on transfer frequently make use of the term "concept attainment" for an explanation of how responses to new situations are learned as a result of prior experiences (e.g. Caroll, 1967; Bruner, Goodnow and Austin, 1956). However, there is some disagreement regarding the definition of concepts as an explanatory construct for transfer of learning (Flavell, 1970). In line with the work of Spradlin, Cotter and Baxley (1973), the term "stimulus class" will be used in this study because it contains less surplus meaning and does not imply shared physical characteristics amongst members of the same class. For instance, the printed word, "go", a picture of a green light, and the audio signal for crossing a roadway are all members of the same class since they all control an identical movement response. Related to this, Jenkins and Palermo (1964) and Sidman (1971) suggest that response equivalence paradigms can be used to explain transfer. This is illustrated in the following diagrammatical sequence:

STIMULUS		RESPONSE
* 1. Auditory word	(controls)	2. Pointing to a picture
T 1. Auditory word	(controls)	3. Pointing to a printed word
	THEN	
2. Picture	(might tend to control)	3. Pointing to a printed word
3. Printed word	(might tend to control)	2. Pointing to a picture

In the above example, the subject has already learned to point to pictures in response to spoken words (*). Training was then given in pointing to printed words in response to spoken words (T), followed by practice in matching printed words to pictures without direct training. Sidman also found that when the same subject was trained to point to pictures and referent words, he could also name the printed word. This study suggests that equivalent choice stimuli control one another; and when one stimulus is conditioned to control a new response then the other stimulus will also control that response. In this sense, each stimulus shares membership in a common class.

Following up Sidman's work on stimulus sets, Spradlin, Cotter and Baxley (1973) carried out a series of experiments to determine if establishing a common choice response was sufficient to obtain transfer when one of the conditioned choices was used to control a new response; with and without direct training. An auto-instructional device containing a stimulus panel and two response panels was employed to teach paired associates of geometric forms. Stimuli were displayed by means of a rear image slide projector and subjects responded by pressing one of the lower panels which would activate a microswitch that advanced the slide projector. Feedback consisted of a door chime for correct responses and a buzzer for incorrect answers.

Results of this investigation showed that when a common response (R1) is conditioned to two stimuli (S1) and (S2), and a second response

(R2) is then conditioned to the first stimulus (S1), the remaining stimulus (S2) will also control the second untrained response (R2). On the basis of this evidence it would seem that stimuli which have not received direct training but are in the same stimulus class can control a new response. The practical implication of this work is that mentally retarded persons can be taught to make a common response to a variety of objects when given a relevant stimulus from a known class. This again supports the point that transfer is likely to be enhanced when practice is given in learning to identify dimensional mediators within a common class of stimuli.

The preceding research is by no means an exhaustive review of transfer studies but does serve to highlight some of the issues and methodological problems that deserve further study. There is little known, for example, about the extent to which personal preference for certain stimulus dimensions affects transfer. It seems likely that dimensional preferences have been confounded with mediational transfer in many of the studies to date. An important question that remains to be answered is whether or not subjects learn discriminations involving nonpreferred dimensions as readily as those containing preferred dimensions. Another theoretical aspect that seems worthy of investigation is the extent to which transfer in ED or ID shifts depends upon whether shift dimension is a preferred or a nonpreferred dimension. It seems possible that persons transferring toward preferred dimensions will learn shifts at a more rapid rate than when transferring toward nonpreferred dimensions (Shepp and Turrisi, 1966).

Summary

In summary, there are a number of principles emerging from studies on transfer that appear to have practical importance for future experimentation. These can be stated as general process factors:

a. Subjects do learn to respond to a discrimination cue which is common to a stimulus class and appear to transfer these dimensional responses to subsequent discrimination problems.
b. Transfer of learning on tasks involving ID shifts appears to be enhanced when opportunities for overlearning are provided. Thus, with a minimal criterion or just a few overlearning trials, it seems likely that the relevant mediating response will be weak. Conversely, the strength of relevant mediators increases in proportion to the number of overlearning trials. This is consistent

with the theoretical proposition of Zeaman and House (1963) stated earlier.

c. Cue distinctiveness during original learning appears to affect transfer. There is evidence to suggest that when highly distinctive cues are provided, subjects may learn to solve problems by responding to obvious cues while failing to learn any dimensional mediators.

The literature reviewed in this chapter is considered to be representative of the diverse research that has been conducted in the cognitive domain with mentally retarded persons. It is apparent that much work remains to be done in an attempt to identify process variables that account for the extent to which learning is acquired, retained and transferred to new situations. Yet there is a common set of principles emerging from these studies that bear directly upon this current research. The importance of overlearning, distinctiveness of stimulus cues, and development of a learning "set" are just a few examples of the research findings cited here that offer direction for future investigations.

The purpose of this study is to compare certain specific approaches for teaching word recognition to mentally retarded persons. On the surface at least it might appear that the behavioural nature of this work does not lend itself to an examination of underlying cognitive processes. While the major aim of this work is to conduct field trials on actual teaching programmes, an attempt will be made to align the experimental findings with some preceding research on information processing. This may serve to explain the results in more substantial theoretical terms by providing a conceptual framework for translating theory into practice. Unfortunately, there has been a tendency amongst research workers to overlook the theoretical foundations of learning when conducting applied research on education and training of mentally retarded persons (eg. Holz, 1976; Vandever, Maggart and Nassar, 1976). The result of this has been the emergence of isolated bits of information that uphold certain teaching procedures as being more effective than others with no clear indication as to which factors contained in the programmes appear to facilitate the learning process. This approach has for the most part failed to provide a set of learning principles which have direct practical application in developing habilitation programmes for use with handicapped individuals.

CHAPTER III

REVIEW OF RESEARCH ON TEACHING WORD RECOGNITION

Introduction

Attention in this chapter will be given to some of the contrasting approaches that have been employed for teaching mentally retarded persons to recognize social sight words. An attempt will be made to discuss practical applications of the different theories which are most commonly used to explain the conditions under which learning is most likely to occur. Some important issues concerning the mode of presentation and use of extra stimuli for guiding subjects' responses will also be discussed.

Definition of a Social Sight Vocabulary

In contrast with the traditional view that moderately retarded adults require a protected environment, it is now generally accepted that a far larger number of persons with intellectual limitations can function independently in the open community than has been assumed in the past. But preparation for more independent living requires that a host of life skills be taught through continuing education. Practical education programmes should primarily be directed toward the person achieving a measure of self sufficiency and occupational competence. Consideration of the role of education in social habilitation of mentally retarded persons indicates that objectives need to be formulated not as subjects, e.g. reading, writing and arithmetic, but rather as areas of competence such as getting on with other people, basic arithmetic for money handling, awareness of time, and the ability to recognize functionally important words (Gunzburg, 1974). All of these skills can be considered as falling within the scope of social education since mastery of the above content areas largely determines the extent to which a handicapped person can be integrated into society as a working and contributing member (Crawley and Pappanikou, 1967).

For the purposes of this research the terms "social sight reading" and "word recognition" shall be used interchangeably to mean training in the recognition and understanding of certain written symbols. This can be defined in terms of messages that are commonly used by the community to give information and warnings in as short and cogent a form as possible (Gunzburg, 1973). Such words or word combinations as 'Bus Stop', 'Railway', 'Push', or 'Pull' are of practical significance and if a person can learn to recognise and react appropriately to these symbols, then a major purpose of literacy has been achieved. Common grocery and tool items should also be included in the social sight vocabulary as knowledge of these familiar items is reinforced through experiences in real life. This may in turn provide the person with a greater sense of awareness and control over the community environment in which he lives and works.

Recognition of words is most often taught to groups or individuals by using a blackboard, flash cards, or special reading books. For example, Gunzburg (1973) has developed sets of flashcards and corresponding books ('CLUMSY CHARLIE' and 'OUT WITH TOM') for the purpose of teaching a social sight vocabulary to adolescents and adults. It is notable also that Gunzburg described some practical approaches for teaching word recognition by means of commercially available teaching machines. He stresses, however, that these machines should probably be used in conjunction with other teaching aids and as a means to reinforce traditional methods.

The rationale for teaching a social sight vocabulary is based upon the observation that an individual has mastered necessary prereading skills (e.g. attention, matching to sample) to benefit from such instruction but is unlikely to manage reading in the traditional grammatical sense. This is a functional definition that highlights the role of sight reading as a social 'survival' skill for persons who have, over long periods of time, continued to underfunction in the learning of formal academic concepts.

Effects of Extra Stimulus Dimensions for Teaching Word Recognition

Teachers commonly make use of extra stimulus material such as pictures, real objects and sound effects to introduce the meaning of new words or simply as a means of getting students to pay attention to a learning task. This additional stimulus is often referred to as a "prompt" on the basis that it consists of familiar material that the learner can employ to help him solve problems that might otherwise be too complex. Prompting can generally be defined as a pairing of a "cue", a stimulus that will control a response on the completion of training, with a prompt, a stimulus that currently controls a desired response. The use of prompting in self instructional programmes is usually based on the assumption that a shift of control will occur from the prompt to a new cue with which the prompt is compared. Zeaman and House (1963) deal with the conditions under which attention is likely to be shifted from one stimulus to another and point out the problems mentally retarded persons seem to experience in sorting out relevant from irrelevant dimensions. Although there is a large amount of research evidence to support the use of prompted training sequences, much remains to be learned about conditions under which extra stimulus dimensions can be used to advantage (Anderson, 1967).

There is much conflicting evidence concerning the use of extra stimulus dimensions for teaching mentally retarded people to recognize words. Several studies discussed later in this chapter (e.g. Vergason, 1968; Parmenter et al., 1979) uphold the utility of picture-word associates whereas other research (Walsh and Lamberts, 1979) has questioned the view that attention to an extra dimension (e.g. pictures) will strengthen responses (e.g. saying the word) to a cue within that dimension. Little is known about the manner in which printed words serve as a within dimension cue. It may be, for example that the word's relation to a referent picture, if indeed it is noticed, is perceived by the subject as coincidental to the learning of printed symbols. In fact the picture could be the only aspect of the paired stimuli that students are able to process.

Samuels (1970) has argued that from the principle of least effort, subjects may attend to a familiar stimulus while failing to attend to another dimension which is less readily identifiable. He questions the view that a shift in stimulus control will occur across dimensions from picture to word. Evidence for this proposition is obtained from earlier research (Samuels, 1967) which compared word-picture presentations with word-only approaches for teaching kindergarten children to read words. The results indicated that significantly more correct responses on the learning trials were made by subjects given word-picture associations than by children receiving word-only presentations. However, on the test trials it was found that when pictures were not used as prompts, the no-picture group gave significantly more correct responses.

Further evidence on the role of prompting procedures is available from the work of Duell (1968) who compared prompting sequences that forced a student to notice word cues versus prompted sequences that did not. All subjects were first presented with a card containing a picture and referent word. Children in the forced prompting condition were then given a second card displaying the target item and a distractor word with no pictures. Conversely, subjects in the unenforced condition were shown a card containing two words and corresponding pictures. Children were free to point to either the picture or the printed word, the assumption being that the location of the child's point would correspond to the focus of his attention. The results confirmed that children learned significantly more words when given a prompted training sequence that forces them to notice a cue than when a sequence does not require use of the cue as a condition for giving a correct response. The practical implication of this is that the desired shift in stimulus control is more likely to occur when children are forced to notice the cue while responding.

Other studies have reported problems associated with the use of pictures to teach word reading. McNeil and Keislar (1962) found that a child's preference for one picture over other alternatives could lead to selection of the preferred item even if it were the wrong response. As Hall (1961) has pointed out, a major limitation of pictures as prompts is that only a limited number of concrete nouns, adjectives, and verbs can be presented as pictures. Another shortcoming of pictures as cues is that they may not reliably elicit the same response; for example when shown a picture of a railway, one subject may say "railway", another "train", and a third person "railroad".

On the basis of available evidence there remains some doubt about the value of using extra stimuli for guiding responses in the acquisition of a social sight vocabulary. But there are no clear cut guidelines on the use of these materials and very favourable outcomes have been achieved with and without the use of additional cues. In the next section, a number of studies are presented to illustrate the many diverse approaches that have been used for teaching word recognition to mentally retarded subjects.

Research Findings

A considerable amount of research has been carried out to examine learning and memory characteristics of mentally retarded persons. Many studies have involved experiments with paired associate learning. These studies call into question the stereotyped view that this group is slower to learn and has poorer memory than nonretarded persons. There was, for example, a large number of successive studies conducted during the late 1950's and early 1960's which showed little or no difference in the rate of learning paired-associates by retarded and nonretarded individuals when matched for either chronological or mental age.

The work of Vergason (1964) indicated that retarded and nonretarded subjects learned a paired-associated task at the same rate. To examine whether retention was a function of the degree of original learning, Vergason trained one group of subjects to a minimum acquisition criterion while another group was given additional overlearning trials. A comparison of the groups revealed that nonretarded persons were superior to the retarded on retention of the minimum task after one and thirty days. But when retarded subjects were given the additional overlearning trials, it was found that their performance equalled that of the nonretarded group. The practical implication arising from this work is that retarded persons are likely to benefit from programmes in which emphasis is placed on overlearning following acquisition of a task.

In a follow-up study, Vergason (1966) investigated retention of a social sight vocabulary in retarded individuals using both traditional and auto-instructional methods. Sixteen children attending special classes were equally divided into two groups and taught by either traditional or paired-associated methods using an automatic slide projector with pairings of words and pictures. Training for both treatments was counterbalanced to control for order effects. The results showed that retarded children retained a high percentage of sight words which had been overlearned through training by an automated procedure. The same group of subjects were less able to retain words learned through traditional methods in a group instruction situation. It was found that at conclusion of the training phase there were no differences between the two methods of teaching. But from one month through to fourteen months, words learned by means of the auto-instructional device were retained significantly better than those learned through a traditional programme. Vergason suggested that one factor in favour of automated instruction is the consistent manner in which the paired-associates are presented. Overlearning of a task was considered to be crucial for improving retention effects. Other support for the teaching of social sight words by automated instruction is found in the work of Holz (1976) and Malpass (1968).

More recent work by Parmenter et al. (1978) lends support to the use of a sound on slide projector for teaching paired-associate words to mildly mentally retarded adults. Trainees who had difficulty recognising tool names were shown slides of the various tools and asked to attempt naming them. After a brief interval, pre-recorded confirmation was given by an audio cassette, and a peer who accompanied the trainee recorded whether the person undergoing instruction was correct or not. The names of the tools were printed on a checklist and numbered consecutively from one to twenty. After each trainee completed his trials he reversed roles with his peer. At no time were trainees encouraged to read the names of tools and it was assumed that owing to difficulty of the words, the trainee completing the checklist would simply follow the numerical order of the slides. The rather unexpected finding was that trainees had incidentally learned to read the tool names during the process of checking peer responses. This was, in effect, a paired-associated learning task in which names appearing on the list were matched with the visual slides and audio messages.

In a subsequent study, Parmenter et al. (1979) compared the incidental learning method described above to a more structured audio-visual reading programme. Eight mildly retarded adults were first shown a set of eleven paired-associate items. Each item consisted of two elements; a tool name was displayed on a photographic slide followed after a brief interval by a picture of the tool. Subjects were instructed to attempt reading each tool name. In a second word list, subjects worked in pairs and reversed roles to check each others'performance. Pictures of each tool were displayed along with audio confirmation of the tool name. It was not expected that subjects would read the names under this latter condition. A comparison of the two methods indicated that both approaches were equally effective for teaching the sight words. Furthermore, all of the trainees effectively retained the skill up to twenty-four weeks after training.

These studies by Parmenter et al. (1979) raise important questions concerning conditions under which the mentally retarded are able to learn a paired-associate task. One possibility is that the experimental procedures were effective for increasing the organisational skills of retarded persons. Support for this contention is found in the work of Bilsky and Evans (1970) who report a number of studies to illustrate that a characteristic feature of mentally retarded persons is their deficit in ability to organise input materials. The practical implication is that trainees may be able to develop their own learning strategies through more efficient input organisation by means of automated audio-visual instruction. Moreover, because the major objective is for the individual to transfer his learning to real life situations, it stands to reason that the person must ultimately gain responsibility for his own learning. It also remains to be determined whether automated instructional techniques are superior to individual prescriptive teaching with regard to acquisition and retention of basic reading skills.

In contrast to the paired-associate methods, other researchers have based their approaches on the attention theory of Zeaman and House (1963). In this approach pictures are used to ensure gaining the learner's attention, which is considered to be a most crucial step for retarded persons. This theoretical position stresses that a characteristic deficit of the mentally retarded is an inability to sort out relevant from irrelevant stimulus dimensions in a learning task. Training is conducted by gradually fading the pictorial stimulus in each subsequent trial while the word remains fully visible throughout the learning sequence. The word is thought to be more readily learned because of a strong attention response mediated by the picture stimulus. Dorry and Zeaman (1973) have offered three plausible reasons for the effectiveness of fading procedures. The first reason can be seen in terms of stimulus generalisation. In a practical sense, this principle predicts that the closer the stimulus conditions are to those of testing, the less will be the generalisation decrement in performance. The fading sequence forms a successive approximation to the testing condition of word alone. In contrast to this, the standard method of pairing word and picture presentations yields a much larger stimulus shift when the subject enters the test condition of word alone. A second explanation assumes that a mixture of noncontingent (classical) and contingent(instrumental) conditioning is superior to either alone. The fading trial starts out noncontingently on the first trial, but as the picture fades on ensuing trials, the paradigm becomes contingent or instrumental in nature. The third reason offered in preference of fading can be seen in terms of attention theory. There is no guarantee in the standard paired-associate method that the subject will attend to the written word; all that is required for a correct response in training is to observe the picture. Conversely, the fading procedure encourages a gradual shift of attention from the fading picture to the relatively salient (nonfaded), printed word.

Research by Dorry and Zeaman (1975) has illustrated the value of fading procedures in comparison to other approaches for teaching social sight reading. Thirty-six nonreading retarded children were pretested to determine whether they were able to recall or recognise any of the words to be trained. Each of the children was then given a standard recognition pre-training to ensure that they were familiar with the verbal names of items to be taught. Children were assigned to one of four groups using mixed, control, faded and standard procedures. The faded group was trained by presenting words and pictures together on the first trial; then on each of five subsequent trials the picture was gradually faded out. The standard group followed the same training sequence but with no picture fading. The mixed group received alternating trials of word-and-picture (unfaded) and word alone. The control group were exposed to alternating trials of word-alone followed by picture-alone. As was originally hypothesised the fade condition yielded the best results and the control condition the poorest. Subjects in the mixed condition did better than those exposed to the standard paired-associate method but not so well as those in the fade condition. The standard condition was shown to be slightly superior to control subjects but less effective than either the mixed or fade methods. Instruction for all groups was carried out on an individual basis by training staff and no automatic teaching procedures were employed.

In direct contrast to the work of Zeaman and Dorry (1973, 1975) it was found by Walsh and Lamberts (1979) that adolescent mentally retarded persons learned a greater number of social sight words using an errorless discrimination method than they did with a cue fading technique. Under the errorless discrimination procedure students were first taught a target word that appeared alone and then had to match-to-sample for a list of discrimination items that increased in complexity over subsequent trials. The ineffectiveness of cue fading procedures was tentatively interpreted as a failure of shifting of control from picture to printed word. Whereas Dorry and Zeaman (1975) argued that a chain of two responses is necessary for sight word learning by retarded students (attending and transference of attention to the word), it is conjectured that the second step may not automatically follow from the first. This view is supported by Samuels (1970) who proposes that when children are confronted with a stimulus that they can readily identify and another which they cannot, they are likely to attend to the former. Walsh and Lamberts also suggest that the fading procedure alone might have high stimulus value for the child. That is, the child attends to a novel illustration of an object disappearing and fails to focus on the printed word.

Support for the errorless discrimination procedure is also found in the work of Vandever, Maggart and Nassar (1976) who evaluated three approaches to beginning reading instruction with mentally retarded children. These researchers conclude that errorless discrimination programmes such as Edmark (1972) are superior with children for whom the prognosis for future success in reading is most guarded. However there are some problems with this method as it tends to foster rapid initial learning at the expense of transfer. Samuels and Jeffrey (1966) found that children make use of cues such as beginning and ending letters which work when words are highly discriminable but do not work when stimulus items are very similar. It was found that when children were tested on words having the same first or last letter as the taught words, they mistook them for words from the original list. Despite this shortcoming, it appears that the errorless discrimination approach is likely to be effective with this population.

Summary

It is clear from preceding research that there is a great deal of conflicting evidence concerning the manner in which basic sight reading skills can most effectively be taught to mentally retarded persons. Differences in experimental methodology, chronological age of subjects and individual versus group instruction make it exceedingly difficult to extract any common factors that might account for variations in learning. Importantly, no attempt has been made to compare both standard paired associate and errorless discrimination procedures in terms of automated instruction and traditional teacher-dominated training. There is a need to further explore and identify conditions that are likely to facilitate the development of reading skills with mentally retarded adults. The lack of a firm theoretical base has given rise to adhoc teaching methods without consideration for learning principles that could exert an important influence upon the acquisition of a functional reading vocabulary.

With this conflicting evidence in mind, this present research seeks to compare two frequently used methods for teaching word recognition. The first of these procedures involves the pairing of pictures and words in which the subject must select each target word from a list of printed items (paired associates). A second method is a straight word approach that requires subjects to select target words from a series of increasingly complex discriminations with no picture cues provided (errorless discrimination). While this study makes use of automated procedures under computer control, it was deemed essential to compare also the two methodologies using more conventional individual tuition presented on a one-to-one basis. It was felt that this would provide a meaningful framework in which to compare the teaching methods while concurrently exploring practical applications of computer technology using parallel procedures in providing individualised instruction. This avoids some of the shortcomings of previous research that have arisen from a fascination with technological innovations and resulting disregard for the substantial theoretical and practical base that has been developed on teaching word recognition to mentally retarded adults.

CHAPTER IV
REVIEW OF RESEARCH ON PROGRAMMED INSTRUCTION AND AUTOMATED TEACHING IN SPECIAL EDUCATION

Introduction

This chapter provides a detailed discussion on programmed instruction (PI) and automated teaching devices recognising from the view that these methodologies were developed to teach one person at a time using a predetermined sequence of learning materials. Neither programmed instruction nor automated teaching methods are seen as a subset of the other since both of these stress the systematic application of learning principles in a medium which is intended to allow the learner to progress at his own rate of study. It was deemed essential to provide a historical perspective that highlights the evaluation of automated instructional devices from electromechanical teaching machines through to the present day microcomputer. Very recent advances in microprocessing technology are likely to have a significant effect on the application of automated instruction in special education. For this reason, it is important to understand advances in educational technology as these pertain to the teaching of handicapped persons. While it is beyond the scope of this study to provide a comprehensive historical and technical account, an attempt has been made to review studies that illustrate the developmental sequence of machine- and computer-based instruction. Attention is also given to the problems and issues associated with this educational technology.

A Process Definition of Programmed Instruction

Programmed Instruction (PI) is primarily associated with the work of Skinner and his colleagues in the mid 1950's (Skinner, 1953; 1968). Development of these PI procedures was from earlier work on operant conditioning and the extent to which behavioural principles could be employed in educational environments. The Skinnerian approach made use of linear programming in which material was arranged in a unitary ordered sequence such that the student must proceed from the first frame of information through to the last programme unit. Skinner stressed that the technical problem of providing the necessary instrument aid could easily be managed through the use of inexpensive teaching devices which arrange necessary contingencies of learning. He noted that the advantages of these devices include immediate reinforcement for correct responses, active participation in learning through manipulation of the machine, and self pacing instruction in which each child progresses at his own rate. Material can be carefully designed so that one problem is presented at a time with additional steps inserted where students tend to encounter difficulty.

During the early 1960's, definitions of programmed instruction were primarily tied to recognisable aspects of format (small frame, response requirements, branching capability, etc.). But as Susan Markle (1967) pointed out, such definitions unnecessarily restrict the range of materials that can be called "programmes". She proposed that instead of focusing upon the characteristics of the production, definitions of PI should be centred on the characteristics of the process of development. Markle suggested that an instructional programme be defined in empirical terms as a "reproducible sequence of instructional events designed to produce a measurable and consistent effect on the behaviour of each and every acceptable student". In this definition, emphasis is obviously placed upon validated instruction and the extent to which PI is a reliable procedure for bringing about changes in learning and behaviour.

Bunderson and Faust (1976) have noted that validated instruction is a necessary but not sufficient definition of PI. It may be the case, for example, that a programme teaches irrelevant objectives extremely well, which meets Markle's definition of external validation while failing to accomplish educationally worthwhile goals. On the basis of this argument, it can be seen that PI needs to be defined with regard to meaningfulness of objectives, technical accuracy of instructional content, and empirical validation of the extent to which stated objectives of the programme can be met.

A wide range of instructional packages are now available in several media including sound/slide productions, television programmes, and programmed textbooks. This scope of products has led to some confusion over a definition of programmed instruction and a general loosening of what is meant by the term PI. For the purpose of this study, the view is taken that programmed instruction should include some attempt at empirical validation such that student's performance is compared with the stated aims of the programme. Additionally, PI methods should demonstrate some form of problem analysis that focuses on real life performance using effective and efficient instructional techniques.

Programmed Instruction Research

The initial thrust of the programmed instruction movement began in the early 1960's and the movement continues its rapid momentum to this day. PI with its emphasis upon the individual learner showed much promise for improving educational programmes for more severely handicapped persons. The principles of programmed instruction (small steps, active participation, immediate confirmation, self pacing instruction) caused educators to examine their objectives and methods in great detail. This in turn, encouraged widespread evaluation of the progress of individuals in learning and the manner in which teaching materials were presented. PI was upheld as a cost effective method that could increase performance capabilities of handicapped persons in a more efficient manner than conventional forms of instruction. The PI era has been characterised by the development of literally thousands of programmes for normal children with small steps being the order of the day. Such material is so familiar now that it seems unnecessary to take space here to describe the various formats.

By examining current educational practice in schools for the mentally retarded, one can easily see that PI did not have the desired effect, especially with regard to more severely handicapped persons. The shelves began to fill with unused programmes which bear mute testimony to the fallacy of small steps and overt responding for ensuring effective instruction. In general, the claims of programmers far outreached their skill level with the delusion that the PI formats could be easily produced. In the race to produce novel materials, little attention was given to evaluation studies during the 1960's.

It became clear during the late 1960's and early 1970's that effective programmed instruction required systematic and empirical validation during the development process. The production of programmed materials, especially PI textbooks, slowed down markedly with the realisation that these approaches required a great deal more preparation on the part of authors and practitioners than was originally envisaged (Bunderson and Faust, 1976). No doubt Skinner also under-estimated the requirements for operationalising PI methods. He seldom dealt with the logistics of acceptance and evaluation of PI or the apparent assumption that the efficiency of programmed approaches for enhancing performance of the learner would demonstrate the efficacy of these methods.

Several comprehensive reviews on the application of programmed instruction in the special education field are available in the literature (e.g. Stolurow, 1963; Haskell, 1966; Hegarty, 1975; Greene, 1966; Malpass, 1968). The conclusion arising from these reviews is that PI appears to be an effective method for teaching mentally retarded persons. But as Blackman and Capabianco (1965) have pointed out, there is an absence of evidence to prove that PI is more effective than traditional teaching methods. In fact Eigen (1965), Lumsdaine and May (1964), and Stolurow (1963) have all argued against the use of research designs which attempt to compare programmed instruction with conventional teaching methods. The major reservation these workers have is that the two conditions themselves are too ill-defined to permit comparison. In the same way that there is no "conventional teaching method" there is also no common definition for "programmed instruction methods". Large differences in procedure, content and organisation of material, and amount of training have made it difficult to compare the various PI approaches. For example, in some studies material has been presented completely by automated devices (Beasley, 1974), a typewriter keyboard and a multiple choice apparatus (Malpass, Gilmore, Hardy and Williams, 1963), a manually operated teaching machine (Hewett, 1968), and no machine at all (Davy, 1962). Nevertheless, a large number of studies can be cited as evidence that programmed instruction in its various forms, both automated and manual, is an effective means of instructing mentally retarded persons.

Early work by Stolurow, Peters and Steinberg (1960) demonstrated that programmed instruction for mentally retarded persons was an effective approach for teaching word recognition. Investigating the effects of two procedures involving vocal confirmation of printed words and prompting with pictures of words, the results showed that the prompting sequence was superior. Using a criterion of 12 consecutive correct responses, it was found that subjects receiving confirmation only required approximately seven times as many trials to reach criterion. On recall tests of retention given 1, 7, and 30 days later, performance by the prompting group was still superior to that of subjects receiving oral confirmation (50% and 20% correct recall, respectively). A second investigation by Stolurow and Lippert (1962) confirmed that a prompting sequence in programmed learning of social sight words resulted in significantly greater retention compared with an oral confirmation method. The findings of this study support the view that overlearning or repetition of materials is a necessary condition for recall of information.

Two experiments which evaluated the use of picture programmes and sentence programmes for teaching a social sight vocabulary to retarded subjects are reported by Ellson, Engle, Barber and Kempworth (1962). Both studies made use of a "programming tutor" procedure in which a teacher served as a tutor to reinforce and correct students' oral responses (though the tutor's role was fully determined by the procedure). Programmes were branched in the sense that errors made by subjects served as an occasion for the tutor to interact and take certain steps. In the picture programme, 19 subjects were given five trials on the 82 words being taught. The mean number of words read correctly on trial one was 20.9 and trial five was 32.7, showing an average gain of 11.8 words. A test of retention one month later revealed that an average of 27.7 words were correctly recalled. Twelve subjects including four normal first grade children, four first grade slow readers, and four institutionalised retarded children were given eight sessions on the 165 words of a sentence programme. Gains in learning after completion of training were reported to be 30.5, 20.0 and 19.5 words respectively.

Comparison studies have also been conducted to evaluate PI versus conventional teaching methods. Blackman and Capabianco (1965) for example, carried out an extended PI project using both reading and math materials. The objectives of their work included development of an auto-instructional device, construction of teaching programmes, and comparison of automated versus "traditional" classroom methods. The project covered three years during which 18 months were devoted to development of the apparatus and courseware, six months to construction and piloting of the teaching programmes, and one year for evaluation of the procedures.

The reading programme consisted of 20 units covering more than 500 words. The programme was designed to progress from the matching of single words to a point where the student could answer questions based upon stories that contained the programmed words. However, because subjects progressed at a much slower rate than was originally anticipated, less than half of the teaching modules were completed by the end of the study.

Subjects in the Blackman and Capabianco study were a group of 36 institutionalised mentally retarded persons. Half of the participants were assigned to the teaching machine condition while the remaining 18 were placed in a control group. Both groups received the same amount of instruction on identical materials and progressed at approximately the same pace. Performance for both the experimental and control groups improved to a significant extent over the course of the study as measured by two standard achievement tests and a special test constructed to assess performance on the programmed materials. However, no reliable differences were found between the two groups with regard to acquisition or retention of programme words. Results of a follow-up study showed essentially no retention loss for either group and no differences between groups 3½ months after completion of training.

One final study to be mentioned in this section was the work of Scott (1963) who developed an auto-instructional device for teaching word recognition to 14 adolescent mentally retarded persons attending a New Zealand intermediate school (reported in Survey of Educational Media Research in the Far East). Each subject was shown a series of word pairs on the teaching machine. Each time a pair was shown, one of the words was played over earphones from a tape recorder. Responses were entered by pushing a button over top of the word that had been named. If a choice was incorrect then the word pair was removed. Seven of the subjects were taught by the machine while the other seven received a "conventional method" for learning to discriminate between the same words. At the time of publication of the survey, only preliminary results were available. These indicated that the machine group had gained an average of 20 sight words in comparison with a gain of only four or five words for persons in the control group.

From the above selection of studies it is evident that a great deal of effort went into the development of programmed instruction approaches. It seems reasonable also to suggest that much of the time was spent on actual construction of special purpose equipment or trials of the experimental procedures. The large amount of time and resources expended on the development of PI during the 1960's provides an indication of the hope that was placed upon these learning methods and new educational technology.

In applying the principles of programmed instruction to the education of more severely handicapped persons, it was inevitable that use would be made of machines rather than programmed texts or other conventional materials. Beginning early in the 1960's a wide variety of auto-instructional devices were developed for the most part by a select group of researchers interested in solving theoretical and experimental issues under controlled conditions. It was not until much later on (1968 or so) that an attempt was made to manufacture special purpose teaching machines for more general educational applications. In the following section, an overview of electromechanical teaching devices is presented to highlight some of the more important advances that have ultimately paved the way for more "intelligent" forms of educational technology.

Electromechanical Teaching Machines

The use of mechanical teaching aids in schools and colleges was first advocated by B.F. Skinner (1953) over two decades ago. Skinner argued that traditional educational methods could be made more effective through the application of operant conditioning principles with machine-based instruction. He proposed that the introduction of teaching machines and suitable programmes would result in efficient and economical instruction across all levels of education. Skinner stressed the need for technological innovations to provide an active learning environment for the student. This was based upon the premise that the student was becoming a passive recipient of instruction within the regular classroom.

Earlier work by Sidney L. Pressey (1926) showed that it was feasible to design machine systems for automatic testing of intelligence and information processing. Reliable machines were designed for administration of examinations in multiple choice format. In using this mechanical device, a student pressed the button corresponding to his first choice of answer. A correct response resulted in the device continuing to the next item; conversely each error was tallied and the student must continue to make choices until he is correct. Pressey pointed out that in addition to providing immediate self report, the major advantage of machine instruction could be seen in terms of self pacing instruction. Pressey envisaged a kind of "industrial revolution in education" and forecasted extensive use of programmed teaching machines. By 1932 Pressey was forced to acknowledge that such a revolution had failed to come about.

> "The problems of invention are relatively simple. With a little money and engineering resource, a great deal could easily be done. The writer has found from bitter experience that one person alone can accomplish relatively little and he is regretfully dropping further work on these problems. But he hopes that enough may have been done to stimulate other workers, that this fascinating field may be developed."
>
> Pressey (1932)

It was not until the mid 1950's that Skinner again popularised the notion of machine based teaching systems. The reason for this technological lag seems understandable enough in view of the background of psychological theory of the day which had not yet come to grips with the learning process.

The arguments put forth by Skinner stimulated the development of teaching machines in many areas of education and the last two decades has witnessed an increase in machines, programmes and research in this field. Most studies appear to have focused upon the instruction of reading, arithmetic and writing with the aid of simple and manually operated Skinnerian machines. The results from these investigations are wide and varied, providing little clear cut evidence concerning relative importance of programme and machine variables. However, there is a general indication from the reviews that mildly mentally retarded children are capable of responding to and learning from machine systems.

It is perhaps understandable that teaching machines failed to gain widespread acceptance in education when one considers that most devices were programmed to follow a simple linear progression with little or no branching capability. The mechanical nature of early machines restricted their use almost entirely to repetitive drill work within a single modality of audio or visual instruction. Because of technical limitations very little provision was made for 'built-in' remedial loops which could guide the learner through a graded sequence of difficulty levels matched with individual ability. This rigid approach to instruction was disappointing and encouraged the view that mechanical teaching aids were of relatively little value.

Early studies with mentally retarded persons were frequently based upon parameters of operant responding. Researchers such as House, Zeaman and Fischer (1957) and Bijou and Orlando (1961) studied the sensitivity of subjects to changes in reinforcement schedules. Later studies sought to examine practical applications for elimination of stereotyped behaviour (Gardner, 1971) and long term preferences for various types of reinforcement (Watson, Orser and Sanders, 1968).

Later work by Friedlander, McCarthy and Soforenko (1967) sought to develop free-operant apparatus into a more explicit teaching machine. This involved the use of a flexible apparatus ("Play-test") which was designed to present a wide variety of visual and auditory stumuli to the severely mentally retarded. An important feature of the machine was that it could be operated by the subject in a variety of ways, according to specific needs or handicapping conditions. The apparatus in one study (op. cit.) consisted of two transparent plastic knobs, each of which contained a small red light that blinked continuously. The two knobs were electrically connected to two kinds of auditory feedback; a chime and an ascending scale of organ notes. Pressure against one of the knobs resulted in a single stroke of the chime whereas pressure against the other initiated a series of organ notes. The subject could thus choose his own form of auditory reinforcement.

The significance of the "playtest" device described above was that it formed a conceptual bridge leading from the use of free-operant approaches which explored subject response characteristics to the teaching machines where interest was centred around visual discrimination and performance. This gave rise to a variety of approaches which attempted to teach children to discriminate by shape, colour, size and numerical quantity. Much of the development of these teaching programmes was carried out with young, normal children, but an effort was made by Sidman and Stoddard, (1967) to evaluate the effectiveness of a cue fading technique with severely retarded children. Two groups of children were employed to compare use of a gradually faded sequence with an unsequenced series of instruction. The results favoured teaching a shape discrimination exercise by means of a progressive fading method.

Sidman and Stoddard's teaching machine required children to respond to odd stimuli presented in an array. This errorless discrimination or stimulus-shaping procedure starts by reinforcing a stimulus response relation the learner can acquire easily and gradually changing the stimulus until the subject arrives at a more complex level of visual analysis. A far more popular teaching machine format for the mentally retarded has involved match-to-sample procedures in which the subject is required to identify a set of objects with some common element.

It seems that the first teaching machine which presented programmes in a match-to-sample format was that used by Hively (1960). Working mainly with young normal children, Hively noted how keen children were to use the machine and how easily they worked through matching to sample problems. Although Hively did not study responses of mentally retarded subjects to his machine, he believed that such a device held promise for teaching the very young, handicapped, and mentally deficient. It is notable that Skinner made use of this machine to illustrate how young children could be taught to make discriminations. Moreover, Hively's invention provided the impetus for development of commercially produced machines such as the British "Touch Tutor" which was popularised during the 1960's.

The first published descriptions of a commercially available multiple choice teaching machine appeared in the work of Cleary and Packham (1968) who presented a general account of the device and some descriptions of preliminary research. The 'Touch Tutor' as it was known required the subject to decide which one of three lower, or response panels, is displaying material which correctly relates to the stimulus sample in the upper panel. The child has simply to touch one of the lower panels for his response to be electronically detected. If the child presses a correct alternative, his response is rewarded by an audio recording of the stimulus sample. Selection of an incorrect alternative results in the machine remaining silent. In either case a new presentation appears within a few seconds and remains displayed until a new response is detected.

Work with the 'Touch Tutor' involved three broad areas. Firstly, studies focused on the response of mentally retarded persons who were being taught simple visual discrimination drills (Beasley and Hegarty, 1970; Levinson, 1970; Beasley, 1974). A second area of study concerned the development of teaching programmes for the 'Touch Tutor' which would be of immediate relevance to schools for example, basic academic skills such as sight reading, number concepts and social competence (Moseley, 1970). Thirdly, some attempts were made to employ the 'Touch Tutor' as an aid for diagnosis and remediation of perceptual deficits in severely mentally retarded children (Cunningham, 1970).

Production of the 'Touch Tutor' stimulated interest in machine based instruction and gave rise to modified versions of the device. Beasley (1974) who noted problems children were having in attempting to learn match-to-sample procedures, developed his own machine for use with mentally retarded children. This consisted of a 9 inch square translucent panel on which the stimulus is projected by means of a 35 mm slide projector housed inside the machine. The child has to press the panel in order to receive a commentary on the stimulus being displayed, and this is followed by a change of the stimulus. Auditory comment is presented by means of a cassette tape-recorder synchronised with the slide projector. Several studies were carried out to evaluate the utility of the machine for teaching social sight words. The results were encouraging and showed that subjects made gains in both acquisition and retention of the words taught on the machine. Beasley explicated his rationale for machine-based instruction as a situation where distraction could be minimised and motivation heightened through active responses to the material being presented. He felt that attending behaviour could be strengthened by requiring the child to touch the stimulus material in order to obtain a verbal commentary and stimulus shift.

Unfortunately, few positive results emerged from studies and work with the 'Touch Tutor' ceased. Kapota (1970) on behalf of Behavioural Research and Development Ltd. (manufacturers of 'Touch Tutor') noted heavy production losses: "After four or five years the company has produced sixteen machines at a heavy loss... it is estimated that the sale of 200 machines over the next two years is necessary if we are to recover our losses." The major limiting factor in use of the machine was a lack of educational programmes. Teachers, hard pressed with existing problems and without financial and technical resources were not in a position to create educationally relevant material for multiple choice or free operant devices such as the 'Touch Tutor'.

In his major review of teaching machines for the severely retarded, Hegarty (1975) points to the limited value of expensive and sophisticated machines. He argued that there may be a place for devices of a simpler kind which require fewer financial and teaching resources but have some characteristics of machines such as the 'Touch Tutor'. Hegarty ends on a rather discouraging note by stating that two decades of research is surely long enough to demonstrate that complicated teaching devices are of restricted value with the mentally retarded.

It is important to recognise that nearly all research with teaching machines has involved the use of mechanical devices with very little flexibility for altering the presentation of stimuli or mode of input required from the learner. Machines such as the 'Touch Tutor' were purpose built for match-to-sample learning and could not be easily altered to accommodate other teaching approaches. The rigidity imposed through machine design meant that educational programmers or teachers had to be resourceful in creating relevant programmes that would fit the capability of the machine. Moreover, even when suitable programmes were developed, these were confined to a strict linear presentation of stimuli with no options for branching into remedial routines that might be required to prepare the learner for the next stage of instruction. This lack of flexibility severely restricted the practical application of machine based systems.

Computer Applications of Programmed Instruction

The use of computer assisted instruction (CAI) with the intellectually handicapped has arisen from earlier research efforts which employed mechanical teaching machines to provide programmed learning. Although limited in number, several experimental projects in the habilitation field have demonstrated the technical practicability and effectiveness of such instruction. With the advent of technological advances in the computer science field, relatively low cost microcomputer systems have come available for specialised applications in business and education. There is growing interest in ways this technology can be employed for teaching a wide range of learning skills through remedial branch programmes.

The major premise underlying CAI with the intellectually handicapped is that such persons are capable of mastering considerably higher levels of performance than has generally been assumed when given structured programmes tailored to meet individual needs. Specifically, the need for social education in such areas as basic arithmetic skills, coin computation, time telling, and community awareness are of paramount importance for transition to independent living. It has been well documented that previously institutionalised persons frequently fail to meet community standards as a result of inadequate social educational knowledge even though they may have received the benefit of a long term vocational programme. Computer assisted instruction is a comparatively new means of dealing with these practical educational deficits.

Programmed instruction and CAI both employ techniques which seem to show certain advantages over other forms of instruction for the handicapped. Many of these learning principles have been summarised by Haskell (1966) and Brown (1975). It is important to recognise that these techniques apply to every area of training including social, educational, leisure-time, and vocational skill development.

1. Small logical units - Tasks can be broken down into very small units and gradually built into larger ones. This provides an opportunity for the learner to assimilate the sequences of a complex task. Arrangement of concepts into a calculated hierarchy will help ensure a gradual progression of understanding.

2. Self-Pacing - The learner works at his own speed and difficulty level on individually tailored programmes.

3. Active Participation and Immediate Feedback - Positive reinforcement of cause and effect relationships along with active and purposeful participation enhance learning efficacy.

4. Attention Span - Many intellectually handicapped persons have attention difficulties. Zeaman and House (1963) have proposed that such persons may experience difficulty in sorting out relevant from irrelevant cues. Discrimination is enhanced by having the learner attend to meaningful aspects of the task.

5. Reduction of Emotional Dependence - The learner has an opportunity to participate in a self-directed task which decreases tendencies toward passivity and dependency. Ryba (1976) has highlighted the importance of training for social autonomy by strengthening personal adjustment of the intellectually handicapped.

6. Overlearning - Repetition of the task after adequate performance has been attained leads to better retention over time. CAI provides a continuous learning experience.

7. Tutorial Role of Teacher - The teacher is forced to spend more time with learners who are having difficulty and less time in the preparation of routine teaching materials.

8. Motivation - Low motivation is a major cause of underfunctioning in the slow learner. Evidence relating to rewards suggests that when these are given frequently and over small intervals, they are likely to promote effective behaviour.

Moreover, computer assisted instruction appears to possess certain additional advantages in that programmes can, to some extent, be "personalised" for each student. The student's first name can be used in association with reinforcing messages, and difficulty level of the programmes can automatically be adjusted to match the ability of the learner. CAI equipment can be modified in various ways to meet the needs of the handicapped. Alternate input forms allow severely physically disabled persons to interact with the computer. Output channels can be provided by means of audio messages for nonreaders and photographic slides for those who need to associate between pictures and written material.

With the recognition that intellectually handicapped persons can benefit from programmed instruction, it appeared logical to assume that computer-assisted instruction would also prove to be an effective teaching method. A large amount of experimental work has been carried out to explore ways in which this technology can be applied within the framework of what is already known about the psychology and education of slow learners.

Types of Computer Assisted Instruction

The focus of this section is upon describing ways in which computers have been used to provide course content instruction in the form of games, simulations, tutorials, and drill and practice. In the United States these practices have come to be known as computer assisted instruction (CAI) whereas elsewhere, notably in the United Kingdom, the term computer assisted learning (CAL) has been used. Throughout this study the term CAI is considered to be synonomous with CAL.

Literature on CAI has tended to neglect the various distinctions between kinds of instructional uses for which computers have been used. The first consideration is whether CAI is employed to supplement the learning situation, or to provide a substitute for other modes of instruction. Most studies in the special education area (e.g. Hallworth and Brebner 1976; Sandals, 1979) have made use of the computer as an adjunct to regular instruction. Typically, the learner spends a period of time each day interacting with the computer while continuing to participate in conventional classroom activities. In contrast, CAI materials that provide instruction of a substitute or stand-alone nature tend to be of longer duration and are less common than the supplementary approaches. In the United States, CAI has been used to provide entire credit courses at universities and colleges. This approach is exemplified by the computer assisted renewal education (CARE) course developed at Pennsylvania State University for inservice training of teachers (Cartwright and Mitzel, 1971). In the United Kingdom the open university is experimenting with substitute applications of CAI for teaching at a distance. Teaching over broad distances has typically made use of many types of educational technology, including radio, television, electronic conferencing, and satellite transmissions. More recently experiments have been conducted on the use of computers for distance teaching. Sandals (1979), for example, has placed a self contained microcomputer at a school in an isolated centre of northern Canada. Teaching programmes for language arts and arithmetic are regularly updated and made available on a mail order basis to the school.

A second distinction refers to the type and sophistication of equipment that is being used. CAI usage has until recently relied almost exclusively on centrally based mainframe or minicomputers which are accessible via remote terminals linked to the computer by telephone connection. This means that a wide range of facilities can be serviced from a central location. Moreover, several individual teaching programmes can be carried out simultaneously on a time shared system. One of the earliest applications of a centrally based time shared system for providing CAI was by Atkinson (1968) and colleagues at Stanford University. This project represented the first attempt to increase children's skill levels in basic English and Mathematics through computerised drill and practice. Telephone lines linked the minicomputer (PDP-10) to student terminals located in schools near the university and as far away as Florida, Oklahoma, Texas, and Washington, D.C. The computer was primarily used to supplement classroom teaching.

With the proliferation of microcomputer based systems over the past three years or so, much effort has been placed into "downloading" instructional programmes from larger time shared systems to stand alone microcomputers. Sandals, McMillan and Workman (1980) describe the rationale for developing a microcomputer based system with downloading capabilities. These researchers stress that it has now become possible to provide a high quality of computer assisted forms of learning on self-contained microcomputers. The current availability of these low cost computers with their multisensory capabilities seems to be the technological breakthrough which is likely to result in substantially greater CAI usage at all educational levels.

The third distinction is with the simplicity-complexity level of CAI languages. The simplistic approach employs easy-to-learn programming languages with minimum hardware to support the use of the programmes. Such basic CAI does produce limited results however with less graphics capabilities and computational procedures. On the other hand, complex

CAI which makes extensive use of graphics, has large computational capabilities, and multimedia input/output devices requires more elaborate program routines, and in some cases at least, more complex author languages (Chambers and Sprecher, 1980). But this distinction is arbitrary and has become less obvious with the emergence of very flexible microprocessing devices.

A final distinction concerns the level of interaction which is to be provided by CAI. Training features of programmed instruction such as active participation, immediate feedback, etc. can readily be incorporated into the CAI system. Additionally, there are several further features available on the computer which can be utilised to increase the realism of the learned interaction with the computer. Salisbury (1971) has provided a clear description of the basic instructional modes used with computer assisted instruction:

Drill and Practice: This mode essentially involves repetition, practice and remediation in specific areas of study. Simulation of normal student-teacher interaction is achieved through generation of problems by the computer, input of responses by the learner, and immediate feedback as to whether an answer was correct or not. Various formats of instruction can be provided such that the student responds to a pre-programmed set of problems or, alternatively, the computer may offer the student a choice of parameters which set the limits of difficulty and/or number of problems to be presented. Common applications of this mode are in areas of arithmetic and language arts.

Tutorial: In this mode the student is given a complete sequence of instruction under control of the computer. It is characterised by presentation of the learning material in small units, test items for analysis by the student, and evaluation of student responses to determine feedback and branching routines. Highly individualised instruction may be achieved in this mode though the computer programs are complex to write and more processing capability is required than with simple drill and practice procedures.

Simulation: The simulation mode is particularly useful for replicating problem situations and providing experiences that might otherwise not be available to the learner. Common examples of simulation programmes are in areas of flight training, genetic experimentation, and military operations. Simulation programmes that make use of audio-visual output have been devised to teach budgeting and shopping skills to mentally retarded people (Sandals, 1973). Most of the "games" devised for modern day microcomputers make use of simulation techniques (e.g. piloting airplanes, flying space craft, and making hypothetical decisions that determine military and political consequences).

Dialogue or Inquiry: This mode provides relatively free conversation between the student and computer. Control and direction remain with the program though an extremely large range of responses is possible. The development of vocal synthesisers and voice pattern detection devices permits some logical conversation with the computer. This is a complex proposition which might ultimately lead to the use of computers in counselling and solving problems in real life. Computers have frequently been used in medical settings to assist with rapid diagnosis and monitoring of life support systems. Dialogue mode is restricted at present by the need for reliable equipment and software programs that can cope with the complex expressions of grammar and language. However, it is important to recognise that intelligent conversation with computers is no longer within the realm of science fiction.

The present project has primarily been designed to provide CAI in a tutorial mode though some aspects of drill and practice are also included. Programmes were created to guide the subject through a graduated series of steps with various branch routines made available according to whether correct or incorrect responses were selected. Another element of the tutorial mode contained in the programmes was evaluation of responses and calculation of the subjects' performance at each point in the instructional sequence.

Early Developments of Computer Assisted Instruction

CAI usage was primarily initiated in the United States during the late 1950's and early 1960's though some parallel work was undertaken in England as well. The literature on CAI with intellectually normal subjects is voluminous though most early work has been reported in technical reports and information newsletters rather than in referenced journals and books. This situation has changed in more recent years with the recognition that computers are generally available to educational settings and that CAI is no longer a sophisticated area of research involving elaborate hardware and financially expensive resources. This changing trend is largely because of the availability of low cost, versatile microcomputers. For the purposes of this review only a few major projects that established future trends will be discussed: Dartmouth College, University of Illinois, Stanford University, and Pennsylvania State University.

The BASIC language and time sharing system, developed at Dartmouth College, provided an easy means for programming computers and making these more readily available to students and teachers. BASIC which stands for 'Begineers All-Purpose Symbolic Instructional Code' has emerged in more recent years to be the most common interpreter language. It was developed in 1963 by Professor's Kemeny and Kurtz, and because it is so easy to learn to use, more computers understand BASIC than any of the other hundreds of computer languages. The vocabulary of BASIC is very limited, several hundred words at most, and unlike English must be used with great precision. Many of the CAI software applications that are used with micro- and minicomputers in schools today can trace their history to this early development. In fact, to the author's knowledge there are no commercially available microcomputers which do not have a version of the BASIC interpreter language.

During the early 1970's Dartmouth College formed a consortium (CONDUIT) with several other universities, notably Oregon, North Carolina, Iowa, and Texas, to acquire, evaluate, and distribute high quality instructional programmes on a national basis (cited in Chambers and Sprecher, 1980). Supported by the National Science Foundation and the Fund for the Improvement of Post Secondary Education, CONDUIT currently offers some 75 computer programs in a variety of fields to support higher education classes (cf. Pipeline, 1979).

Work undertaken at the University of Illinois by Donald Bitzer in 1959 led to the development of PLATO, the largest and most well known of all CAI projects. This system uses a high level language termed TUTOR and requires a large mainframe computing facility that is entirely devoted to operation of PLATO. PLATO was originally implemented on a vintage 1954 Illiac 1 computer but has since been modified to operate on the more powerful CDC6500 Series computer (Bunderson and Faust, 1975). The system has been linked to more than 1000 terminals, most of which are located in Illinois, but some are as far away as Boston and San Diego. Because PLATO can produce complex CAI programmes with graphic capabilities (including animation), vocal output, and touch sensitive input, it is used for a wide variety of primary instruction. Terminals are located in a wide range of educational settings including universities, junior colleges, elementary schools, military and flight training centres. Pan American Airways is a major commercial subscriber to PLATO for inservice training of staff and operational personnel. PLATO has been used extensively to teach basic academic skills to young children and slow learners as well as language arts instruction for new immigrants (Lyman, 1974). Despite the move toward self-contained microcomputer systems, it seems quite possible that the very flexible CAI capabilities of PLATO will ensure heavy usage of this system.

Mention has already been made of the early work on CAI at Stanford University (Atkinson, 1974). Probably more than any other facility, this project has been directly concerned with providing remedial education to younger school age children. While the first efforts to teach reading under computer control were aimed at a total curriculum, orientation for the past several years has been toward providing supplementary instruction on those tasks in which individualisation is critically important. CAI reading instruction, for example, is given to each child for a period of between 15 and 30 minutes daily. Instruction commences when a student types R for reading, an identification number and then his first name. The system responds by printing the student's last name and transferring him to the point in the curriculum where he finished on the previous day. Reading instruction is offered in two broad areas of decoding and communication. Decoding includes grammatical tasks such as association of phoneme groups with their respective graphics representations. In the communication area, reading for meaning, aesthetic enjoyment, and acquisition of specific subject knowledge are stressed. At a time when most other CAI applications were primarily intended for use with advanced learners, the Stanford project held a special interest in remedial work with young normal and handicapped children.

A final project to be discussed in this section is the Computer Assisted Renewal Education project (CARE) which was carried out at Pennsylvania State University (Cartwright, Cartwright and Robine, 1972). The CARE course was designed to teach regular class teachers and university students to understand the characteristics of and be able to identify handicaps in young children. Over the five years or so in which the project operated more than 25,000 teachers received primary CAI to complete an introductory course on the Education of Exceptional

Children.

The CARE project consisted of several teaching modules designed to promote clinical sensitivity on the part of regular preschool and elementary school teachers as to the strengths and needs of both handicapped and nonhandicapped children. Specific objectives of the course included: ability to select and use appropriate diagnostic procedures, clinical profile analysis of student learning characteristics, evaluation of the adequacy of information as a basis for referral to specialists, and preparation of adequate documentation if a decision is made to refer the child to specialist services. By learning specific behaviour clues, teachers were taught characteristics of a variety of handicaps which would enable them to identify the presence of handicapping conditions in children at the earliest possible age.

The CARE course was programmed to operate on the IBM1500 computer using the now defunct Coursewriter II CAI language. A special purpose van was equipped to contain the computer system and 16 workstations. Each of the work stations contained a projection screen and cathode ray tube (CRT) display. Students could input information to the system using either a conventional keyboard or light-sensitive pen. A major feature of the system was very advanced graphics capabilities for the day which permitted students to compose histograms or diagrams on the CRT display.

With the recognition that lack of early identification and subsequent intervention of handicapped children was relatively higher in rural schools than in urban areas, a main aim of the project was to locate the CAI van at schools in remote areas of Pennsylvania. This made the course available on an inservice basis to teachers who could not otherwise participate in special education, with a minimum of disruption to their work schedules.

The effectiveness of CARE has been evaluated at several levels including assessment of students' performance, evaluation of CAI by students, and professional consultation. In one of these studies, the CAI version of CARE was compared to conventional in-class lecture-discussions (Cartwright, Cartwright and Robine, 1972). Results of this study revealed that students receiving CAI completed the course in 12 hours less time (33 per cent) than the time scheduled for conventional instruction. Moreover, the data indicated that the CAI students obtained a mean score 24 percent higher on a criterion test than students participating in the conventional instruction group. A student opinion survey suggested that nearly all participants had a favourable attitude toward CAI.

Unfortunately the use of such sophisticated and expensive equipment led to the demise of the CARE project. In the words of Professor Cartwright "the complexities of this project both in terms of technical and financial requirements probably did more than anything else to discourage the development of CAI" (Personal Communication Nov. 1979).

Computer Assisted Instruction with Handicapped Persons

In this section of the literature review, attention will be given to current CAI projects which are actively engaged in the teaching of handicapped persons. This will primarily involve discussion of larger time shared computer systems as very little research has been reported to date on the use of microcomputers in special education. The majority of work on CAI with handicapped learners appears to have been concentrated in Canada and the United States though it is probable that many other countries have initiated research in more recent times. Unfortunately, the majority of studies are found in technical reports or unpublished papers rather than referenced journals and periodicals. This makes it difficult to bring together all relevant works though the studies presented here would seem to be representative of the major advances in contemporary CAI research.

Several recent studies have indicated that the learning of handicapped students can be enhanced through interaction with computer assisted instruction systems (Holz, 1976; Fiorentino, 1977). Moreover, demonstration projects such as research by Sandals and colleagues (1980) at the University of Manitoba point out that such instruction is cost effective and technically practicable.

One of the earliest studies with handicapped adolescents and adults was carried out at the University of Texas by Knutson and Prachnow (1970). These researchers designed a CAI system to teach student coin equivalence, summation, and making change for purchases of less than $1.00. An IBM1500 computer was linked with two special purpose teletype terminals. A metal overlay keyboard containing 10 large keys with removable caps for insertion of real coins was constructed as an input device for use by students. Instructional material in either English or Spanish languages was presented by audio output, a slide projector, and cathode ray tube (CRT) for visual display of written questions. Thirty-one subjects ranging in age from twelve to thirty years and in IQ from 45-80 participated in the training programme. All of the students who completed training showed gains from pre- to post-test in coin identification, selection of appropriate coins for a purchase, and ability to determine if the value of a set was sufficient to buy an item. The authors concluded that while CAI appeared to be an effective means for teaching skills to retarded subjects, the lack of portability of their equipment was a distinct disadvantage. Because the terminals could only be used in a CAI laboratory and not taken to remote locations, students had to travel long distances and wait their turn for each 15 minute session of instruction.

Beginning in 1967 the National Research Council of Canada (NRC) carried out preliminary work on the application of computers as aids to learning. This was a cooperative project involving several Canadian Universities including the University of Calgary and Ontario Institute for Studies in Education. The NRC programme is aimed at the development of facilities necessary to permit the computer to be used effectively by teachers, students and researchers for conversational tutorial interchange, drill and practice, and information retrieval systems. A medium-scale, time sharing computer (PDP-11) located at the NRC research facility in Ottawa was made available to remotely located research groups in the CAL project.

One of the earliest members of the NRC research team was the Computer Applications Unit at the University of Calgary. This unit has been actively engaged in providing CAL to intermediate and high school students as well as mentally retarded adults (Brebner and Sandals, 1973). During 1971 a single teletype terminal was placed at the Vocational Rehabilitation Research Institute (VRRI), a specialised training facility for handicapped persons. This was attached by a telephone line to a computer located in the Faculty of Education Computer Applications Unit. Subsequently, a caravan containing four CAL work stations, each with a teletype, rearview screen and computer controlled slide projector was located at the VRRI. This facility was permanently installed in the Institute during 1976. Over the course of the project, a wide range of research has been carried out on various aspects of CAL with mentally retarded adults (Sandals, 1973; Strain, 1974; Eaton, 1975; and Holz, 1976).

Sandals (1973) conducted a study to evaluate the utility of CAL for teaching banking skills to mildly mentally retarded adults. Several skills were taught, including how to budget, to open and use savings and chequing accounts, and to balance personal finances. This research made use of four teletype terminals interfaced with a random access slide projector under computer control. The terminals were housed in a mobile caravan parked on the site of a training centre for handicapped persons. A data modum was used to link each of the remote terminals to a small control computer (PDP-8) located at the University of Calgary.

The banking programmes were designed for higher level trainees who had attained a reading age of at least seven years and had demonstrated a reasonable proficiency on a test in making change up to a dollar. Training consisted of 12 half-hour lessons which followed the activities of a hypothetical character named "Bill", who had just started a job as a petrol station attendant. It was felt that this type of work might well be one which a trainee could aspire to after completing basic social and vocational training. A comparison of pre- versus post-test results showed significant gains in performance immediately after training and that trainees were able to recall their learning on a test of retention administered some months later.

Using the same computer facility, Strain (1974) also designed a CAI programme for teaching simple money-handling skills to mentally retarded adults. A teletype terminal and random access slide projector under computer control was utilised to display pictures of money and price tags. Seventeen subjects were taught to identify price tags, determine whether they had sufficient money to purchase an item, and finally to calculate the amount of change they should receive. Results of the study showed that there were significant improvements both in terms of accuracy and amount of time taken to answer questions.

Eaton (1975) made use of a touch-sensitive panel to investigate the effectiveness of CAI for promoting visual discrimination of letters and words amongst normal pre-school and mentally retarded adolescents. Audio instruction was provided by means of a random access tape recorder while visual information was displayed on slides, which were rear projected on to a touch sensitive screen. Students responded by touching a letter corresponding to the audio instruction they were given. The results showed that both groups improved to a statistically significant extent following interaction with the CAI system.

Another Calgary Study was carried out by Holz (1976) who investigated the effectiveness of CAL for teaching a social sight vocabulary to mentally handicapped adolescents. The computer equipment was identical to the preceding study, consisting of a visual display screen, random access projector, an audio unit, and touch-sensitive screen. A sample of nineteen subjects were given the same amount of instruction, though ten of the students received audio messages throughout their training (audio group) while the remaining nine did not. The results of a pre-versus post-test comparison indicated that both groups improved to a significant degree. However, the findings also confirmed that such training was more effective with students who were given audio support than those who were not.

A second major project is being carried out by Sandals (1980) and his colleagues at the University of Manitoba in Winnipeg, Canada. Over the past six years, research has been undertaken to evaluate the utility of CAL in several different educational settings for children with learning handicaps. A very significant feature of this project is that CAL has been made readily available to classrooms for handicapped persons within the school system on a large scale. CAL has been and is presently being used with children who are deaf from grades K-12 in a residential school for the deaf, an elementary school for physically handicapped children, a high school for mentally retarded adolescents, and intermediate school for learning disabled children, a juvenile corrections centre, and instruction for intellectually normal children in seven other schools.

The Winnipeg project makes use of remote terminals located in each of the schools and linked to a central computer (CDC Cyber 171). Additionally a microcomputer is being used to provide CAL at a distant centre in Northern Canada. Courseware consists of over 300 drill and tutorial programmes, primarily in areas of arithmetic and language arts. During the course of the project, several studies have been carried out to evaluate CAL.

The first of these was by Hill (1976) who researched the use of CAL in mathematics as a drill and practice programme for physically handicapped children. A comparison of students receiving supplementary CAL versus those receiving classroom instruction only, showed no significant difference in achievement between the groups. Working on the same project, Fiorentino (1977) compared the performance of learning disabled children given additional CAL drill and practice programmes with groups of students receiving conventional classroom instruction only. Again, no differences were found between the CAL and control groups though significant improvements occurred over time for both arithmetic and spelling. A similar study by Reeves (1978) failed to show any gains in pre-versus post-test performance with deaf children who were given CAL drill and practice programmes in arithmetic and language arts.

While the above results do not appear to support the efficacy of CAL as a supplementary teaching method, it is possible that the type of achievement tests employed may not have been sufficiently sensitive to measure any gains in learning that might have otherwise occurred. The fact that Stanford Achievement Tests were used in all of these studies raises some doubt as to whether such global measures are relevant for assessing gains in specific subject areas. Moreover, there is an admission in the Reeves (1978) study that the use of different alternate forms of the Stanford Achievement Tests and selection of biased treatment groups may have confounded the results.

A final project to be reported in this section is the work of Lally (1980a) and colleagues at the Department of Engineering and Physics, Australian National University, Canberra. Several studies have been undertaken to evaluate the use of CAI for teaching handwriting, number conservation and sight word recognition to mentally retarded children. The project makes use of a medium scale computer (PDP11/20) interfaced with sophisticated input/output devices including random access audio unit and digitised light pen.

CAI programmes were designed to supplement conventional teaching methods for children attending a special school. A study on sight word recognition employed the computer to teach eight children associations between written and spoken versions of the words (Lally, 1980a). Results showed that children taught by the CAI method increased their sight vocabularies by an average of 128 percent compared to an increase of 34 percent by a comparison group. Reassessment some twenty-six weeks after the end of the four week non-intensive training programme indicated that increases in sight vocabulary were retained.

Other research by Lally (1980b) explored the application of CAI for teaching number conservation. During training, subjects were required to make judgements concerning the numerosity of differently coloured sequences of squares which were displayed in various orientations. Significant improvements were recorded at the end of training and on a test of retention after nine weeks.

A third study was conducted to assess computer applications for teaching handwriting skills to mildly retarded children (Lally, 1980c). This made use of a display screen upon which children wrote using a light pen. The tip of the pen was spring loaded and operated a switch which activated the photo cell mechanism. The impression of writing was given by means of a lighted track which appeared directly under the tip of the pen as it was moved over the screen. Training primarily involved tracking exercises in which the student was given cues to complete the tracing of lower case letters. The cue stimuli were progressively removed over the course of training. Handwriting samples collected before and after training showed that students participating in the CAI programmes had improved in their ability to copy letters in contrast to a control group who did not receive the supplementary instruction.

Despite these positive findings, Lally makes the point that rate of learning new words did not improve amongst students after completion of the training programme. He recommends that a longer programme would probably have been required to increase generalisation of learning. Or alternatively, it was advanced that the teaching of sight words might be more effective using a phonic word attack skill. All of the studies cited above provide a clear demonstration that students have little difficulty interacting with a computer when simplified input devices and audio visual instruction are available. Even low ability students could operate the equipment and appeared to learn through interaction with the system.

Summary and Implications for Further Research on CAI

This chapter has highlighted the many diverse forms of programmed instruction and automated teaching that have been provided in special education. Because of the variety of approaches used to date, it is difficult to offer any clearcut recommendations on the effectiveness of these methods. The main problem is that effectiveness has been defined differently by different investigators. In some studies, effectiveness has been defined in terms of the amount of learning that takes place initially (e.g. Holz, 1976; Strain, 1974). Other research has been concerned with the amount of retention of information (Lally, 1980b, 1980c) or ability to transfer learning to new situations. Due to the fact that CAI is still largely undeveloped within the mainstream of special education, some researchers are simply concerned at this point with transportability of equipment, design of special purpose input/output devices that can effectively be operated by handicapped students, and acceptability of the learning medium for use by others (Hallworth, Brebner and Brown, 1974). There is a general lack of well designed, tightly controlled studies on the use of CAI.

A major shortcoming of much of the research on automated teaching has been the absence of meaningful contrast samples with which to compare performance outcomes. Many of the studies reviewed in this section were concerned with assessing the use of CAI as an adjunct teaching method with handicapped persons (e.g. Sandals, 1980; Eaton, 1975). Few attempts have been made to evaluate the instructional procedures using both automated teaching and more conventional individual tuition with matched groups of students. The general indication seems to be that CAI is effective when used in a supplementary role along with classroom instruction. Yet there is little evidence concerning the utility of primary CAI as a substitute teaching method in special education. Moreover, most studies have been carried out with mildly retarded persons (Sandals, 1973; Strain, 1974). There is a need to examine possible applications of CAI with more severely handicapped students as well.

Until recently, automated teaching and in particular CAI, were sophisticated areas of research that required large amounts of financial and technical backup. The general availability of inexpensive microcomputers has altered this course so that powerful and affordable CAI is now within reach of most educational settings. However, the advent of the microcomputer has given rise to much controversy concerning the relative merits of CAI systems supported by large-scale computer facilities as contrasted to CAI presented by means of stand-alone microcomputers. Because microcomputers are of recent origin, very little research has been done to evaluate the usefulness and reliability of these systems for teaching practical academic skills to the mentally retarded. To date, no work has been done on microcomputer generated CAI in the context of New Zealand Special Education.

Finally, there is a need to obtain some estimates of the cost-effectiveness of CAI. Several studies have reported on cost factors resulting from the use of larger time-shared systems (e.g. Hallworth and Brebner, 1976). There is, however, an absence of information on cost accounting with regard to self-contained home computers. Materials running on microcomputers have been reported to have the lowest operating costs (Avner, 1978). Some further indication of the level of expenditure with regard to purchase of equipment, development of courseware, and systems operation would be useful in weighing the relative merits of this new technology. In these early stages of development, significant expense has been incurred with preparation of courseware. It seems likely that the cost of providing CAI will continue to decrease as more teaching programmes come available. Some commercial software is already being marketed overseas for use in teaching language arts and arithmetic on microcomputer systems.

Of central interest to this study is the comparison of parallel forms of individual instruction presented by means of computer based and teacher dominated programmes. This is a particularly important focus of attention because the computer is being utilised as a substitute teacher to provide drill and tutorial programmes intended to foster the acquisition of word recognition skills. As detailed in this review, the computer is used to incorporate well known learning principles derived from previous work on programmed instruction. The branching capabilities of the auto-instructional system are intended to simulate the remedial steps that a human teacher might follow in a similar teaching situation.

It remains to be determined whether computer-generated instruction can indeed approximate human interaction in a structured teaching sequence where standard remedial drills are followed. The very presence of technical equipment in the absence of interpersonal contact is a decisive factor that may influence subjects' performance in different ways. Yet to the greatest possible extent, parallel forms of instruction have been devised which incorporate identical criterion measures and teaching procedures.

Two instructional methods have been selected for investigation in the present study, on the assumption that these are representative of the many procedures commonly used to teach word recognition to mentally retarded adults. The import of these methods is from both practical and theoretical work already reviewed. Of particular interest to this study is the utility of extra stimulus cues to guide subjects' responses during the learning of new material. There is controversy about the effects of using pictorial materials as prompts in learning to recognise printed words (Samuels, 1970; Duell, 1968). Because this research seeks to explore techniques that make use of picture-word associations as well as a straight word focus, it should be possible to provide some evidence concerning the use of added stimulus dimensions.

With the preceding points in mind, there appears to be an immediate need to evaluate microcomputer technology within the framework of existing theory and current practice for training mentally retarded people. In effect, the auto-instructional system has been designed to simulate teacher-student interactions that occur in interpersonal modes of instruction. While recognising that automated systems cannot yet be made to totally replicate human interaction, there is no reason to believe that learning can only be successful in the presence of human dominated teaching environments.

Psychologists in particular are well aware of the many fallacious results arising from human error and response latencies occurring during the administration of standardised tests. Intelligent automated systems avoid some of these shortcomings perhaps at the cost of being overly rigid in their approach to wide variations in the learning and behaviour of handicapped people.

Research Questions

The observational methodology used in this study is designed to answer certain specific questions:

1. To what extent, if any, do two contrasting methods (paired associate versus errorless discrimination) differ in their utility for teaching word recognition to mentally retarded adults?
2. How does computer-assisted instruction compare with individual tuition for teaching subjects to recognise a set of words on each of the experimental methods?
3. Are there any differences in the amount of information recalled by subjects who participated in either of the two treatments (computer-based versus instructor-dominated) or conditions (paired associate versus errorless discrimination) four weeks after completion of the teaching programmes?
4. Are there any differences in the ability to transfer reading skills to new situations between subjects who participated in either of the two treatments (computer-based versus instructor-dominated) or conditions (paired associate versus errorless discrimination)?

CHAPTER V

DEVELOPMENT OF INSTRUMENTATION AND TEACHING PROGRAMMES

Introduction

This chapter contains a brief account of preceding work, carried out over the past two years, which led to development of the present microcomputer based instructional system. A nontechnical description of the computer hardware and peripheral equipment used in this investigation is provided. This consisted of a self-contained microcomputer interfaced with a sound-slide projector for presentation of both audio and visual information. Subjects interacted with the system by pointing a light-sensitive pen at designated positions on a video display screen in response to recorded audio messages. The system was specifically designed for use by handicapped persons with very limited reading ability.

Details on the courseware developed by the experimenter for the study are presented in this section. The CAI programs were written in BASIC, a high level interpretive language, and stored on magnetic disks for immediate retrieval. A description of the corresponding teacher-based instructional procedures are provided to demonstrate the manner in which parallel programmes were designed to compare CAI with more conventional interpersonal tuition.

Background to the Study

Earlier work had been undertaken prior to commencement of this study to implement assessment and training programmes aimed at teaching skills of living to mentally retarded adults (Ryba and McDonald, 1979a, 1979b). These training procedures were developed to teach practical skills in such areas as personal grooming, money handling, time-telling, number concepts and word recognition. A social education continuum was organised into a number of units that provided a structured sequence of small learning steps. Each unit had clear behavioural objectives and assessment methods for monitoring progress in training. The focus was upon tailoring programmes to meet each person's needs within designated training areas. Pilot development of these materials and procedures was carried out at training facilities operated by the New Zealand Society for the Intellectually Handicapped, Manawatu Branch, in Palmerston North, New Zealand.

As a logical extension of this work, the feasibility of using a computer to provide individualized instruction in some of the training areas was explored. Initially, it was intended that a remote terminal be placed at one of the Training Centres and linked to a large mainframe computer at Massey University by means of a telephone data modum. But the high cost and technicals obstacles associated with this approach precluded development of a CAI system on this scale. Fortuitously, microcomputers became available in New Zealand during 1978 and offered a practical alternative to the central system approach for providing CAI. An immediate attempt was made to develop some simple drill and practice programs in arithmetic for trial application with handicapped persons (Ryba, Christiansen, McDonald, and Drawneek, 1979; Ryba and Christiansen, 1980).

Experimentation with computer assisted instruction commenced during the latter part of 1978 with the purchase of a low cost TRS-80 microcomputer system. The TRS-80 is a minimum system which consists of a keyboard unit (also housing the microprocessor and memory), a T.V. display screen, and a conventional cassette tape recorder. Input is via the keyboard, output appears on the video display screen, while programs can be stored on cassette tapes.

The first task that was undertaken was simply to determine whether or not trainees could manage the system and presumably learn through interaction with a computer. It was found that the vast majority could do so when given brief instructions and a short training sequence. It was noted that those who were successful became highly motivated and were able to concentrate for extended periods of time. Also, some persons who were previously unable to spell their name could do so accurately using the computer keyboard.

The ordinary keyboard supplied with the TRS-80 is not very robust however, and since the system was required to be in almost continuous operation, it was decided to construct a heavy duty input device. This consisted of 20 one-inch square keys housed on a metal keyboard, including all numerical figures, + and -, YES and NO, as well as some letters for answering multiple-choice problems. This simplified input device was interfaced with the main keyboard and can easily be programmed to meet the requirements of each learning task.

Another simplified input unit was designed for use by severely physically disabled persons such as those with cerebral palsy and paraplegic conditions. By simply sipping or blowing on a mouth piece, a totally paralyzed person can select and activate one of the characters displayed on the video display screen. This form of input can be used for answering questions and storing information in the computer. Other types of input controls, for example, a joy stick, a dual rod control, a large hand switch, and a foot switch can easily be adapted to the system. The result is that there are no trainees to whom the computer is inaccessible because of their physical handicaps.

Despite the successful development of these simplified input devices, the range of teaching programmes that could be provided was restricted to those which could be visually presented on the video display screen. Moreover, manipulation of the keyboard for answering multiple-choice questions proved to be a complex task for many of the trainees. In some cases, it seemed that the response requirements of a task, for example, identifying letters or numbers and matching these with response items, was a rather more difficult operation(involving complex psycho-motor coordination)than the simple problem being presented. A more optimistic view suggested that as a matter of course some useful training occurred on pre-skills required to operate the system.

Most of these early programmes were concerned with the teaching of basic number concepts. Programmes in this area ranged from those which simply asked the learner to count boxes, to more advanced practice in addition and subtraction. The counting drill was a useful introduction to the computer and guaranteed a successful learning experience. The number concepts programme consisted of four difficulty levels that automatically adjust to the ability of each person. Alternate subroutines were developed to provide experience with pre-number concepts such as 'more-less comparisons' and 1 - 1 correspondence. For example, it was possible to draw a moving arrow which followed the objects and assisted learners to count in a sequence.

In order to overcome some of the complex requirements of entering answers into the computer by means of the conventional keyboard, a simplified input routine was developed. This routine required that the learner simply press a key when a moving arrow (graphics symbol) appeared alongside the selected response item. In one of the programmes, this approach was used to teach recognition of various letters, to locate letters from a list, and at a more advanced level, to select identical words. The trainee was given a specific word or letter combination and then had to locate an identical match by pressing the "YES" key when an arrow appeared opposite the item he/she wanted to select. Diagnostic information was automatically accumulated by the computer and displayed for the teacher at the end of each session to show the number of correct and incorrect responses.

Trial application of these pilot CAI programmes highlighted the fact that visual display of information alone restricted the range of interaction with the computer and types of learning drills that could be provided. This was particularily evident with more severely handicapped persons who encountered difficulties operating the system, comprehending visual instructions, and responding to material presented on the video display screen. A major challenge was to reduce the barriers between the trainee and computer. It was considered that this could be achieved through increased utilisation of audio and visual output.

To extend the range of communication offered to trainees, a Bell and Howell 'Ringmaster' slide projector was interfaced with the computer during 1979. Photographic transparencies (35mm slides) are displayed by means of a rear image projection screen and accompanied by a sequence of audio messages presented on a cassette player. Both audio and visual output are under computer control. This proved very useful for developing word recognition programmes which required the learner to associate a situation displayed on the slide with a word chosen for a list displayed on the video screen. Other drill and simulation programmes involving coin recognition, counting and matching, and selection of leisure-time interests were also developed for experimental trials on this multimedia system (Ryba, Christiansen, and Drawneek; 1980).

A major shortcoming with all of this proceding work was the absence of an efficient and reliable storage medium. In the minimum system, programmes are stored on ordinary cassette tapes and loaded into the computer as required. Because this involved conversion of analog into digital signals for use by the computer, it was found that minor faults caused by the stretching of tape or minute power interruptions would impede proper loading of the programmes. Moreover, the process of loading a programme in real time was relatively slow - several minutes were required to enter any one of the drill routines. Often programmes would have to be loaded several times before complete reading accuracy was achieved. These difficulties were overcome by the addition of a magnetic disk drive for reliable and rapid loading and storage of the CAI programmes. A low cost line printer was also purchased to generate a permanent record of the CAI sessions and to provide the learner with a hard copy summary of his/her performance.

A light-sensitive pen was interfaced with the system to further simplify procedures for entering a response into the computer. This required that the learner point to designated positions on the display screen, thus bypassing the use of the keyboard altogether. The light pen made possible a host of programming routines that could not otherwise have been developed. For example, this replaced the use of moving arrows for selecting responses to multiple-choice problems displayed on the video screen. The learner could simply touch an item with his pen placed on the screen surface rather than pressing a key in response to location of an arrow.

The above developments were made over a two-year period prior to commencement of the present study. Throughout the experimental phase, the computer system was located at the Cook Street Training Centre operated by the New Zealand Society for the Intellectually handicapped in Palmerston North. A special cabinet that permanently housed the equipment was constructed and located in one of the specialized training rooms. This provided a quiet area where trainees could concentrate and work independently on their programmes. Staff and volunteers assisted with management of the CAI system. It is estimated that in excess of 2000 individual sessions were offered over this 24 month trial period.

Expansion of the CAI system to incorporate both audio and visual instruction was an essential modification that made possible the presentation of learning tasks such as word recognition that could not be offered on a minimum system. Also, the adaptation of a simplified input device -a light-sensitive pen- opened channels of communication for less able persons. These procedures suggest that any meaningful attempt to provide microcomputer based instruction for mentally retarded individuals will require an interactive system with sound and touch sensitive capabilities.

Equipment and Technical Modifications

A concise account of the computer system and peripheral equipment used in this investigation is presented in this section. Modifications were carried out over a two year period preceding the study and were based on extensive observations of trainees interaction with the CAI programmes. It is considered that the microcomputer and supporting equipment described here is a minimum system for providing a practical form of CAI to handicapped persons. The relatively low cost of the equipment and interfacing procedures was achieved through purchase of common microprocessor based components that have only recently come available in New Zealand.

Microcomputer: The microcomputer used in the study was a commercially available TRS-80 System developed by the Tandy Radio Shack Corporation in the United States. This contains a Z-80 microprocessor chip that is widely used in personal computer systems. In the microcomputer, the processor and memory are mass produced silicon chips - the least bulky and cheapest parts of the system. These chips contain vast numbers of circuits, the amount of which determines memory and processing capabilities. The memory stores both instructions for the processor (the program) and the data to be processed. However it is difficult to write programs directly in the processor's instructional code. Instead these are written in a high level language, usually BASIC (Beginners All-Purpose Instructional Code), and the processor executes a fixed program that interprets the BASIC text. Because the interpreter is a fixed program, it is stored in read-only memory (ROM). The remainder of the memory, referred to as random access memory (RAM) can be both read and written. RAM is erasable and remains only so long as the power is on. The Z-80 processor contains 8 K (approximately 8000 characters) of ROM and 16 K (16000 units) of RAM. This random access memory can easily be expanded by the addition of other silicon chips. Available RAM for the TRS-80 used in this study was 32 K. This was more than adequate space for storing the CAI programs. The input-output devices make up the bulk of the microcomputer and most of the cost. The universal input device is the keyboard which resembles that on a conventional typewriter. The keyboard unit of the TRS-80 also houses the microprocessor and memory from which connections can be made to other types of peripheral equipment.

Visual Display Unit (VDU): The configuration of the display screen allows 16 lines of 64 characters each with total graphics resolution being 128 by 48. An important option of the TRS-80 is the facility to display double size characters (32 figures per line) on a conventional black and white screen. These larger letters were used throughout the experiment to ensure that subjects could easily view the visual material. An additional feature is that simple pictures, geometric drawings, and animated figures can be displayed on the screen.

Magnetic Disk Drive: Programmes were stored on conventional 5¼ inch floppy diskettes and loaded into the microcomputer by means of a disk drive. Operation of the disk storage system requires additional memory (ROM) which is contained in an Interface Control Unit. Each diskette holds approximately 80000 bytes of information which may be read or written in seconds. All of the CAI programmes used in this study were contained on a single disk with room to spare.

Sound/Slide Projector: A Bell and Howell 'Ringmaster' projector was interfaced with the computer to provide a display of 35mm slides and accompanying audio messages. Several functions could be controlled by the computer including slide advance, turning the projection light on or off, starting and stopping the cassette player, and activating the microphone. A major feature of the interface system was the capability to advance the cassette tape with the microphone turned off. This permitted audio messages to be played or bypassed according to the requirements of the programme and performance of the subject. For example, error messages could be played when necessary or omitted when a correct response was registered. Computer control of the sound/slide projector was accomplished by means of a specially designed interface unit that translated port addresses originating from the microprocessor into electromagnetic signals that activated the projection functions. Simple commands were incorporated into the BASIC language to permit programming of these audio and visual functions.

Light Sensitive Pen: This enabled subjects to interact with the computer by simply touching designated positions on the video screen in response to audio messages. The light pen was a particularly important addition to the system as it replaced more complex keyboard manipulations with a simple pointing response. The types of CAI programmes employed in this study would not have been possible without this relatively inexpensive input device. The pen contains a photo-sensitive cell that is activated by an amplifier placed on a small circuit board. A connector is attached that plugs into the expansion port at the left rear of the TRS-80 keyboard. Light is detected by placing the pen on a graphics block alongside items printed on the screen. By initializing all possible responses and testing to determine where the pen is being pointed, a programme can be written to provide confirmation of correct and incorrect responses. The pen is sensitive and works as much as 2 cm away from the screen surface. A time delay is included, however, such that the subject must hold the pen in a selected position for 2 or 3 seconds. This helps minimize the triggering of false responses that might occur while moving the pen on the screen surface to locate a specific item. The use of the light pen required less fine finger dexterity than operation of a keyboard. Moreover, it was a logical form of input that compared favourably with pointing responses characteristically required in more conventional interpersonal instruction methods.

Line Printer: A 40-column width alphanumeric line printer was used to generate a hardcopy printout of subjects' performance. This made it possible to retain a permanent record of each CAI session and to give the learner a copy of his own work to show others what he has accomplished.

A photograph displaying the configuration of the computer equipment is displayed in Figure 1.

The Computer Software

The experimental CAI system consisted of a set of four computer programmes written in BASIC, a high level interpretive language commonly available on microcomputers. The programmes contained both operating instructions and data concerning the words to be taught for each of the following training modules:

1. PAL 1: Paired Associate Learning of Tool Names
2. PAL 2: Paired Associate Learning of Grocery/Information Words
3. ED 1: Errorless Discrimination of Tool Names
4. ED 2: Errorless Discrimination of Grocery/Information Words

All of the programmes were contained on a single magnetic disk for immediate access at the beginning of each teaching session. The disk also incorporated a management routine that would automatically list the programmes available for selection by the experimenter.

Each CAI drill was self-contained in the sense that all subroutines required to operate an instructional sequence were available within a single programme. This provided a straightforward command structure that avoided the need to call in multiple programmes during the course of instruction. The logical design of the software helped to minimize the complexity of the CAI system and thus overcome some of the technical problems that can arise when using two or more supporting programmes. The disk space required to run any one of the programmes on the system was approximately 20 K (20000 characters).

In order to minimize the length of each programme, a set of subroutines was created to carry out the drill and diagnostic procedures.

FIGURE 1

Audio and visual information are presented under computer control.

Responses can be input to the computer using a light sensitive pen.

Some examples of these routines are presented here to illustrate the manner in which programmes were designed:

MENU: This was a management programme that provided a directory of CAI drills contained on disk. By pressing a number corresponding to the required programme, MENU would automatically load then execute any of the available CAI procedures. This simplified access to the teaching programmes by overcoming the need to manually enter system commands at the beginning of each session.

DISPLAY: This included several subroutines that controlled display of target words and distractors on the video display unit (VDU). Items were randomly assigned to one of the four designated screen positions for each presentation. It was felt that random placement of the items would help minimize any tendencies toward perseveration and position preferences that might otherwise occur with a fixed sequence of words.

FADE: This subroutine first tested the input response and then replaced or removed distractors according to whether a response was correct or incorrect. A second function of FADE was to govern the presentation of audio messages and slide projection. Accumulation of error responses would activate the audio cassette to play an additional message. Alternatively, a correct response was used as a signal to bypass these error messages by playing the cassette with the microphone switched off.

CONFIRM: The first subroutine of CONFIRM was designed to print a flashing message (***IS RIGHT***) alongside the target word as visual confirmation of a correct response. A second subroutine was then called to display a graphics figure of a "HAPPY FACE" on the VDU. Both of these routines were activated whenever a correct response was detected by the programmes.

ERROR: Whenever an incorrect response was entered, the ERROR routine was called to print the message ***NO, TRY AGAIN*** at the bottom of the video display screen. A second subroutine was also activated to draw a "SAD FACE" in graphics blocks whenever an error was detected.

LIGHT PEN: This consisted of two subroutines for initialization of the data points on the VDU and detection of the pen location. A graphics block was created alongside each of the items displayed on the screen. These blocks served as a light source for checking to determine where the pen was being pointed. Placement of the pen on a graphics block corresponding to the target word activated the CONFIRM subroutines. Conversely, detection of other light sources (distractors) called the ERROR routine described above.

DIAGNOSE: Data on the number of attempts and time spent on each of the four trials for all ten items was automatically accumulated by this subroutine. Total time spent working on the problems and elapsed time for a completed session were also recorded. This information was accumulated and printed at the end of each session on the VDU screen.

Development of Computer Assisted Instruction Courseware

Two major instructional sets considered to be representative of conventional interpersonal approaches for teaching word recognition were designed for presentation by the computer. The first of these, termed errorless discrimination, made use of a straight word focus in which the subject was guided through a progressively complex series of visual discriminations. The second instructional set involved the teaching of picture-word combinations using a paired-associate format. Care was taken to design the CAI drills in a logical format to facilitate comparison of treatment effects for complementary programmes using either the computer-based or instructor-dominated approaches. From the outset, it is stressed that the purpose of the investigation was to evaluate the teaching of social sight word recogniton. This was based upon the assumption that subjects could visually identify pictures or real life objects of the words to be taught but were unable to read the referent word for each item.

The CAI courseware was constructed so that each subject could work at his/her own pace. Subjects could take as long as they required to work on each problem though once a response was registered the system provided immediate visual feedback. Overlearning was offered according to each person's needs by repeated presentation of the stimulus material and simplification of the task requirements when mistakes were made. This errorless learning procedure ensured that participants would experience success at several points in the programme.

The instructional sequence presented by the computer contained both linear and branching routines that were followed according to the progress of each learner. At several points in the programmes, additional audio and visual support were available when errors occurred but could be bypassed on detection of correct responses. A detailed description of the two training procedures and corresponding CAI programme structures is presented in the following section.

1. Errorless Discrimination Learning

This approach made use of a straight word focus and no pictorial material was presented. With the errorless discrimination or word shaping technique (Terrace, 1963; Walsh and Lamberts, 1979), the teacher or computer initiates learning by reinforcing a stimulus-response relationship that the subject can easily acquire, and progressively alters the complexity of discriminations until a restricted stimulus-response relation (the terminal teaching objective) is attained. The Edmark Reading Programme (1972) is perhaps the most well documented application of this teaching method.

In the discrimination approach of the Edmark Programme, the word to be taught is first presented and identified by the teacher who says, "Point to the word _____." Over a series of four to six trials, the pointing response is shaped by displaying distractor items along with the target word. Each trial is intended to provide a more difficult discrimination. Comparison stimuli are initially very dissimilar but eventually become similar to the target word with only subtle differences between the words or word-like letter configurations. Following is the sequence for computer presentation of the errorless discrimination method:

CAI Training Sequence: Errorless Discrimination

Step 1 - Introduction

(a) An audio message was presented to introduce the session; "Hello, my name is Micro." "I'm a talking computer." "Today we are going to read some new words." "Please tell me your name." Coinciding with this audio message, a programme title was displayed on the video screen.

(b) The subject entered his name into the computer by means of the keyboard. Assistance from the examiner was available where necessary though most subjects were able to type their own names unaided.

Step 2 - Presentation of Target Word

(a) Presentation of item to be taught in 32 characters per line mode (large upper case letters) on the video display unit of the TRS-80 microcomputer.

(b) Audio information on the word to be taught. "This word says _____." "Now have a look at the word _____ on your screen." Target word is displayed for five seconds.

Step 3 - Trial 1

(a) An explanatory audio message is provided on the word to be identified. "Now you point to the word _____." (Using the light sensitive pen)

(b) VDU screen display of the item plus three distractors. For Trial 1, the three distractors are grossly dissimilar from the target word to be taught.

e.g. BUS STOP
???
???
???

(c) The subject identifies the response item by pointing the light pen at a graphics block alongside and immediately to the left of the item selected.

e.g. ☐ BUS STOP
☐ ???
☐ ???
☐ ???

The light pen must be held in a selected position for 3 seconds. This response delay was intentionally built in to the programme to minimize the triggering of false responses that might otherwise occur while accidentally moving the pen across the screen surface to locate a specific item.

(d) If the subject was correct, the message ***IS RIGHT*** was flashed alongside the target word for a duration of approximately 3 seconds. Following this, a "HAPPY FACE" drawn in graphics blocks was displayed on the screen for 2 seconds to provide further confirmation of a correct response. The program then automatically advanced to trial 2 (Step 5). In this case, the error fading routine of Step 4 was bypassed.

(e) If wrong, the subject is advanced to the error fading routine of Step 4.

Step 4 - Error Fading Routine

(a) If the student failed to identify the correct word an error message appeared at the lower left-hand corner of the VDU (***NO,TRY AGAIN***). This was followed by a graphics display of a "SAD FACE" for 2 seconds only. Total elapsed time for error feedback is 5 seconds.

(b) VDU screen display of item plus 2 distractors for Trial. The distractor selected by mistake is removed (faded out) for this presentation.

(c) If the subject is correct on (b) above, the message ***IS RIGHT*** was flashed alongside the target word. This was followed by presentation of the "HAPPY FACE." Then the complete list comprising the target word and 3 distractors was again presented. An additional audio message was played at this point. "Find _____."

(d) If wrong on (b) above, the error message and "SAD FACE" routines are called for display. Continued errors caused the remaining distractors to be removed one at a time until only the target item was displayed. Then the subject is branched back to (c) above for another attempt at the complete list.

Due to practical limitations of the equipment and time available, subjects were allowed a maximum of 9 attempts on each trial. This included a total of 3 attempts at the complete list (with accompanying audio messages) following which the programme automatically advanced to the next trial.

<u>Step 5 - Trial 2</u>

(a) Trial 2 was displayed on the VDU. This contained a slightly more complex discrimination; the item to be identified and 3 distractors placed in random order.

e.g. □IN
□AT
□BUS STOP
□ON

An audio message was provided at this point: "Point to _____."

(b) If correct, the flashing confirmation and "HAPPY FACE" subroutines are displayed and the programme branches to Step 6 (Trial 3).

(c) If wrong, the error message and "SAD FACE" subroutines are displayed and the programme branches to Step 4 (error fading). A maximum of 9 attempts, including 3 tries at the complete list (with accompanying audio messages) were provided.

Step 6 - Trial 3

(a) Trial 3 was displayed on the video screen. This required a moderately difficult discrimination between the target word and 3 distractors, all of approximately the same word length though commencing with different letters.

e.g. ☐ DANGER
☐ BUS STOP
☐ RAILWAY
☐ COFFEE

An audio message was again provided concurrent with the above presentation: "Point to ______."

(b) If correct, the flashing ***IS RIGHT*** confirmation and "HAPPY FACE" subroutines are presented. The subject is then automatically advanced to the fourth trial described in Step 7.

(c) If wrong, the error message ***NO, TRY AGAIN*** and "SAD FACE" subroutines are displayed. The programme then branches back to the fading procedures described in Step 4.

Step 7 - Trial 4

(a) The fourth and final trial was presented on the video screen. This comprised a very complex discrimination in which the target word and 3 distractor items started with the same letter and were all of similar length.

e.g. ☐ BLAMELESS
☐ BIRD HOUSE
☐ BUS STOP
☐ BINOCULAR

(b) If correct, the flashing ***IS RIGHT*** confirmation and "HAPPY FACE" subroutines are displayed and the programme branches to the next training sequence.

(c) If wrong, the error message ***NO, TRY AGAIN*** AND "SAD FACE" subroutines are displayed. The programme then branches to the fading procedures described in Step 4.
By default, the programme advanced automatically to the next training item when a target word was selected from a complete list or after 9 attempts were completed.

The above sequence was identical for the two practice items and eight target words presented in each module. A maximum of 360 attempts and 120 audio messages were available for each training session though many of these branches could be bypassed in the event that subjects registered correct responses.

2. Paired Associate Learning

In this method, a picture and corresponding printed word are presented simultaneously with the intention that responses to the printed word are learned with repeated pairing (Vergason, 1968; Parmenter et al.,1979). The paired associate items each contained two elements: (1) a stimulus element (photograph) presented on 35 mm slides, and (2) a response element (word) displayed on the video screen. Thus, the pairing consisted of a response word which students did not know accompanied by a stimulus element (picture) which all subjects could recognize. As with the errorless discrimination method, four trials were presented to teach each of the eight target words. Two practice items were also included at the beginning of each session for demonstration purposes and pre-training. Following is a description of the computer based paired associate programme developed for use in the investigation:

CAI Training Sequence: Paired Associate Learning

Step 1 - Introduction

(a) An audio message was played on cassette tape under computer control to introduce the session. "Hello, my name is micro." "Today we are going to look at some pictures and read some new words." "Please tell me your name." A programme title was displayed on the video screen.

(b) The subject entered his name into the computer using the keyboard provided. Assistance from the examiner was given as required although most subjects could type their name without assistance.

Step 2 - Presentation of Target Word and Referent Picture

(a) A 35 mm transparency was displayed by means of the rear image projection screen of the sound/slide projector.

(b) Audio information was provided on the word to be taught. "This picture shows _____." "Now look at the word ____ on your screen.

(c) Target word was displayed on the video screen for 5 seconds. The slide remained in view during the entire teaching sequence for each item.

Step 3 - Trial 1

(a) An audio instruction was provided on the word to be identified. "Now you point to _____." (Using the light sensitive pen)

(b) The target word was displayed on the video screen. For trial 1 no distractors are presented.

e.g. BUS STOP

(c) Subjects entered their response by pointing the light pen to a graphics block alongside and immediately to the left of the item.

e.g. □ BUS STOP

(d) Visual feedback was provided by flashing the message *** IS RIGHT*** alongside the target word for approximately 3 seconds. This was followed by a 2 second screen display of a "HAPPY FACE" drawn in graphics blocks on the VDU.

Step 4 - Trial 2

(a) Trial 2 was presented on the VDU. This consisted of the target word and 1 distractor selected at random from a pool of 3 items for that trial. An audio message was provided: "Point to _____."

e.g. □ BUS STOP
□ RAILWAY

(b) If correct, the flashing confirmation and "HAPPY FACE" subroutines were presented. The subject was then automatically advanced to trial 3 described in Step 6.

(c) If wrong, an error message appeared on the lower left-hand corner of the video screen (***NO, TRY AGAIN***). This was followed by a graphics display of a "SAD FACE" for 2 seconds. At this point the programme branched to the error routine decribed in Step 5.

Step 5 - Error Fading Routine

(a) Failure to identify the correct target word resulted in presentation of the error message and "SAD FACE" routines.

(b) VDU screen display of the target word and distractors less the item selected by mistake on the previous trial. The distractor chosen by error was removed (faded out) for this presentation.

(c) If the subject was correct on (b) above, the printed confirmation message and "HAPPY FACE" subroutines were presented.

The complete list comprising the target word and distractors was again displayed (Trials 2, 3, and 4 contained 1, 2, and 3 distractors respectively). An additional audio message was played at this point to remind the subject of the target word for that sequence: "Find _____."

(d) If wrong on (b) above, the error message and "SAD FACE" subroutines are displayed. Continued errors on each attempt caused the remaining distractors to be removed one at a time until only the target item was displayed. Subjects were then branched back to (c) above for another attempt at the complete list.

As with the errorless discrimination procedure, a maximum of 9 attempts, including 3 tries at the complete list (with) accompanying audio messages was provided. The programme then automatically advanced to the next trial.

<u>Step 6 - Trial 3</u>

(a) Trial 3 items were displayed on the VDU. This contained the target word and 2 distractors. For example:

☐ BUS STOP
☐ RAILWAY
☐ SCREWDRIVER

An audio message was played under computer control: "Point to _____."

(b) If correct, the flashing ***IS RIGHT*** confirmation and "HAPPY FACE" subroutines were presented. The programme then advanced to Trial 4 as described in Step 7.

(c) If wrong, the error message ***NO, TRY AGAIN*** and "SAD FACE" subroutines were displayed. The programme then automatically advanced to the fading procedures in Step 5.

<u>Step 7 - Trial 4</u>

(a) The fourth and final trial was displayed on the VDU. This comprised the target word and 3 distractors.

e.g. ☐ RAILWAY
☐ BUS STOP
☐ SCREWDRIVER
☐ COFFEE

An accompanying audio message was played: "Point to _____."

(b) If correct, the flashing ***IS RIGHT*** confirmation and "HAPPY FACE" subroutines were displayed on the screen. The programme then advanced to the next training sequence and followed an identical set of procedures to those outlined in the above steps.

(c) If the subject was wrong, the error message ***NO, TRY AGAIN*** and "SAD FACE" were displayed. The programme then branched back to the fading routine in Step 5.

By default, the programme automatically advanced to the next training sequence when a maximum of 9 attempts were completed or whenever a target word was selected from a complete list. Precisely the same procedures were followed for each of the 2 practice and 8 training words contained in a training module.

Development of Individual Instruction Programmes

In order to provide a meaningful framework for comparing computer-based instruction with more conventional interpersonal methods of tuition, complementary programmes were devised to teach word recognition by means of individual instruction. Essentially the procedures used by teachers were identical to those presented by the microcomputer. One major exception was that flashcards and photographs were used to present the stimulus material rather than the video and slide displays employed with the computer system. Another difference can be seen in terms of the amount of verbal interaction which, despite standardisation of instructions and feedback, was naturally greater in the interpersonal situation. Notwithstanding these practical differences, every attempt was made to ensure that the individual teaching procedures paralleled those of the CAI programmes with regard to type of verbal information, presentation of materials, and sequence of instruction.

As with the computer assisted instruction, two programmes were devised to teach word recognition by means of the errorless discrimination (word only) and paired associate (picture-word) methods. Following is a description of the precise sequence used in the two experimental methods for teaching each of the target words:

1. Errorless Discrimination Training Sequence (ED)

A flashcard displaying the word to be taught is first presented and verbally identified by the teacher. Over a series of four trials, the teacher attempted to shape a correct response by having the subject point to the target word in the presence of other distractor items. Each trial was intended to provide a slightly more complex discrimination. Comparison stimuli are initially very dissimilar but eventually become similar to the target word with only subtle differences between the words or word-like configurations. An example of the four trials used for teaching one of the practice items is presented below:

Trial 1	Trial 2	Trial 3	Trial 4
???	IN	BUS STOP	BINOCULAR
BUS STOP	AT	DANGER	BUS STOP
???	BUS STOP	RAILWAY	BIRDHOUSE
???	ON	COFFEE	BLAMELESS

Placement of the items for each trial was random. Incorrect responses resulted in the removal of distractors until the target word was correctly identified. A maximum of 9 attempts for each trial was provided. The precise sequence of instructions were as follows:

Individual Training Sequence: Errorless Discrimination

Step 1 - Presentation of Target Word

(a) The examiner (E) presented a flashcard containing the word to be taught.

(b) E provided a verbal label for the word: "This says _____." "Now you say _____." The target word was displayed for five seconds.

Step 2 - Trial 1

(a) Flashcards containing the target word and three distractors for trial 1 are randomly presented. These are placed out vertically on a desk directly in front of the trainee.

(b) E says, "Now you point to _____."

(c) The subject responds by pointing to a chosen item.

(d) If the subject was correct, then E provided verbal feedback (e.g. "Good", "Okay") and advanced to trial 2 as described in Step 4.

Step 3 - Error Fading Routine

(a) If the subject failed to point to the correct target word then E said, "Let's try again." All flashcards were removed from the table.

(b) Presentation of target word plus 2 distractors. The distractor selected by mistake is removed (faded out) for this presentation.

(c) If the subject is correct, then E provides neutral verbal feedback (e.g. Good, Okay). Then the complete list comprising the target word and 3 distractors are again randomly presented. An additional verbal message is given at this point: "Point to _____."

(d) If wrong on (b) above, neutral verbal feedback was given: "Let's try again". Continued errors cause the remaining distractor(s) to be removed one at a time until only the target word is displayed. Then the subject is given another attempt at the complete list. The cards are removed from the table following each presentation and then randomly placed in preparation for the next attempt.

Due to practical limitations and available time, subjects were allowed a maximum of 9 attempts on each trial. This included a total of 3 attempts at the complete list, following which the examiner advanced to the next trial.

Step 4 - Trial 2

(a) Trial 2 cards are presented by E. These contain a slightly more complex discrimination; the item to be identified plus 3 distractors placed in a random order. E says, "Point to _____."

(b) If correct, then E provided verbal confirmation. E advanced the subject to trial 3.

(c) If wrong, then E provided verbal feedback (e.g. "Let's try again") and removed the cards. The error fading routine in step 3 was followed until a correct response was illicited. A maximum of 9 attempts including 3 tries at the complete list are provided.

Step 5 - Trial 3

(a) Trial 3 cards were presented by E. This required a moderately difficult discrimination between the target word and 3 distractors, all of approximately the same word length. E says, "Point to _____."

(b) If correct, then E provided verbal confirmation. The subject was then advanced to the final trial.

(c) If wrong, then E provided verbal feedback ("No, Let's try again.") and removed the cards. The error fading routine in step 3 was followed until a correct response was made by the subject from a complete list of words.

Step 6 - Trial 4

(a) The fourth and final trial was presented by E. This contained a very complex discrimination in which the target word and 3 distractor items had the same beginning letter and were all of approximately the same word length. E said, "Point to _____."

(b) If correct, then E provided verbal confirmation and advanced the subject to the next training word.

(c) If wrong, the error fading procedures described in Step 3 were followed. On attaining a maximum of 9 attempts the subject was advanced to the next training item.

The same sequence of instruction was used for the two practice items and eight target words. A maximum of 360 attempts were possible though advancement through the programme could be rapid when correct responses were made. Four trials for each of the 10 words results in a total of 40 trials for each session.

2. Paired Associate Training Sequence (PAL)

A picture and corresponding word are presented simultaneously in an attempt to teach responses to the printed word by repeated pairings with a familiar picture. In this case, the picture serves as an additional prompt that remains in view during the entire training sequence. The paired associate items each contained two elements: (1) a stimulus element (picture) presented in high quality colour photographs, and (2) a response element (word) displayed on a flashcard using upper case letters. Four trials were presented to teach each of the 8 target words. Additionally, 2 practice items were included for demonstration at the beginning of each session. Each trial became progressively more difficult as the subject was required to select a target word from a list of items. An additional distractor was added to each consecutive trial:

e.g. Trial 1	Trial 2	Trial 3	Trial 4
BUS STOP	BUS STOP	RAILWAY	HAMMER
	RAILWAY	BUS STOP	RAILWAY
		HAMMER	BUS STOP
			ENTRANCE

The target word and distractor items were placed vertically and at random on a desk in front of the subject. Incorrect responses resulted in the removal of distractor(s) on which a mistake was made until the target word was correctly identified. Following is the instructional sequence for each word taught:

Individual Training Sequence: Paired Associate Learning

Step 1 - Presentation of Target Word and Corresponding Picture

(a) E presented a photograph and said, "This shows ______."

(b) E then presented a flashcard containing the target word and said, "This word says _____." "Now you say _____." The target word was displayed for five seconds and then removed while the referent photograph remained in view during the entire sequence.

Step 2 - Trial 1

(a) E presented the target word saying, "Now you point to ___."

(b) The subject responded by pointing to the target word. No distractors were presented for Trial 1. Verbal confirmation was given by E (e.g. "Okay","Good").

Step 3 - Trial 2

(a) Trial 2 cards are presented by E. This consisted of the target word and 1 distractor selected at random from a pool of 3 items for that tiral. E said, "Point to ____."

(b) If the subject is correct, then E provides verbal feedback (e.g. "Good","Okay"). Then the subject is advanced to Trial 3.

(c) If wrong, then E provided verbal feedback (e.g. "Try again") and removed the 2 cards. The error fading routine was followed by removing the distractor and presenting the target word alone. Following this, the distractor was again introduced until the subject could correctly identify the target word.

Step 4 - Error Fading Routine

(a) If the subject failed to point to the correct target word then E said, "Let's try again." All flashcards were removed from the table.

(b) Presentation of the target word and distractor(s) less the item selected by mistake on the previous trial. The distractor chosen in error was removed (faded out) for this presentation.

(c) If the subject was correct on (b) above then E provided verbal confirmation (e.g. "Good", "Okay"). The cards were then removed.
The complete list comprising the target word and distractors was again displayed by E (Trials 2, 3, and 4 contained 1, 2, and 3 distractors respectively).

(d) If wrong on (b) above, E provided verbal feedback, saying, "Try again." Continued errors on each attempt cause the remaining distractors to be removed one at a time until only the target item was presented. Subjects were then given another attempt at the complete list. A maximum of 9 attempts including 3 tries at the complete list was provided. E then advanced the subject to the next trial.

Step 5 - Trial 3

(a) Trial 3 cards were presented by E. This included the target word and two distractor items. E provided a verbal instruction, saying, "Point to the word _____."

(b) If correct, then E provided verbal confirmation. E then advanced the subject to trial 4.

(c) If wrong, then E provided verbal feedback, saying "Try again." The cards were removed from the table. The error routine in step 4 was followed until the subject made a correct response for the complete list of words (target word and 2 distractors).

Step 6 - Trial 4

(a) The final trial was presented by E. This consisted of the target word and 3 distractors placed at random on the table. E said, "Point to the word _____."

(b) If correct, then E provided verbal confirmation and advanced the subject to the next training word.

(c) If wrong, E gave verbal feedback, saying, "Try again." The fading routine described in Step 4 was followed until the subject could correctly identify the target word from a complete list.

The above sequence was precisely followed for each of the two practice words and eight training words contained in each module. This provided a total of 40 trials for each session. With the exception of verbal feedback, this manual procedure was identical to the CAI version of the paired associate programme.

CHAPTER VI
RESEARCH DESIGN AND PROCEDURES

Introduction

This chapter describes an evolution of the study through a pilot phase to the main research project which was undertaken in this investigation. A detailed account on the procedures used to select training items and subjects is included. It was considered essential also to describe the development of criterion measures designed especially for this study. Administration of the test items and training programmes is discussed in this section with regard to both the computer assisted instruction and individual tuition groups. This is followed by a statement of specific hypotheses to be tested and comments on design of the study.

Pilot Phase

As with all innovative programmes, it is desirable to carry out some trial training procedures prior to implementation of a major research project. Much informal information was collated during the course of preceding research with microcomputer-based instruction at Cook Street Training Centre in Palmerston North. It was determined that trainees could, for the most part, operate the equipment and learn through interaction with the computer to carry out basic arithmetic and pre-reading drills. Problems were also identified that led to several modifications in the learning programmes. These included adjustment of speed at which visual information was given and amount of audio instruction provided. The piloting phase took place over a six month period from January to June, 1980.

Several purposes can be advanced for a preliminary phase of the investigation: firstly, to test all aspects of the courseware both in terms of theoretical and practical application; secondly, to determine how well intellectually handicapped adults can handle the computer equipment; thirdly, to assess the reliability of the computer programmes and hardware; and finally, to determine a suitable schedule for instruction and amount of supervision required for students interacting with the computer.

Over the pilot period, many changes were made to both the equipment and programme routines. These were based upon systematic observations of learner's interaction with the computer and experimental findings obtained in a preliminary study that compared the performance of subjects receiving computer assisted instruction with other persons who were given comparable individual tuition on a word recognition task. Modifications were necessitated by limitations in the capabilities of low cost equipment and practical considerations such as the optimal amount of time for each session and number of trials presented in the learning of a task. The results of ongoing research and systematic observation provide a logical base on which to design the teaching programmes ultimately used in this investigation. Following are some of the developments made in preparation for trial evaluation of the teaching programmes.

1. Unlike larger, more sophisticated terminal equipment, the microcomputer and special purpose peripheral equipment are proving simple to operate and reliable in performance. Of the approximately 1000 hours of computer assisted instruction that has been provided to the present, very little time (less than 5 per cent) has been lost due to equipment failure.
2. Reliability of the courseware was also determined through the pilot phase. It could be hazardous or detrimental to expose learners to courseware that 'falls out' of audio-visual sequence or fails to provide appropriate feedback. To this point it appears that the disk operating system (DOS) provides reliable loading of teaching programmes over many trials. Previous experience showed that use of cassette tapes can be an unreliable input medium whereas DOS offers fast and accurate translation of the programmes stored on diskette. The teacher can automatically load a wide variety of programmes by simply reading a 'menu' and pressing a numeral corresponding to the teaching drill required. Loading of programmes is almost instantaneous and takes a matter of seconds.
3. The teaching routines of the programme modules originally displayed a fixed sequence of multiple choice items with feedback on correct and incorrect performance. Because some trainees have demonstrated a tendency to perseverate on order of the items, a routine was developed to provide random displays of the target words and distractors.
4. Another modification to the courseware involved development of a fading routine in which a distractor word was removed from the screen each time the subject recorded an error. Thus, the word

recognition task can be made easier when the learner is encountering difficulty or progress to more complex problems once the basic level has been mastered. This has made it possible to branch the programme according to each person's performance and carry out remedial drills or overlearning as required.

5. Earlier social sight reading programmes presented between ten and twenty words in a linear progression. This was a considerable amount of information for the learner to retain in a single session. A modular teaching approach was adopted such that the individual receives instruction on a maximum of eight words within a similar class of events (e.g. tool recognition, information signs) and must master these target words before progressing to a new module. Simple practice items were also provided at the beginning of each session as a pre-training exercise.
6. An automatic clock subroutine was incorporated into the programme to provide an exact breakdown of the amount of time and number of attempts spent on each trial. This information was automatically printed in the diagnostic summary at the end of each session.
7. A line printer was interfaced with the microcomputer to provide a hardcopy printout of the learner's performance in the session. This printout was automatically generated and contains information on the results of each trial along with amount of time spent on individual items. A paper printout could then be given to the learner as a personal copy of his work while a duplicate printout was retained for training file records.

Trial Evaluation

After completion of the modifications described in the previous section, a trial evaluation of the CAI teaching programmes was undertaken to obtain some practical information on the utility of the procedures for teaching handicapped persons. It was deemed essential to carry out a small scale study similar in format to the main project. A brief account of the evaluation is presented here.

1. Subjects: Eight trainees attending the Cook Street Training Centre, Palmerston North were initially pretested on a word recognition task. The test simply involved individual presentation of eight flashcards containing common words and required that the trainee say each word he or she already knew. Four subjects who were unable to recognise five or more of the words were selected for

participation in the trial study. Subjects were randomly assigned to computer assisted instruction or individual tuition groups.

2. Procedure: Parallel programmes for teaching word recognition by means of CAI and individual tuition were devised. An errorless discrimination approach (Sidman and Stoddard, 1967), with a strict word focus that employed no pictures, was used for the experimental trials. Over a series of five training sessions, three trials were provided to teach each of the eight target words (24 trials per session). "The word says ____." For each of the three trials, a target word and two distractor items was displayed. Subjects were instructed to "Point to the word ____." In the first trial, comparison stimuli were grossly dissimilar while in trials two and three the distractor items more closely resembled the target word.

e.g.	Trial 1	Trial 2	Trial 3
	???	DANGER	DANGER
	DANGER	IN	GROUND
	???	OUT	DROPPED

When subjects made an error, the mistaken distractor was removed for the next presentation. Once the target item was correctly identified, the distractor(s) were again introduced. Subjects were not advanced to the next trial until they could locate the target word in the presence of two other distractors. This fading procedure guaranteed success at several points in the programme while providing overlearning trials when errors occurred.

For the CAI version of the programme, stimuli material was displayed on the video screen. Students identified response items by pressing a 'YES' key on a simplified keyboard when a cursor arrow came alongside the answer chosen. Speed of arrow movement was a constant two seconds per item to help minimise errors that might occur when subjects were slow in responding. For example, pressing the 'YES' key just as the cursor moves to the next location will result in an error message even though the intended item was correct. Feedback was given on the visual display by means of a flashing *** IS RIGHT*** message that appeared alongside the target word. Selection of an incorrect item would be followed by the error message "NO, TRY AGAIN", displayed at the bottom of the screen. Taped audio messages were played at the beginning of each new sequence and trial under computer control.

In the individual instruction version, stimulus materials were presented on flashcards. The experimenter identified each word and instructed subjects to point to the target item as required. An identical instructional sequence to that presented by the computer was used for the individual tuition. However, a verbal feedback was offered in place of visual messages; for example, "That's Right" or "Try Again" were consistently used for correct and incorrect responses.

Upon completion of the five training sessions the word recognition test was again administered using a flashcard method. Subjects were asked to provide a verbal label for each of the target words.

3. Results: As can be seen in Table 1, a comparison of pre-versus post-test scores indicates that all four subjects made gains in word recognition. There appears to be similarities between the performance of subjects given individual tuition versus those who received CAI though caution must be exercised in generalising these findings on the basis of such a minor evaluation. The number of attempts to mastery for each trial is presented in Table 2. The very large range of attempts between subjects (166-427) highlights the variations in performance on the experimental task. It is felt that in the case of S2, problems with psychomotor speed accounted for an inordinately large number of errors. In general, it can be stated that all four subjects improved following participation in training regardless of whether they were given CAI or conventional instruction.

The trial evaluation served as a basis for obtaining observational and anecdotal data on practical aspects of the CAI teaching programmes. Through this analysis, it became evident that the computer generated instruction was deficient in a number of important ways with regard to presentation of information and response procedures. Identification of these problems led to further modifications in an attempt to develop more equivalent forms of CAI and individual instruction. Following is a brief account of some changes that led to final development of the CAI system and teaching programmes.

a. Audio messages were played under computer control only at the point of introducing each new target word or trial. Thus, when subjects made errors they would follow through the fading routine with no further audio instructions. It was observed that this lack of audio support often resulted in the subject losing track of the learning set, especially when several attempts were re-

Table 1

Pilot Study

Pre- Versus Post-Test Comparison

SUBJECT	*MODE OF INSTRUCTION	PRETEST RECOGNITION		POST TEST RECOGNITION		DIRECTION OF IMPROVEMENT
		RECOGNITION	ID	RECOGNITION	ID	
S1	IND	0	3	1	4	+
S2	CAI	0	1	1	4	+
S3	CAI	3	6	7	8	+
S4	IND	0	2	4	4	+

Table 2

Pilot Study

Number of Attempts to Mastery

SUBJECT	*MODE OF INSTRUCTION	NUMBER OF ATTEMPTS TO MASTERY					
		SESSION 1	2	3	4	5	TOTAL
S1	IND	74	45	53	42	29	243
S2	CAI	106	66	92	77	86	427
S3	CAI	36	32	30	34	36	168
S4	IND	38	34	40	28	26	166

*CAI = Computer Assisted Instruction

IND = Interpersonal Tuition

quired to complete a given trial. This problem was overcome by providing two additional audio messages, "Point to ______.", which were played when an incorrect response was registered. In the event that the subject selected the appropriate target word, these extra audio messages would be bypassed in preparation for an introduction to the next item or trial. A limitation of this method was that, in the case of correct responses, the audio cassette player required several seconds to advance beyond the extra support messages. Consequently, there was a brief (five second) waiting period between each stage of the programme.

b. During the trial CAI evaluation, a fading routine was followed until such time as the subject could correctly identify the target word from a complete list (training item and two distractors). On occasion this required an inordinately large number of attempts on any one of the trials where subjects experienced difficulty. Due to time factors imposed by the length of each session and amount of repetition, it was deemed advisable to set the maximum number of attempts to nine for each trial. This criterion for continuation was chosen because a certain amount of overlearning was considered advisable, though subjects were not constrained from advancement to subsequent trials or items when a major obstacle was encountered.

c. The number of trials used during the pilot phase was set at three per each item. It was decided to extend this to four trials for each target word in the main investigation. This decision was based on the assumption that more effective learning might occur as a result of reduction as step size and progressive advancement of difficulty level over each of the four trials. This also served to increase the amount of overlearning that was possible at each level of the programme.

d. Only visual feedback was presented by the computer system. This consisted of a flashing *** IS RIGHT *** message or error term ***NO, TRY AGAIN *** displayed on the video screen following each response. Informal observations suggested that an additional feedback mechanism was required to ensure that subjects received meaningful reinforcement for each kind of response. For the main project it was decided to include a happy/sad face routine drawn in graphics blocks on the VDU. Immediately following each written confirmation, a happy face or sad face was displayed according to whether the subject was correct or not. It was felt that this routine was somewhat parallel to providing gestural feedback (a smile or frown) in an interpersonal situation and ensured that subjects received a comprehensible form of reinforcement. Technical limitations precluded the use of audio confirmation.

e. The input routine of pressing a key in response to location of a cursor on the video screen involved a complex psychomotor operation. Informal observation suggested that while trainees could comprehend the response requirements, they were unduly penalised for slow speed of movements, or inability to coordinate visual and motor responses. In any case, it was obvious that this input mechanism was not equivalent to the simple pointing response employed in individual tuition. This problem was overcome with the addition of a light sensitive pen to the system. The subject could then identify a response by simply pointing the photosensitive pen to a position alongside the item selected. This avoided the need to use a keyboard for interaction with the computer programmes.

Survey of Social Sight Words

Selection of words for inclusion in the teaching modules was carried out in consultation with supervisors at the Cook Street and Aokautere Training Centres. Sixteen staff members were individually asked to nominate a set of sight words that they felt were of practical value in community life. A copy of the survey form is presented in Appendix A. Staff were asked to list words within each of four categories: (1) community information, (2) traffic safety, (3) tool names, (4) grocery/food items.

The frequency of items nominated by supervisors was tabulated to identify a common pool of words. From this master list, forty words most frequently mentioned were selected for trial administration to trainees in the screening phase of the project. It was felt that this survey approach would provide a meaningful and objective base for selection of training items. This avoided arbitrary designation of words and ensured that the contents of the teaching programmes was representative (by consensus) of items that supervisors might normally teach by means of conventional instruction.

Screening of Subjects

Sixty-eight trainees attending two Training Centres and a Special School in Palmerston North were chosen for participation in the screening phase of the project. These subjects were selected on the basis of a previous assessment, the Social Education Test (Marlett, 1973), which indicated they were unable to recognise a basic set of social sight words. Some of the subjects had not yet been given this assessment but were judged by staff members to have little or no reading ability.

The screening was conducted during April and May 1980. Trainees were seen by the experimenter, or one of two trained assistants, and individually administered a set of three tests, involving visual discrimination, word recognition, and word identification. The screening phase served two functions: to determine which subjects would participate in the study, and secondly, to select the words that would be taught. Following is a description of the screening procedures:

1. Visual Discrimination Test (Brown and Bookbinder, 1967)

This test was administered to observe if the student could recognise then match shapes and groups of letters. A copy of the test form is presented in Appendix B. The test was administered using a flashcard method. Each card contained a stimulus item on the left hand margin and four multiple choice items on the right hand side of the card.

e.g. Item 10	OES
EOS	SEO
	ESO
	EOS

The test items are arranged so that substitutions, omissions and reversals can be detected. Subjects were instructed to look first at the stimulus item then examine the four choices to locate an identical match. It was deemed essential that subjects selected for participation in the study could accurately decode printed material in the form of letters and word combinations. This test served as a basis for determining that subjects' visual perception and cognitive ability (matching to sample) was sufficiently developed prior to receiving instruction in word recognition. The absence of these pre-requisite abilities was used as a criterion for exclusion of subjects from participation in training. Because of the very difficult items contained in the later half of the visual discrimination test, it was arbitrarily decided to exclude subjects who were unable to achieve a 50 percent (23/45) performance level. This was deemed to be a conservative enough estimate for selection of subjects who possessed the necessary preskills and could potentially benefit from participation in word recognition training. Only four of the sixty-eight were omitted from the study on the basis of this 50 percent criterion.

2. Word Recognition and Identification

This test made use of the forty words previously identified by survey consensus of the training staff as having potential survival value in community living. A test form and list of nominated words is displayed in Appendix C. The forty words were randomly allocated to five modules of eight words each. Immediately following administration of the Visual Discrimination Test, the Word Recognition and Identification test was individually presented to each subject using a similar procedure to that employed by Dorry and Zeaman (1975). Word modules were randomly presented to counterbalance any list order or test sophistication effects. The procedure involved random placement of the eight flashcards in a 4 x 2 matrix arrangement on a desk directly in front of the subject. Spacing between the cards was approximately five cm.

e.g. Random Module 1

EXIT	MILK
HAMMER	FORK
SPANNER	SHOVEL
BUTTER	SUGAR

Only upper case letters were used in the investigation because of the predominant use of capital letters on information signs in the community. Also, it was considered likely that subjects had prior familiarity with capital letters which are commonly employed for teaching a social sight vocabulary in special education environments. Words were stenciled onto 8 x 16 cm flash cards using black ink on a white surface. To ensure that subjects could view the words clearly from a normal sitting posture, a large letter format of 2.5 cm was used for all of the test items.

Subjects were first asked by the experimenter if they recognised any of the words, saying, "Do you know any of these words?" "Please point to any word that you know." If the subject pointed to a word then he was asked, "What does this word say?"

In word recognition the subject was required to verbally label (say) each word presented. For each of the eight words in turn, the examiner pointed to the flashcard and said, "What does this word tell us?" If no response was made by the subject within 10 seconds then the next word was presented.

For the Word Identification part of the test, subjects were asked to "Point to the word that says ______." This procedure was administered after the Word Recognition Test to rule out the development of a restricted verbal response set by subjects. Identical administrative and recording procedures were employed for all five of the word modules. Subjects generally responded well to the individual attention given and appeared motivated, thus providing a meaningful sample of their ability to recognise a basic set of words. All testing was conducted in a relaxed informal setting, for instance, the livingroom of a group home or workshop lunchroom.

The results of the Word Recognition and Identification Tests were used as a basis for selection of items to be included in the experimental teaching programmes. Scores were tabulated to identify the number of subjects who could both verbally label (say) and correctly point to each of the forty words. From this list, sixteen words that were correctly identified by two or less of the subjects were selected for inclusion in the training modules. It was felt that this identified a reasonably homogeneous set of items that were not known by subjects. The test was also used to select a sample for random assignment to the experimental conditions of computer assisted instruction or individual tuition. On the basis of these results, fifty-two subjects were chosen to participate in the main investigation.

The Sample

Initially, sixty-eight subjects were selected for participation in the screening phase of the investigation. Of this group, sixteen were eliminated on the basis that they already knew the items to be taught, or did not possess pre-requisite abilities (matching to sample, following verbal instructions) required of the experimental procedures. This left a sample of fifty-two subjects, including twenty-six males and twenty-six females.

The fifty-two subjects were drawn from three training facilities including Awatapu Special School operated by the Department of Education, and the Cook Street and Aokautere Training Centres which are controlled by the New Zealand Society for the Intellectually Handicapped. Care was taken to ensure that none of the subjects had auditory or visual impairments which could impose restrictions on active participation in the teaching programmes. This information was obtained from school and social work files that noted the results of vision and hearing assessments routinely carried out by the Department of Health. None of the subjects were found to have perceptual deficits. The Visual Discrimination Test

(Brown and Bookbinder, 1967) also provided a means for assessing visual acuity, ability to follow verbal instructions, and cognitive aspects of matching visual material.

The sample was not randomly selected as the majority of subjects (45) were in attendance at two adult training centres while the remaining participants (7) were chosen from a senior class at Awatapu School. However, it should be mentioned that the senior class students also attended the Cook Street Training centre on a part time basis and were in transition to a full time work experience programme next year.

No attempt was made to control for etiological classification of mental retardation though it can be stated with reasonable confidence that intellectual deficits are due for the most part to genetic factors, perinatal and prenatal influences. Approximately twenty-five percent of the subjects (thirteen) were diagnosed as having Down's Syndrome, one subject was microcephalic and two others were considered to have deficits due to cerebral anoxia. The remaining persons (thirty-six) had undifferentiated classifications of mental retardation diagnosed at an early age. The incidence of Mongolism in this sample reflects the proportion of Down's Syndrome commonly found in a population of moderately retarded people (descriptively, IQ > 30 < 60). It is considered that the etiological characteristics of the sample are representative of a population of mentally retarded adults attending similar training facilities in other New Zealand Centres.

Age range of the subjects was very wide (M = 23.5, Range = 15-56), but was considered to be representative of the variations in age groups found amongst clients attending adult training centres in New Zealand. Similarly wide variations in cognitive abilities are evident though the majority of subjects were functioning in the "moderate" range of mental retardation (Mean IQ = 40.9, Range = 30-55). Intelligence scale estimates were obtained from school and social work files that recorded the results of previous assessments using either the Wechsler Adult Intelligence Scale or Stanford Binet Test (Form L-M). It should be noted that in most cases the IQ assessments were carried out several years prior to the current investigation. The results are presented here for descriptive purposes only and will not be used in analysis of the experimental results.

Approximately twenty-nine percent of the subjects (fifteen) have spent long periods of their lives (one to ten years) in institutional schools or psychopaedic hospitals. The remainder of the sample came from special school backgrounds and have generally resided at home with their parents or lived in foster home environments. It was not possible to determine the previous educational experience of the subjects though this would be varied according to the availability of special school and training facilities. Those attending psychopaedic hospitals, for instance, would have received very little in the way of formal schooling.

In summary, the heterogeneous nature of the sample appears to be representative of a population of adolescents and adults who, due to intellectual impairments, have been placed in long-term social and vocational training programmes operated by the New Zealand Society for the Intellectually Handicapped. No attempt was made to control for sex, age, IQ or etiological classification. However, screening was carried out to ensure that subjects had sufficiently developed visual discrimination skills, could follow verbal directions, and could attend to the requirements of the experimental procedures.

Procedure

Overview

The fifty-two subjects selected for participation in the investigation were randomly assigned to computer assisted instruction or individual tuition groups. Overall, twenty-six subjects were given word recognition instruction by computer while the remaining twenty-six individuals received individual tuition from trained teachers.

Initially, subjects were administered a Word Recognition and Identification Test, and Picture-Word Matching Test. These instruments were devised specifically for the purpose of this study to measure any changes in learning before and after participation in training. The pretesting was carried out during July, 1980, approximately eight weeks after completion of the screening phase of the project.

With each of the CAI and individual groups, subjects were randomly allocated to errorless discrimination (word only focus) or paired associate (pairing of pictures and words) conditions. Two training modules containing eight words each were presented in succession. Thus, an attempt was made to teach a total of sixteen words over the full course of training. The modules contained words within each of two categories: (1) Tool Names, and (2) Grocery/Information Items. Counterbalancing of module order was accomplished by randomly assigning subjects to receive either list 1 (Module 1 Words, followed by Module 2 Words) or list 2

(Module 2 Words first, followed by Module 1 Words). This was deemed necessary to control for possible confounding effects of module order. An outline of the research design is displayed in Figure 2.

Subjects were tested individually on the set of pretests for either module 1 or 2 then given five instructional sessions using the programme previously described (Chapter 5). Upon completion of the first module, the complete set of tests was readministered to provide a pre-versus post-test training comparison of word recognition. Additionally, a Transfer Test was administered at the end of each module. This was devised to assess the extent to which subjects could generalise their learning to more decisive real life situations. Identical procedures were followed for presentation of the next module; pretesting, training, post-testing and transfer measure. This resulted in two sets of scores corresponding to each of the two modules. In all, ten training sessions were provided at the rate of two sessions per week for five weeks.

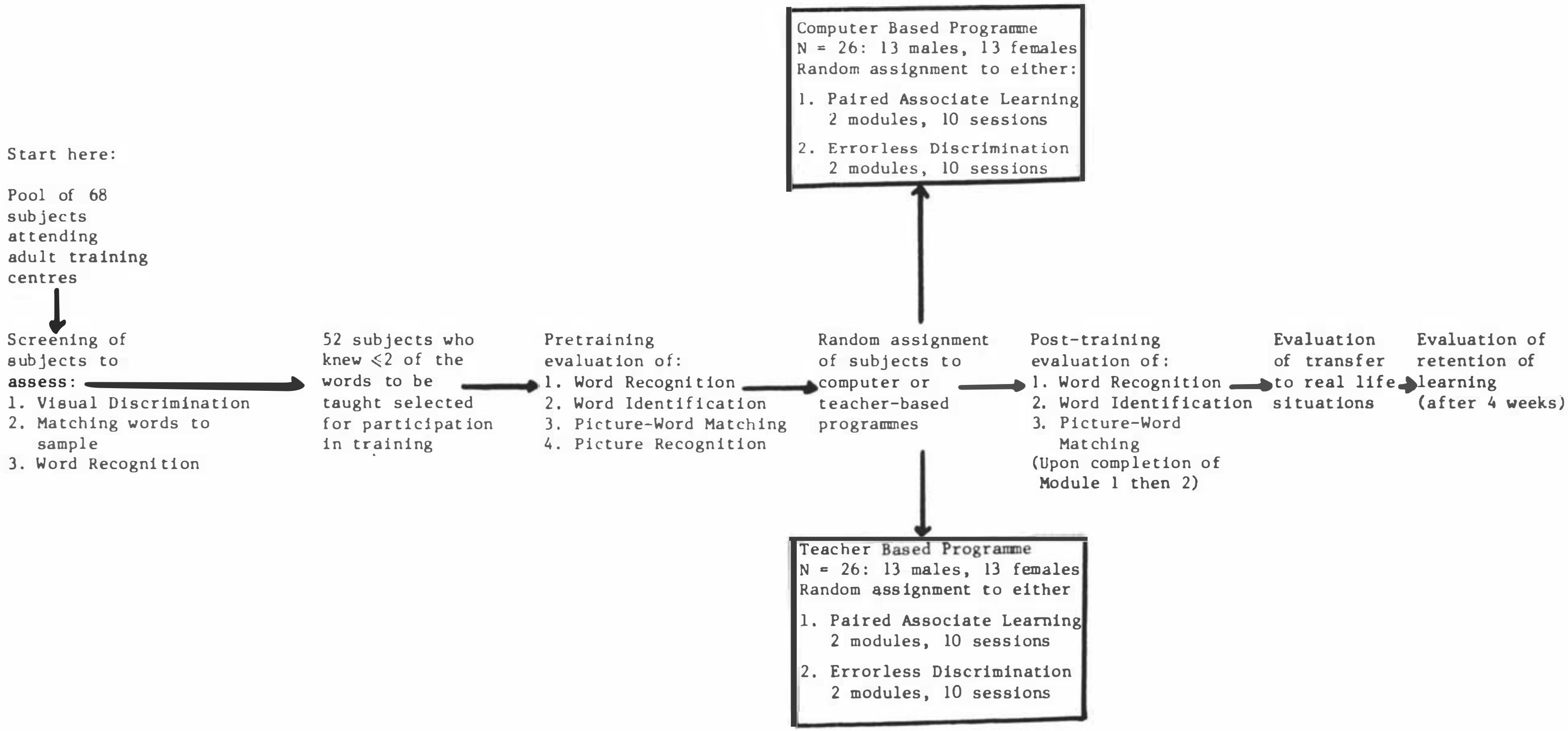
Four weeks after completion of training, subjects were again administered the Word Recognition, and Word Identification Tests for both training modules. This provided an estimate of the amount of information subjects had retained over a one-month period immediately following the investigation. A detailed description of the criterion measures is presented in the next section.

Evaluation Procedures

All pre- and post- tests were individually administered by the investigator or by one of thirteen trained examiners who assisted with the individual instruction group. With the exception of the transfer measures, testing was carried out in small training rooms, or a classroom adjoining the main workshops. Subjects were all seen informally by the examiners on at least one occasion prior to test administration. This helped offset extraneous effects of unfamiliarity with the examiner that have been shown to impede performance of handicapped persons (Brown, 1975). Testing was carried out according to standard instructions provided though an attempt was made to reduce the formality of the session by conversing casually on a topic of common interest prior to administration of the measures. Every attempt was made to elicit the subject's cooperation from the outset in a manner that would not interfere with standardised test administration. Because of the verbal nature of the tests, it was deemed essential to place the subject at

FIGURE 2

Design of Study



ease and thus obtain a reasonable estimate of each persons' word recognition knowledge. Testing and training were carried out on the words contained separately in Modules 1 and 2. The content of these vocabulary items is displayed in Table 3. According to whether the subject was assigned to list order 1 or 2, he/she was tested on one of the modules prior to training. Pre- and post-test procedures were identical for both modules. A description of the criterion measures is presented in the following section. Additionally, complete details on standard instructions and administration procedures is displayed in Appendix D.

1. Word Recognition: Using a flashcard method, subjects were asked to label verbally (say) each word they knew. A practice trial was provided prior to the main test in order to ensure that the subject understood the directions.

Two flashcards containing the practice items (BUS STOP, GO) were placed vertically on the desk directly in front of the subject. Spacing between the cards was about 5 cm. Firstly, the subject was asked to point to a word if he knew what it said. Then the examiner pointed to each word in turn and asked, "What does this word say?" If no response was made within ten seconds the next item was presented.

Following a similar procedure to that employed by Dorry and Zeaman (1973, 1975) eight flashcards were randomly placed in a 4 x 2 matrix arrangement on the desk. Words were stenciled on the 8 x 16 cm flashcards using capital letters in black ink on a white unlined surface. A large letter format of 2.5 cm was used to ensure that subjects could view the words without difficulty from a normal seating posture. Using identical procedures to those of the practice trial, subjects were asked to point at any word they knew and then verbally label each word. A record of the initial response (pointing) and recognition (saying) was kept for each subject.

2. Word Identification: For the Word Identification Test, subjects were required to locate each of the eight target words randomly placed in the 4 x 2 matrix of flashcards presented above. The examiner instructed the subject, saying, "I'm going to say a word then I want you to point to the word which tells about (shows) _____." This method was similar to word identification task employed in a study by Walsh and Lamberts (1979). It was considered that selection of a single item from eight choices would minimise error due to "chance" identification

Table 3

VOCABULARY ITEMS
ARRANGED BY MODULE

MODULE 1:	BUS STOP	Practice
	GO	Practice
	HAMMER	
	SPANNER	
	FORK	
	KNIFE	
	DRILL	
	PLIERS	
	SAW	
	SCREWDRIVER	
MODULE 2:	BUS STOP	Practice
	GO	Practice
	SUGAR	
	PUSH	
	BREAD	
	PULL	
	COFFEE	
	MEAT	
	CROSS	
	RAILWAY	

of the correct target word. Each of the eight target words were presented in an identical sequence for all subjects. A record of correct and incorrect responses was kept by the examiner. This assessment was administered after the Word Recognition Test to avoid obtaining spurious results that could otherwise occur from development of a restricted verbal response set by the subject.

3. Picture-Word Matching: This test required the subject to match each of the target words with a referent picture. Pictures were 12 x 17 cm colour photographs of situations depicting the training items. For example, a photograph of people boarding a bus was used to illustrate the word "BUS STOP". Photos were taken by a professional photographer using a 35 mm single lens reflex camera with Kodachrome high speed film. The photographs were dry mounted on 21 x 27 cm strips of black posterboard. It was felt that this large photographic format would help ensure that subjects could analyse the visual material without difficulty from a normal seating posture.

Prior to administration of the test, pretraining was carried out to ensure that all subjects were familiar with the visual material. For picture recognition pretraining, the subject was first shown the ten pictures (eight target words and two practice items) one at a time and told, "This is a _____." and asked to repeat the word. The subject was then asked to identify each of the ten pictures as they were presented. This procedure was repeated until the subject was able to correctly identify each of the pictures on at least one occasion. Ability to identify the pictures represented a minimum entry skill since it was assumed in the investigation that subjects were familiar with the real life items being taught but could not recognise words corresponding to the concrete presentations. This pretraining procedure was identical to a method devised by Dorry and Zeaman (1973).

For the Picture-Word Matching Test, three each of the pictures were selected and placed horizontally on the table in front of the trainee. One of the pictures referred to the target word while the other two photos were distractors selected at random. The subject was then given a word item (flashcard) and instructed to place the word with its corresponding picture. Each of the two practice and eight training items were presented in turn using precisely the same sequence with all subjects.

Because the chance probability of correctly corresponding a picture and word was high (1-3), the test was administered a second time following identical procedures to those above. Correct and incorrect responses were scored for each of the two separate administrations. A composite score was obtained by rating only those items for which the subject correctly matched a picture and word on both administrations. This test was similar to an assessment used by Walsh and Lamberts (1979) with the exception that their study employed a single administration for matching words and referent pictures.

4. Transfer Tests: These tests were carried out to evaluate the extent to which subjects were able to transfer their learning to real life situations. Because of the nature of the training items, the transfer tests were devised corresponding to Module 1 (Tool Names) or Module 2 (Grocery/Information). These situational tests were devised specifically for the purpose of this investigation as very little previous research has been carried out on transfer of word recognition skills. Details on administration and scoring of the transfer measure are contained in Appendix E. Following is a description of the two transfer tests used:

a. Module 1 (Tool Names): This test was carried out in the main workshop immediately following administration of the Word Recognition, Identification, and Picture-Word Matching Procedures. Eight tools corresponding to the training items were randomly placed on a work bench within easy reaching distance of the subject. The subject was then given a word card and asked by the examiner, "What does this word say _____?" Next the subject was instructed to "Place the word card next to the tool it tells about (shows)." After each presentation the flashcard was removed from the table and the next word was presented. The same sequence of presentation was used with all subjects. Subjects were scored according to whether they could verbally label each word and place the flashcard with a corresponding tool item.

b. Module 2(Grocery/Information): The transfer test for module 2 was carried out in a lunch room or kitchen at each of the two Training Centres. For practical reasons it was decided not to attempt a transfer assessment on two of the items (RAILWAY, CROSS) as real life representations of these words could not be achieved in the workshop environment. Hence the four food items (SUGAR, BREAD, COFFEE, MEAT) and two information words (PUSH and PULL) were used as objects of the assessment.

For the grocery words, eight food items including the above four and four other distractors (BISCUITS, CHEESE, MILK, BUTTER) were placed randomly on a table within easy reach of the trainee. Subjects were then given a word card and asked by the examiner, "What does this word say?" Then the subject was instructed to "Place the word card next to the food it tells about (shows)." After each presentation the flashcard was removed from the table and the next word was displayed. An identical sequence of presentation was used for all subjects.

For the information items (PUSH, PULL), the trainee was taken to the location of a conventional door (not sliding or swinging door). The door was opened to about 45 degrees or so (halfway). Each of the flashcards in turn was placed just above the door handle, held in position with cellotape. The examiner then asked the subject to verbally label (say) the word. Following this, the subject was instructed to "Go ahead and do what the word says."

Correct and incorrect responses for verbally labelling and placing the word cards was recorded by the examiner. Flashcards displayed each word in capital letters using the same size format (2.5 cm letter height) as the cards employed in the Word Recognition, Identification, and Picture-Word Matching Tests.

5. Retention: Approximately four weeks after completion of training, the Word Recognition and Identification Tests were readministered to provide an estimate of retention of original learning. However, unlike the pre- and post-tests, both modules 1 and 2 were presented on the same occasion. The subject was first asked to verbally label each of the words displayed in a 4 x 2 matrix (Recognition) then point to each word verbally presented by the examiner (Identification). Precisely the same administrative procedures were used as in the pre- and post-test situations. Module 1 was presented first, followed by Module 2 irrespective of whether the subject was trained on list order 1 (Module 1 then 2) or list order 2 (Module 2 then 1). Retention testing was carried out during September and October 1980 corresponding to a four week period following completion of the teaching programmes.

Training Administration Procedures

The training programmes were administered by the experimenter and thirteen senior students enrolled in a Special Education course at Massey University, Palmerston North. All of the students were Teachers' College graduates working toward completion of a B.Ed. or B.S.W. degree. One of the students was a practising teacher enrolled at the University on a part time basis while the remainder were engaged in full time studies. Because of the large amount of individual instruction required of this investigation, it was essential to enlist the aid of trained and qualified teachers. Each of the teachers was responsible for administration of the assessment and training procedures with two subjects. Paralleling the work of the teachers, the examiner carried out assessments on the computer assisted instruction group, and supervised administration of the CAI programmes.

The main project commenced during the second week of July, 1980 and was completed during mid-September, 1980. Both the Individual Instruction and CAI groups received two training sessions per week over a five week period. This provided a total of five sessions on each of the two training modules. For practical reasons related to the scheduling of teaching times, it was considered that two sessions per week was an optimal number. This limit was also imposed by the amount of travel required between the University and Training Centres. Due to sickness, timetable conflicts, and absenteeism, some minor deviation from the training schedule was required on occasion. For example, the elapsed time between sessions for a few of the subjects was increased on account of ill health. Also, it is important to point out that while 52 subjects participated in the project, only 44 persons completed both training modules. Because of sickness, placement in other facilities, or vacation leave, seven subjects received only one module. However, counterbalancing of list order helped to randomise the loss of data over the complete sample. This lack of information on some of the subjects was taken into account when evaluating the results of the study.

The applied nature of this research necessitated a considerable amount of preparation, both in terms of training the individual tutors and administering the various programmes. Following is an account of the methods used to carry out both the individual and computer-based programmes.

1. Individual Instruction Procedures: A request from the experimenter to University students enrolled in a Special Education course resulted in obtaining thirteen volunteers to assist with the project. From the outset students were made aware that the purpose of the study was "to compare different methods for teaching word recognition to mentally retarded adults". However, it was stressed that all of the methods

had been used with some success in the past and that there was no reason to believe that one method was better than another. Thus, students had some awareness of the overall aim of the project but had little knowledge of the specific teaching programmes to be evaluated. Students undertook this work in partial completion of the practical requirements of their course.

During June, 1980 the students met with the experimenter once a week for three weeks to learn how to carry out the assessment and training procedures. On the first occasion all thirteen students met with the examiner for a one-hour period following their regularly scheduled class time. This initial session was to provide an overview of learning principles with handicapped persons and outline the requirements of the project with regard to test administration and timetabling of sessions. Students were informed that no comparison would be made of one teacher to another but rather a comparison of teaching methods was the aim of the project. The thirteen students were randomly allocated to either the paired associate or errorless discrimination methods. On week two and week three, the two groups met separately, one hour before or one hour following their class time, to learn the specific teaching procedures.

All student teachers received the equivalent of three one-hour instruction sessions to ensure as far as practically possible fidelity of teacher behaviour to the requirements of the programme. Procedures for administration of the teaching programmes were demonstrated and practised by having teachers work in teams. Individual coaching was provided by the experimenter to teach the specific programme methods. Student teachers were instructed to precisely follow the sequence of instruction though ensuring at the beginning of each session that rapport had been established with the subject. Advice was given on management problems that can occur with very active and passive subjects. It was recommended that a brief informal conversation at the beginning and end of each session would help provide a "comfortable" approach to administration of the structured procedures. To minimise variations in verbal feedback, students were instructed to use neutral terms, for example, "Good", "Try again", and "Okay". Further advice and consultation was available from the experimenter and course instructor at any time during the project when specific behavioural difficulties were encountered.

During the final instructional session, the student teachers were individually videotaped administering one of the training items. This provided visual feedback for analysis by the teacher and peers. The videotape sessions were useful for ensuring that teachers were aware of any deviations from the instructions provided. In turn, it was felt that this increased the level of reliability with regard to standardisation of the teaching procedures. Additionally, the student teachers were formally observed by the course instructor and experimenter working with their assigned subjects in the teaching situation. Subjective impressions indicated that a high level of standardisation of administration procedures had been achieved despite wide variations in behaviour and learning demonstrated by the subjects.

Complete details concerning the two teaching methods are presented in Chapter 5. A description of the instructions provided to the student teachers is also displayed in Appendix F. Following is a brief description of the materials and record-keeping procedures for the two modes of instruction.

a. Errorless Discrimination: This was a straight word focus approach with no pictorial material. The target word was first identified by the teacher and then taught over a series of four trials using a flashcard method. Words were stenciled on 8 x 16 cm flashcards using black ink on a white surface. The same point size format (2.5 cm) was used for both the evaluation and training procedures. A pointing response was shaped over a series of four trials in which other words or word-like letter configurations appear with the target word.

For each of the four trials, the word to be taught and three distractor items was presented at random. The cards were placed vertically on a desk directly in front of the subject with spacing of approximately 5 cm between each card. Trial 1 contained grossly dissimilar items while Trials 2, 3 and 4 contained a progressive sequence of more difficult discriminations. The task required that subjects point to the target word for each trial. When subjects made an error, the distractor item mistaken for the target word was removed for the next presentation. Once the subject correctly identified a word, the distractors were again introduced. A maximum of nine attempts was allowed for each trial following which the subject advanced to the next level. This fading routine guaranteed success at several points in the programme. Five sessions were provided for each training module. Each module contained two practice items (BUS STOP and GO) along with eight target words. In sum, sixteen words were taught in two modules over ten sessions.

Materials for the errorless discrimination programme were provided in'kitsets' located at both of the Training Centres. Each kit had separate envelopes containing the target word and distractor items. Organisation of materials was essential since every item and trial had a unique set of distractors. Care was taken to correctly replace the cards for use by the next teacher. The teacher maintained a log for each session noting the number of attempts to master each item and trial, as well as the time spent on a given session.

b. Paired Associates: A picture and corresponding printed word was first presented and verbally identified by the teacher. As with the errorless discrimination approach, the target word was taught over a series of four trials using a flashcard method. In this programme, Trial one contained only the target word. The subject was instructed to look at the photo and point to the corresponding word item. Ensuing trials made use of one, two and three distractors chosen at random from a set of comparison words. Thus, the discrimination became increasingly more complex as the range of possible choices increased from one to four words. However, comparison stimuli were not graded in difficulty as was the case in the errorless discrimination method. The distractors were selected at random from the pool of training words with three distractors assigned to each target word presentation. Flashcards were arranged vertically and placed at random on the desk directly in front of the subject.

As with the errorless discrimination programme, a fading routine was employed. Whenever an error was made, the mistaken distractor was removed for the next presentation. Then if the subject was correct, the distractor(s) was again presented along with the target word. A maximum of nine attempts was permitted for each of the trials. The two practice items and eight target words provided for forty trials in each session.

Materials were provided in 'kitsets' located at both the Training

Centres. The kitsets for modules 1 and 2 had separate envelopes containing the target word and distractor items. The same photographs as those employed in the Picture Recognition and Matching Test were used for the paired associate programme. These were high quality 12 x 17 cm colour photographs drymounted on strips of black posterboard. Photographs depicted the target word (e.g. HAMMER) or action associated with a word (e.g. BUS STOP - people boarding a bus). Each photo was placed to the right side of the flashcard(s) and remained in view throughout the four trials. Records were kept by the teacher regarding number of attempts to master each trial and item, and also the time spent on the session.

Both of the individual instruction programmes were carried out over a five week period commencing during the second week of July 1980 and finishing in mid-August. All pre- and post-testing and training of the two modules was completed over the five weeks. Sessions were provided at the rate of two per week though absenteeism occasionally interfered with the time interval between sessions.

2. Computer Assisted Instruction Procedures: The twenty-six subjects assigned to the CAI group received an identical amount of training to that of the individual instruction group. This consisted of twice weekly sessions for a period of five weeks. Thirteen of the subjects were randomly placed in the paired associate learning programme while the remaining thirteen persons were given errorless discrimination training. In view of the fact that only one microcomputer system was available for use in the study, it was necessary to offer two consecutive terms of five weeks duration at each of the training centres. The computer was first located at the Cook Street Centre for use by trainees in that setting and then moved to the Aokautere Training Complex. In this way, one group had completed both training and post-testing before subjects in the other group commenced their training period. An identical assessment and training sequence was followed during both terms so that it can reasonably be stated that conditions of instruction were the same for all subjects. The two consecutive terms were offered during July and August, 1980.

The microcomputer work station was located in a small office at both facilities so that subjects could work on their own with a minimum of distractions. A timetable was followed to ensure that the interval of time between sessions was reasonably consistent for all subjects.

Typically, trainees attended their twice weekly sessions on Monday and Wednesday, or Tuesday and Thursday. Friday was available for additional sessions with subjects who had missed regular instruction times due to illness.

Because of the experimental nature of both the equipment and teaching programmes, the investigator was present at several of the sessions to observe trainees interaction with the computer system. No verbal cueing was provided by him during presentation of the training sequences, with the exception of an occasional "Try again" if a touch failed to register. During the presentation of the two practice sequences, verbal instructions were given on how to operate the equipment and hints on what to look for in the photographic slides or video display. Most trainees rapidly mastered the use of the light pen on the practice items during the first session and required no further instructions. An explanation was given to subjects as to the meaning of the flashing messages and video feedback displays of "happy" and "sad" faces in response to correct and incorrect choices. The comments volunteered by trainees suggested that the visual displays were a meaningful form of feedback. Only one subject from those originally selected for participation in the CAI group had to be excluded on the grounds that he was unable to attend to visual and audio cues. The presence of the experimenter at some of the sessions provided a considerable amount of anecdotal information that would otherwise not have been available. Informal observations indicated that the experimenter's presence detracted very little from subjects' attention to the learning medium.

During the ten weeks of operation, no days were lost due to equipment failure. Unfortunately though, several sessions were temporarily interrupted due to intermittent faults in the software routines and mechanical errors. When these occurred, the programme was initialised and advanced to a point corresponding to where the subject had previously been working. This necessitated an interruption of several minutes in any session where mishaps were present. Machine failure was a random factor and as such there is no way of controlling for the presence of these errors. However, because most faults were detected during the practice sequences, it can be conjectured that the equipment failures did not interfere with the learning process to any appreciable extent.

The microcomputer work station consisted of a keyboard, video display unit, and sound on slide projector. The subject sat directly in front of the keyboard and video unit while the rear image screen was placed on the desk immediately to the right side of the computer. The projector was angled slightly (approximately 10 degrees) to facilitate shifting of attention from the video screen to the slide display. Both the projector and video screen were elevated to meet the eye level of the subject from a normal seating posture. The equipment was placed for ease of horizontal viewing and did not require the subject to look upward or downward; but simply to look straight ahead at the video screen and move the eyes slightly to the right to view the photographs. Interaction with the computer was by touching designated positions on the screen with a photosensitive pen. At the beginning of each session, subjects entered their name into the system by using the keyboard.

The target words and comparison stimuli were displayed on the VDU using upper case letters with an approximate height of 1.5 cm. The word lists were displayed horizontally on the screen with a space of 2 cm between each item. Each of the training words was first shown in a central position on the screen and followed by lists for Trials 1 through 4. The large print format helped ensure that subjects could view the words without difficulty. Photographic transparencies (used in the paired associate mode) were displayed by means of rear image projection on a 40 x 40 cm screen. This provided high resolution of the slides under normal indoor lighting conditions.

A detailed account of the CAI programmes is presented in Chapter 5. Following is an overview of the materials and record-keeping procedures employed for the two modes of instruction.

a. <u>Errorless Discrimination</u>: Using a straight word focus, subjects were required to locate a target word from a selection of items displayed on the video screen. The target word was first shown on the VDU and identified by an audio cassette message. Then over a series of four trials the target word along with three distractors at random. The word lists for each trial were displayed vertically on the screen. Subjects were instructed by audio cassette messages to point to the training words using a light sensitive pen. The cassette advanced to each subsequent message under computer control.

   Trial 1 contained grossly dissimilar items while Trials 2 through 4 contained a progressive sequence of more difficult discriminations. When subjects pointed to one of the distractors by mistake, that item was removed for the next presentation. Distractors were again introduced once the subject pointed to the correct word. A maximum of nine attempts was permitted for any of the trials. The fading out of distractors guaranteed success at several points in the programme. As with the individual tuition, five training sessions were provided for each of Modules 1 and 2. Visual feedback for correct and incorrect responses was given by printed messages and "happy" or "sad" faces drawn in graphics form on the VDU.

The programme was contained on disk and loaded into the computer as required at the beginning of each session. A diagnostic summary was automatically generated by the computer to note the number of attempts on each trial and time spent working on each of the training items. The total elapsed time was also recorded for each session. This information was displayed on the VDU and then recorded onto a session log retained for all subjects by the experimenter.

A flowchart of the CAI errorless discrimination is presented in Figure 3.

b. Paired Associates: This CAI programme made use of both photographic transparencies and corresponding printed words in the same manner as the individual instruction procedure. Slides were developed from an identical film used to print the photographs described previously. As with the teacher based programme, the target word was taught over a series of four trials. Subjects were first shown a slide and then instructed by audio cassette messages to look at the target word displayed on the VDU. The slide remained in view throughout the complete instructional sequence for each item.

Trial 1 contained only the target word to which the subject responded by pointing a light sensitive pen at the designated screen position. Subsequent trials made use of one, two and three distractors respectively. Distractors were selected at random from a set of comparison words for each item. In this manner, discriminations became increasingly difficult as the range of possible choices increased from one to four words. Unlike the errorless discrimination procedure, comparison stimuli were not graded

ERRORLESS DISCRIMINATION LINEAR BRANCH ROUTINE

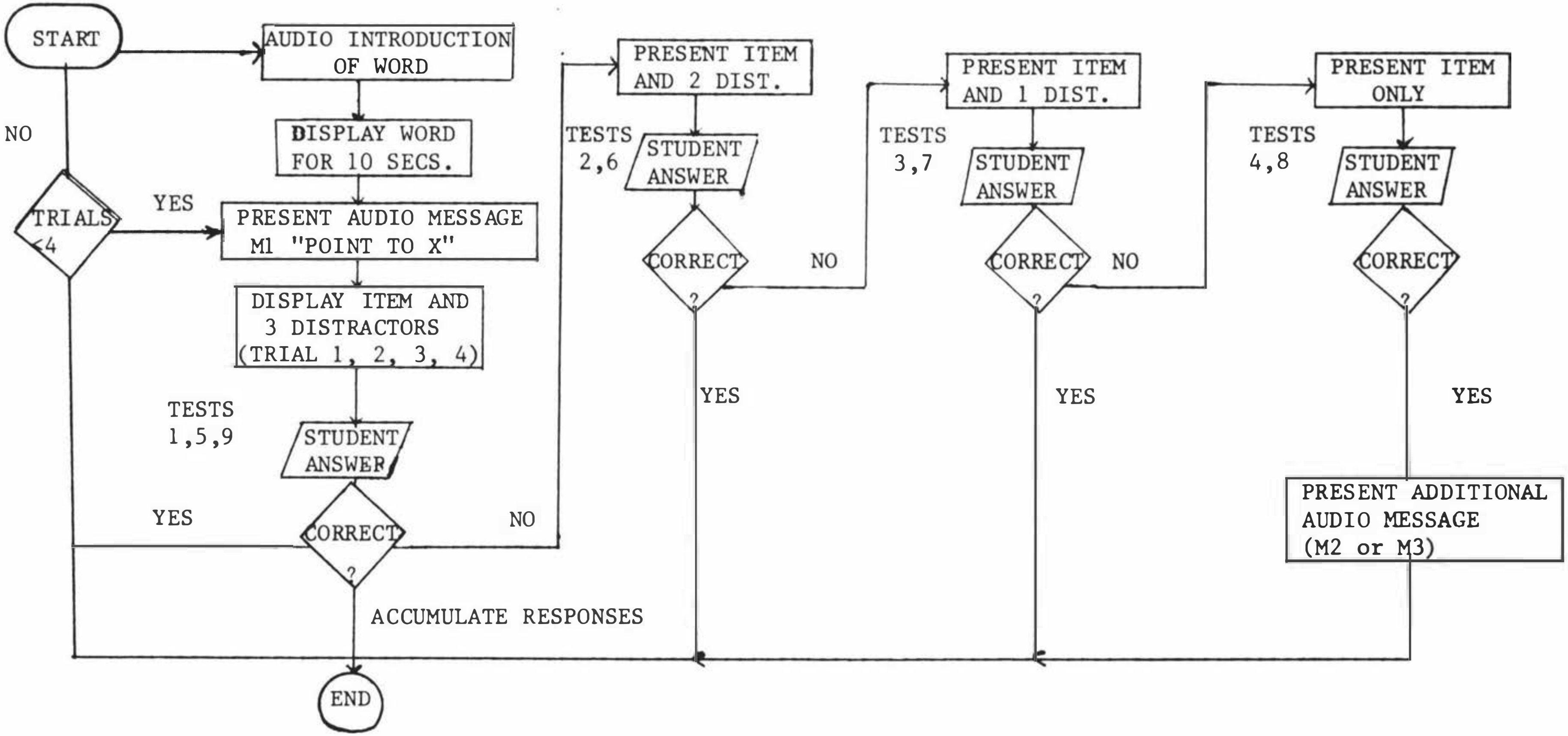


FIGURE 3

DEFAULT OPTION: GO TO NEXT TRIAL WHEN N OF ATTEMPTS = 8
AUTO ADVANCE AFTER FOLLOWING THE COMPLETE BRANCH TWICE (8 TESTS).

in difficulty. Confirmation of correct and incorrect messages was given by visual feedback on the video screen. This included flashing messages, "happy" and "sad" faces. All audio messages were played under computer control for each item and trial in the programme. Additional messages were presented when errors occurred.

A fading routine was employed using an identical procedure to the individual instruction programmes. This involved removal of distractors whenever an error was made. A maximum of nine attempts was allowed for each of the trials following which the programme automatically advanced to the next level. In all, the two practice items and eight target words provide forty training trials in each session.

The Module 1 and 2 programmes for the paired associate method were stored on disk. This contained both the instructions for operation of the programme sequence and data on words to be taught. A subroutine was devised to print a diagnostic summary at the end of each session. This included information on the number of attempts per trial, time spent working on the problems, and total elapsed time for the session. The experimenter transcribed this summary information to a log kept on each subject. A flowchart of the instruction sequence for the paired associates CAI programme is displayed in Figure 4.

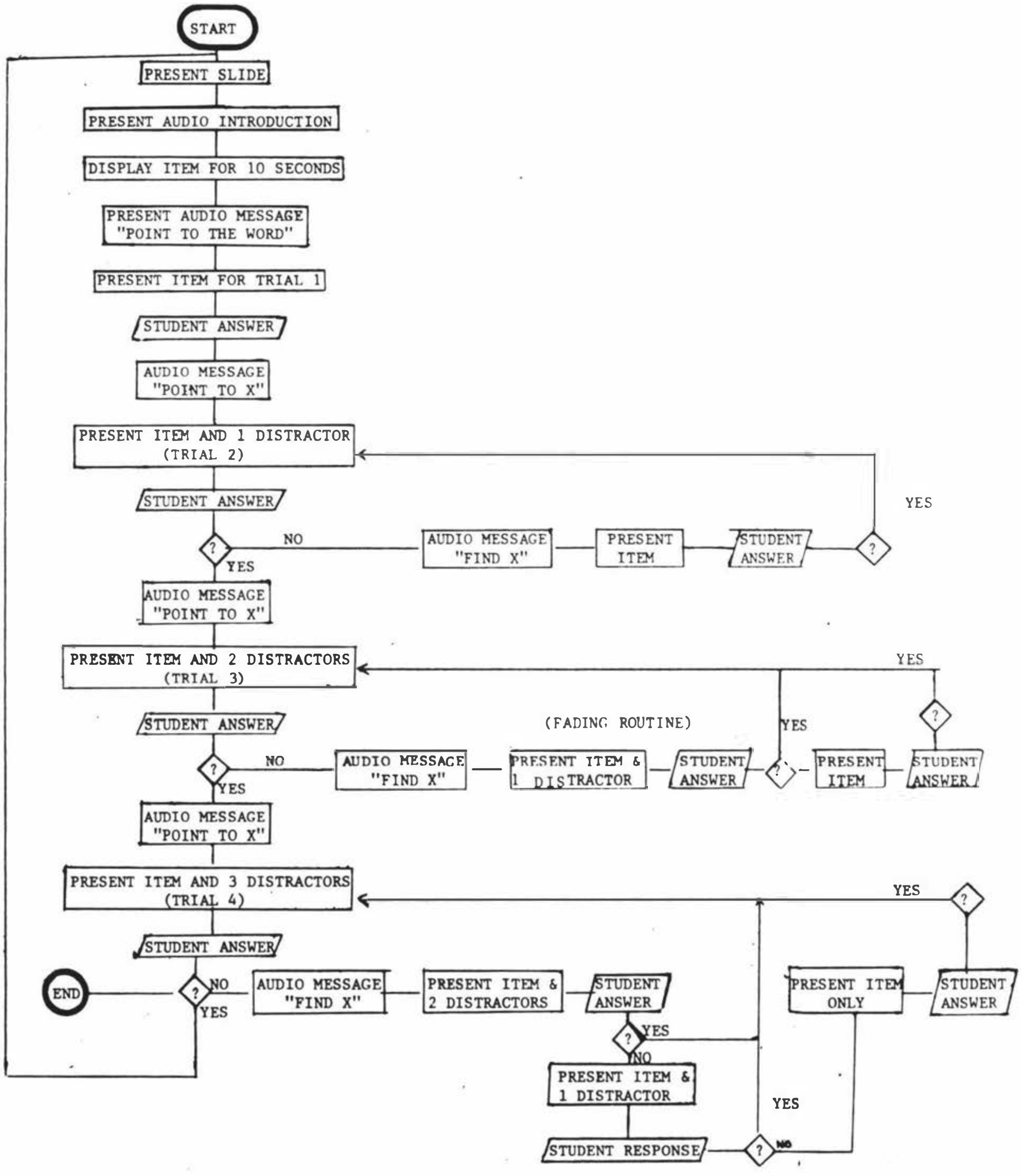
Nearly identical procedures with regard to number of sessions, pre- and post- testing, and training methods were followed using both the CAI and individual instruction programmes.

Hypotheses

Research reviewed in the preceding chapters offered little confirmation as to which methods are likely to be most effective for teaching a word recognition task to mentally retarded adults. Experimental results were cited to confirm the importance of learning principles (self-pacing, immediate feedback, small steps, overlearning) in acquisition, retention, and transfer of information (Malpass, 1966). Moreover, there is considerable support for the use of both automated and manual procedures for teaching visual discrimination tasks (Vergason, 1968; Dorry and Zeaman, 1973). With regard to the various approaches for teaching word recognition, there is much conflicting evidence as to

FIGURE 4

PAIRED ASSOCIATE LINEAR BRANCH ROUTINE



which set of procedures should be employed to optimise learning (Walsh and Lamberts, 1979). Specifically, there is no clearcut evidence as to the utility of using extra stimulus dimensions (e.g. pictures) as prompts for the learning of verbal responses to printed words (Samuels, 1970). A wide range of studies are available to support the utility of these various approaches at one time or another.

In keeping with the main purpose of this investigation, research evidence is being sought to evaluate the efficacy of computer assisted instruction as this compares to traditional forms of interpersonal tuition for teaching word recognition. Two commonly used techniques, errorless discrimination and paired associate learning, have been selected for the purpose of this comparison as these methods appear to provide a meaningful theoretical and practical framework in which to evaluate the results.

An underlying assumption of this investigation was that all of the methods employed here make use of well-known principles of learning. It is clear from research cited in Chapters Three and Four that the specific teaching methods being evaluated in this study have all been shown to be effective in various circumstances.

Despite conflicting evidence that has arisen from wide variations in research methods and designs, the general trend of previous investigations appears to support the view that various forms of programmed instruction can successfully be applied to teach word recognition to handicapped persons. In particular, there is an equal probability that systematic administration of the computer based and instructor dominated programmes will result in similar learning outcomes.

1. Word Recognition and Identification: Studies on the use of automated and manual approaches for teaching word recognition skills have generally indicated that subjects' performance improved to a significant extent as a function of training. Yet there remains some ambiguity concerning the relative merits of computer generated instruction versus more conventional individual tuition.

Again, this controversy stems from the wide range of procedural variations that have been employed in previous research. It seems probable that when a systematic attempt is made to control the content, administration, and duration of teaching programmes, learning outcomes will be similar for all subjects who were given either the automated or manual types of instruction.

Therefore, it was predicted that:

1.1 There will be no differences on word recognition and identification (pre- versus post-test change) scores between subjects who received instruction on the computer versus those who were given individual tuition.

$$CAI_{ED,PAL} = IND_{ED, PAL}$$

1.2 There will be no differences on word recognition and identification (pre- versus post-test change) scores between subjects who received either the paired associate or errorless discrimination modes of instruction by means of the computer versus individual tuition.

$$CAI_{ED} = CAI_{PAL} = IND_{ED} = IND_{PAL}$$

2. Picture-Word Matching: The controversy surrounding the use of extra stimulus materials (e.g. pictures) as prompts for learning concrete word items was discussed previously. Research evidence has been cited to support the use of a straight word focus versus the pairing of pictures and words in training. Because there are no clearcut findings to confirm the role of extra stimulus cues (Samuels, 1970), it seems reasonable to propose that when confronted with familiar words, subjects should be able to match these items with referent pictures.

Because subjects could initially recognise and verbally label each picture used in the investigation, it is contended that matching of the printed and visual items reflects ability to recognise words whether or not pictures were used during the course of training. Thus it is predicted that:

2.1 There will be no differences on picture-word matching change scores (pre- versus post-test comparison) between subjects given computer assisted instruction versus those persons who received individual tuition.

$$CAI_{ED, PAL} = IND_{ED, PAL}$$

2.2 Change scores on the pre- versus post-test results of picture-word matching will not be different for groups who received errorless discrimination or paired associate instruction by means of the computer versus individual tuition.

$$CAI_{ED} = CAI_{PAL} = IND_{ED} = IND_{PAL}$$

3. Transfer: The extent to which subjects can generalise learning from the experimental situation to real life events is an important practical consideration in this study. Previous research has been cited to note some of the issues and methodological problems in training for transfer (Gold, 1972; Zeaman and House, 1963). Again, there are few meaningful guidelines to suggest ways in which transfer is likely to be enhanced. Provision needs to be made during training for subjects to extend their skills to new situations. The learner may function effectively with a person or material he knows well but break down when placed in an unfamiliar circumstance. It is not possible within this study to make any predictions concerning the amount of transfer that may or may not occur. However, it is contended that the extent to which learning is generalised to real life events will be equally distributed across the groups and modes of instruction. Thus it was predicted that:

3.1 The transfer test scores for the computer assisted instruction group will not be different from those of the group who were given their instruction by individual teachers.

$$CAI_{ED,PAL(T)} = IND_{ED,PAL(T)}$$

3.2 The transfer test scores for subjects receiving paired associate or errorless discrimination instruction on the computer and by individual tuition will not be different from one another.

$$CAI_{ED(T)} = CAI_{PAL(T)} = IND_{ED(T)} = IND_{PAL(T)}$$

4. Retention: A large amount of research was cited in Chapter Two concerning retention of original learning (e.g. Vergason, 1968). The main point is that in order to be really beneficial, learning must be available for recall at a later time. There is evidence to suggest that retention of information is enhanced through provision for over-learning trials beyond a minimum success criterion. In this present study, drill and practice was used to ensure that each subject attained a basic level of performance through presentation of repeated trials until a correct response was attained. This included some opportunities for overlearning as each programme mode followed precisely the same sequence; progressing from simple to complex discriminations even when subjects had initially mastered the easier trials. Accordingly, it was predicted that:

4.1 There will be no differences on the retention measures of word recognition and identification between the computer assisted instruction group and subjects who were given individual tuition.

$$CAI_{ED,PAL(R)} = IND_{ED,PAL(R)}$$

4.2 Retention scores for subjects receiving errorless discrimination or paired associate instruction on the computer and by individual instruction will not be different from one another.

$$CAI_{ED(R)} = CAI_{PAL(R)} = IND_{ED(R)} = IND_{PAL(R)}$$

Design

Testing of the hypotheses presented in this study was carried out by means of a 2 x 2 x 2 repeated measures analysis of variance design. The non-metric factors of analyses were Group (CAI and Individual Instruction), Mode (Errorless Discrimination and Paired Associates), and List Order (Module 1 and Module 2). Metric factors were pre- and post-tests of Word Recognition, Identification, and Picture-Word Matching. Additionally, measures of transfer and retention of learning were analysed separately for both modules. Because null hypotheses have been stated for all dependent variables, any resulting differences in group and mode level are centrally important to the investigation. List order was included as well to counterbalance any practice or carry over effects that might have arisen from a fixed sequence of module presentation. Descriptive data concerning time in training and number of attempts to mastery (methods-time measurement) was analysed to provide a between groups and modes comparison.

CHAPTER VII
RESULTS

In discussing the results of this study, sample characteristics regarding sex, age, visual discrimination and IQ distribution for the various subgroups will be presented first. This descriptive data is reported separately for each of the groups (Computer, Individual Instruction), and modes (Errorless Discrimination, Paired Associates) as well as for the combined sample. Secondly, analysis of variance is used to test the specific hypotheses that have been raised concerning acquisition, retention and transfer of learning. Here, trends in the data will be explored by examining any interaction effects between the subgroups for each of the criterion variables. Following this, an analysis of time spent in training and total number of attempts to master the learning task (Methods-Time Measurement) is considered for the various groups and modes of instruction.

Descriptive Data

Table 4 displays the age and sex distribution for subjects in both the computer based and individual instruction groups. As can be seen, each of the two groups comprised 13 males and 13 females (Total N = 52). Random assignment to the two modes of instruction resulted in a homogeneous sex distribution across the subgroups. Similarly, there are no significant age differences between the groups and modes (Total Group Mean = 23.90, S.D.=7.33). Age range of the subjects was very wide (Range = 15-56 years) though considered to be characteristic of the variations found amongst groups attending adult training centres.

Sample characteristics were also considered with regard to IQ and Visual Discrimination Test Scores. An examination of the data displayed in Table 5 reveals that there were no significant differences between the subgroups with respect to IQ (Total Group Mean = 41.81, S.D. = 7.9). A breakdown of Visual Discrimination Scores (Total Group Mean = 32.38, S.D. = 6.35) also confirms that the composition of the groups and modes was homogeneous on this factor. Very slight and nonsignificant differences were observed between the subgroups on any of the descriptive variables.

Table 4

Age and Sex Distribution of Subjects

Group	Mode*	Age Mean	Age S.D.	Number Males	Number Females
Computer Assisted Instruction	Combined	23.52	8.12	13	13
	ED	22.07	4.16	8	7
	PAL	25.08	10.91	5	6
Individual Instruction	Combined	24.32	6.51	13	13
	ED	23.60	5.96	6	7
	PAL	25.40	7.46	7	6
Total Group	Combined	23.90	7.33	26	26

Table 5

IQ and Visual Discrimination Score Distribution of Subjects

Group	Mode*	IQ Mean	IQ S.D.	Visual Discrimination Mean	Visual Discrimination S.D.
Computer Assisted Instruction	Combined	42.55	8.05	32.04	6.50
	ED	40.58	8.02	31.83	5.92
	PAL	45.50	7.64	32.23	7.22
Individual Instruction	Combined	40.88	7.89	32.72	6.32
	ED	41.90	8.05	31.67	6.21
	PAL	39.17	8.04	34.30	6.46
Total Group	Combined	41.81	7.91	32.38	6.35

* ED = Errorless Discrimination
PAL = Paired Associate Learning

In sum, these results indicate that the groups and modes are very similar in composition with regard to age, sex, visual discrimination and IQ.

Statistical Analysis

Hypotheses were tested by performing a repeated measures analysis of variance similar to that found in Winer (1971). The basic concept of the experimental design was a paired comparisons 't' statistic. This was used to test the hypothesis that two variables (pre- and post- test scores) defined over the same subgroups (and consequently almost inevitably correlated) have the same mean. Specifically, ANOVA was applied to determine whether the effects of nonmetric factors (viz. groups, modes) were significant with regard to deviations of group means from the grand mean. Three-way analysis of variance (group x mode x pre-post scores) were performed separately on module 1 and 2 data for each of the criterion measures. Possible list order effects were also tested using a three-way analysis of variance (group x mode x pre-post scores) on data from both of the modules, independently for Word Recognition, Identification, Picture-Word Matching, Transfer, and Retention. It was considered necessary to carry out separate analysis on mode and list order effects in the above manner to avoid obtaining spurious results that could otherwise arise from a four-way analysis with small and unequal cell sizes. Due to absenteeism, it was not possible to obtain complete data on all subjects. Sample sizes and resulting degrees of freedom are noted separately for each analysis.

Word Recognition

The results of the three-way repeated measures analyses of variance indicate no significant interaction effects between groups and modes with regard to pre- and post-scores on the Word Recognition Test. Specifically, interaction effects were found to be non-significant for both modules 1 and 2 (see Tables 6 and 8 for ANOVA summary data on each module).

Pre- versus post- test differences were reliable for both modules over the sample (Module 1: $F=62.31$, 1/45df, $p<.01$; Module 2: $F=56.96$, $df=1/42$, $p<.01$). Means and standard deviations for the individual groups and modes are displayed in Tables 7 and 9. It can be determined that the overall mean increases for modules 1 and 2 were 2.51 and 2.76 points respectively.

Table 6

ANOVA Summary Data for Module 1 Word Recognition
Pre- Versus Post- Test Comparison (Repeated Measures)

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	.267	0.04	.85
M (Mode)	1	1.080	0.16	.69
GM	1	2.662	0.39	.54
T (Pre - Post Test)	1	154.186	62.31	.01*
TG	1	.880	0.36	.55
TM	1	.310	0.13	.73
TGM	1	5.787	2.34	.13
Errors	45	2.47		

*Significant Effect

Table 7

Means and Standard Deviations for Module 1 Word Recognition
Pre- Versus Post- Test Comparison

	Mode	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	ED	0.50	0.80	2.83	2.37
	PAL	0.67	1.23	3.75	2.93
Individual Instruction	ED	0.43	0.94	3.36	2.87
	PAL	0.91	2.38	2.64	2.58
Combined Groups and Modes		0.63	1.08	3.14	2.69

Table 8

ANOVA Summary Data For Module 2 Word Recognition
Pre- Versus Post-Test Comparison (Repeated Measures)

Source	df	M.S.	F Ratio	Probability
G (Group)	1	.197	0.03	0.87
M (Mode)	1	1.282	0.17	0.68
GM	1	25.167	3.41	0.07
T (Pre - Post Test)	1	169.568	56.96	0.01*
TG	1	4.470	1.50	0.23
TM	1	5.161	1.73	0.20
TGM	1	11.588	3.89	0.06
Error	42	2.977		

*Significant Effect

Table 9

Means and Standard Deviations For Module 2 Word Recognition
Pre- Versus Post-Test Comparison

Group	Mode	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	ED	0.40	0.70	4.80	2.82
	PAL	0.30	0.67	2.30	3.20
Individual Instruction	ED	0.60	1.30	2.67	2.72
	PAL	1.18	1.94	3.73	3.13
Combined Groups and Modes		0.62	1.15	3.38	2.97

On the basis of these findings, it can be upheld that treatment effects were statistically significant for Word Recognition.

As predicted, these data indicate that there are no differences between the performances of subjects who were given computer assisted instruction and those persons receiving individual tuition from teachers. Similarly, no significant differences can be implied between subjects in the errorless discrimination and paired associates groups on the Word Recognition Test for either computer or individual tuition based programmes. In specific terms, $CAI_{ED} = CAI_{PAL} = IND_{ED} = IND_{PAL}$ for this criterion measure.

With respect to list order, the only significant effect was for module 1 of the Word Recognition Test (see Table 10). This revealed that interactions between pre-versus post- test performance and order were reliable ($F = 4.58$, 1/45df) at the $p < .04$ level. An examination of the subgroup means suggests that the order effect was due to marginally higher post-test achievement for subjects receiving module 1 first. Conversely, there were no significant interaction effects for module 2 of the Word Recognition Test (see Table 12).

Table 10

ANOVA Summary Data for Module 1 Word Recognition

List Order Effects

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	0.119	0.02	0.89
O (Order)	1	19.348	3.02	0.09
GO	1	5.246	0.82	0.37
T (Pre - Post Test)	1	144.108	61.08	0.01*
TG	1	0.232	0.10	0.76
TO	1	10.814	4.58	0.04*
TGO	1	0.283	0.12	0.73
Error	45	2.359		

* Significant Effects

Table 11

Means and Standard Deviations for Module 1 Word Recognition

List Order Effects

Group	Order*	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	1	0.53	1.19	3.67	2.89
	2	0.67	0.71	2.67	2.18
Individual Instruction	1	0.92	2.22	4.08	2.63
	2	0.33	0.89	1.92	2.43

* Order 1 = Module 1 followed by Module 2

Order 2 = Module 2 followed by Module 1

Table 12

ANOVA Summary Data for Module 2 Word Recognition
List Order Effects

Source	df	M.S.	F-Ratio	Probability
G	1	0.001	0.00	0.99
O	1	6.457	0.83	0.37
GO	1	0.038	0.00	0.95
T (pre - Post Test)	1	171.355	53.27	0.01*
TG	1	5.434	1.69	0.20
TO	1	5.054	1.57	0.22
TGO	1	0.059	0.02	0.89
Error	42	3.217		

*Significant Effects

Table 13

Means and Standard Deviations for Module 2 Word Recognition
List Order Effects

Group	Order*	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	1	.33	.71	4.11	3.33
	2	.36	.67	3.09	3.18
Individual Instruction	1	.92	1.93	3.62	3.33
	2	.77	1.24	2.62	2.40

*Order 1 = Module 1 followed by Module 2
Order 2 = Module 2 followed by Module 1

Word Identification

Results of the three-way analyses of variance with repeated measures for module 1 and module 2 are displayed in Tables 14 and 16 respectively. No significant interaction effects were found between the groups or modes for either of the modules.

An examination of the sources of variance indicates that reliable differences emerged between pre- and post-tests for the combined sample (Module 1: $F=12.79$, 1/45df, $p<.01$; Module 2: $F=24.42$, 1/42df, $p<.01$). Subgroup means and standard deviations for the two modules are displayed in Tables 15 and 17. For module 1 it can be determined that the overall mean increase between pre- and post-tests was 1.11 while gains on module 2 averaged 1.78 points.

In sum, the nonsignificant interaction effects found for Word Recognition and Identification support the null hypotheses (1.1, 1.2) that there would be no significant differences in change scores between subjects who received either the paired associate or errorless discrimination modes of instruction by means of the computer versus individual tuition. It is upheld that $CAI_{ED} = CAI_{PAL} = IND_{ED} = IND_{PAL}$ for both Word Recognition and Identification.

Results concerning the list order effects for modules 1 and 2 (Word Identification) are presented in Tables 18 and 20 respectively. All of the interaction effects for groups, modes, and orders were found to be nonsignificant with respect to both modules.

Table 14

ANOVA Summary Data for Module 1 Word Identification
Pre- Versus Post-Test Comparison (Repeated Measures)

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	15.011	1.42	0.24
M (Mode)	1	1.448	0.14	0.71
GM	1	4.343	0.41	0.53
T (Pre - Post Test)	1	30.215	12.79	0.01*
TG	1	5.340	2.26	0.14
TM	1	0.016	0.01	0.94
TGM	1	2.305	0.98	0.33
Errors	45	2.363		

*Significant Effect

Table 15

Means and Standard Deviations for Module 1 Word Identification
Pre- Versus Post-Test Comparison

Group	Mode	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	ED	1.91	2.06	3.16	2.82
	PAL	2.25	2.37	4.16	3.07
Individual Instruction	ED	1.71	2.13	2.64	2.84
	PAL	1.82	2.23	2.18	2.60
Combined Groups and Modes		1.93	2.20	3.04	2.83

Table 16

ANOVA Summary Data for Module 2 Word Identification Pre- Versus Post-Test Comparison (Repeated Measures)

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	13.622	1.15	0.29
M (Mode)	1	3.526	0.30	0.59
GM	1	18.244	1.54	0.22
T (Pre - Post Test)	1	71.515	24.42	0.01*
TG	1	0.173	0.06	0.81
TM	1	8.846	3.02	0.09
TGM	1	7.230	2.49	0.12
Errors	42	2.928		

*Significant Effect

Table 17

Means and Standard Deviations for Module 2 Word Identification Pre- Versus Post-Test Comparison

Group	Mode	Pre-Test		Post-Test	
		Mean	S.D.	Mean	S.D.
Computer Assisted Instruction	ED	3.00	2.49	5.90	2.59
	PAL	2.90	3.07	3.40	2.76
Individual Instruction	ED	1.80	2.21	3.73	2.89
	PAL	2.36	2.77	4.18	2.99
Combined Groups and Modes		2.52	2.64	4.30	2.81

Table 18

ANOVA Summary Data for Module 1 Word Identification
List Order Effects

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	18.414	1.19	0.28
O (Order)	1	1.237	0.08	0.78
GO	1	3.003	0.19	0.67
T (pre - Post Test)	1	31.103	15.57	0.01*
TG	1	1.612	0.81	0.37
TO	1	5.75	2.88	0.10
TGO	1	0.195	0.10	0.76
Error	45	1.997		

*Significant Effects

Table 19

Means and Standard Deviations for Module 1 Word Identification
List Order Effects

Group	Order*	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	1	2.20	2.48	4.00	3.05
	2	3.18	3.25	4.18	3.46
Individual Instruction	1	1.85	2.38	3.31	2.84
	2	2.30	3.02	2.60	3.27

*Order 1 = Module 1 followed by Module 2
Order 2 = Module 2 followed by Module 1

Table 20

ANOVA Summary Data for Module 2 Word Identification
List Order Effects

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	15.765	1.31	0.26
O (Order)	1	9.869	0.82	0.37
GO	1	2.009	0.17	0.68
T (Pre - Post Test)	1	72.500	22.24	0.01*
TG	1	0.177	0.05	0.82
TO	1	0.083	0.03	0.87
TGO	1	0.389	0.12	0.73
Error	42	3.259		

*Significant Effect

Table 21

Means and Standard Deviations for Module 2 Word Identification
List Order Effects

Group	Order*	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	1	3.11	3.22	4.89	3.18
	2	2.82	2.40	4.45	2.77
Individual Instruction	1	2.62	3.04	4.31	3.01
	2	1.46	1.51	3.54	2.82

*Order 1 = Module 1 followed by Module 2
Order 2 = Module 2 followed by Module 1

Picture-Word Matching

As with the preceding variables, a repeated measures analysis of variance was performed to examine possible interaction effects between groups, modes, and pre- versus post-test scores. The ANOVA Summary data for modules 1 and 2 are displayed in Tables 22 and 24, respectively. All interaction effects with the exception of pre- versus post-test scores were found to be nonsignificant.

For the overall sample, differences in scores before and after training were reliable at the $p<.01$ level (Module 1: $F=23.33$, 1/41df; Module 2: $F=49.08$, 1/36 df). Means and standard deviations for the subgroups and combined sample are displayed in Table 23 (Module 1) and Table 25 (Module 2). The overall differences between pre- and post-test means were 1.84 and 2.47 points respectively for modules 1 and 2. List order effects were not significant for either of the modules (see Tables 26 and 28).

The above findings lead to acceptance of null hypotheses 2.1 and 2.2. These state that change scores on the pre- versus post-test comparison will not be different for groups who received errorless discrimination or paired associate instruction by means of the computer versus individual instruction. Specifically, it is upheld that:

2.1 $CAI_{ED,PAL} = IND_{ED,PAL}$

and, 2.2 $CAI_{ED} = CAI_{PAL} = IND_{ED} = IND_{PAL}$

for the Picture-Word Matching Test.

Table 22

ANOVA Summary Data for Module 1 Picture-Word Matching Pre- Versus Post-Test Comparison (Repeated Measures)

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	23.442	2.50	0.12
M (Mode)	1	7.986	0.85	0.36
GM	1	12.977	1.38	0.25
T (Pre - Post Test)	1	73.142	23.33	0.01*
TG	1	7.325	2.34	0.13
TM	1	1.164	0.37	0.55
TGM	1	0.225	0.07	0.79
Errors	41	3.136		

*Significant Effect

Table 23

Means and Standard Deviations for Module 1 Picture-Word Matching Pre- Versus Post-Test Comparison

Group	Mode	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	ED	1.58	1.98	4.33	3.31
	PAL	2.08	2.27	4.17	3.19
Individual Instruction	ED	2.00	1.68	3.38	2.57
	PAL	0.75	0.89	1.88	3.00
Combined Groups and Modes		1.60	1.71	3.44	3.02

Table 24

ANOVA Summary Data for Module 2 Picture Word Matching Pre- Versus Post-Test Comparison (Repeated Measures)

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	9.316	0.81	0.37
M (Mode)	1	6.431	0.56	0.46
GM	1	8.982	0.78	0.38
T (Pre - Post Test)	1	119.407	49.08	0.01*
TG	1	1.550	0.64	0.43
TM	1	0.007	0.00	0.96
TGM	1	8.762	3.60	0.07
Errors	36	2.433		

*Significant Effects

Table 25

Means and Standard Deviations for Module 2 Picture-Word Matching Pre- Versus Post-Test Comparison

Group	Mode	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	ED	2.50	2.55	5.90	2.28
	PAL	1.90	2.08	4.00	2.83
Individual Instruction	ED	2.08	2.84	3.58	2.94
	PAL	1.50	1.07	4.38	3.62
Combined Groups and Modes		2.00	2.14	4.47	2.92

Table 26

ANOVA Summary Data for Module 1 Picture-Word Matching List Order Effects

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	15.34	1.57	0.21
O (Order)	1	0.00	0.00	0.99
GO	1	2.30	0.23	0.63
T (Pre - Post Test)	1	68.66	22.36	0.01*
TG	1	5.16	1.68	0.20
TO	1	2.73	0.89	0.35
TGO	1	1.31	0.43	0.52
Error	41	3.07		

*Significant Effect

Table 27

Means and Standard Deviations for Module 1 Picture-Word Matching List Order Effects

Group	Order*	Pre-Test Mean	Pre-Test S.D.	Post-Test Mean	Post-Test S.D.
Computer Assisted Instruction	1	1.73	2.28	4.60	3.04
	2	2.00	1.87	3.66	3.50
Individual Instruction	1	1.30	1.64	2.70	2.58
	2	1.73	1.49	2.91	3.05

*Order 1 = Module 1 followed by Module 2
Order 2 = Module 2 followed by Module 1

Table 28

ANOVA Summary Data for Module 2 Picture-Word Matching List Order Effects

Source	df	M.S.	F-Ratio	Probability
G (Group)	1	10.914	0.93	0.34
O (Order)	1	1.213	0.10	0.75
GO	1	3.564	0.30	0.59
T (Pre - Post Test)	1	113.952	44.34	0.01*
TG	1	3.073	1.20	0.28
TO	1	0.002	0.00	0.98
TGO	1	3.823	1.49	0.23
Error	36	2.570		

*Significant Effect

Table 29

Means and Standard Deviations for Module 2 Picture-Word Matching List Order Effects

Group	Order*	Pre-Test		Post-Test	
		Mean	S.D.	Mean	S.D.
Computer Assisted Instruction	1	2.33	2.96	5.56	2.40
	2	2.09	1.70	4.45	2.91
Individual Instruction	1	2.00	2.55	3.56	3.54
	2	1.73	2.15	4.18	2.96

*Order 1 = Module 1 followed by Module 2
Order 2 = Module 2 followed by Module 1

Transfer

Because the Transfer Test yielded only a single score for each subject, a classic three-way analysis of variance was performed to identify any interaction effects amongst the groups, modes and orders. ANOVA summary data for each of the modules is displayed separately in Tables 30 and 32.

An examination of the main effects reveals a significant difference for list order on module 1 ($F=4.55$, 1/47 df, $p<.04$). Deviations of the subgroup means about the grand mean (see Table 31) suggest that this order effect was due to marginally higher scores for subjects receiving module 1 first as compared with persons who received module 2 followed by module 1. A similar list order effect was found for Word Recognition. In general, it appears that persons trained initially on tool word recognition do slightly better in the transfer situation of module 1 than subjects who were first taught grocery/information words (Module 2) followed by tool word recognition.

In order to examine patterns of relationships amongst the main factors (viz. group, mode, order), multiple classification analyses (MCA) were computed separately for each transfer measure. The MCA table provides a straightforward means for examining interrelated factors with regard to the net effect of each upon the dependent measure. An important use of MCA Scores is to examine the pattern of changes on a given variable when more control factors are introduced. Tables 31 and 33 display the subgroup data for module 1 and 2 transfer tests.

For module 1 (see Table 31) it can be seen that the partial regression coefficients (Beta) and multiple R squared are nonsignificant over all the factors. The proportion of variance of the Transfer Test accounted for by interaction effects (multiple R squared) of all factors was 0.12 Similarily, the module 2 results (see Table 33) yielded an R^2 of 0.03. On the basis of these findings, it is concluded that no significant differences exist between the groups and modes with regard to transfer of learning.

Table 30

ANOVA Summary Data for Transfer Test Module 1
Group By Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	3.291	0.46	0.50
Mode	1	4.875	0.68	0.41
Order	1	32.764	4.55	0.04*
2-way Interactions				
Group Mode	1	0.682	0.10	0.76
Group Order	1	0.524	0.07	0.79
Mode Order	1	23.121	3.21	0.08
3-way Interactions				
Group Mode Order	1	0.092	0.01	0.91
Explained	7	9.859	1.37	0.25
Residual	40	7.199		
Total	47	7.595		

*Significant Effect

Table 31

Multiple Classification Analysis
of Transfer Test, Module 1

Grand Mean = 3.02 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-0.41		-0.28	
2 Computer Assisted Instruction	0.38		0.25	
		0.14		0.10
Mode				
1 Errorless Discrimination	-0.28		-0.28	
2 Paired Associate Learning	0.36		0.36	
		0.12		0.12
Order				
1 Module 1 then Module 2	0.79		0.77	
2 Module 2 then Module 1	-0.93		-0.91	
		0.31		0.31
Multiple R Squared				0.12
Multiple R				0.35

*Deviations of Subgroup means from the grand mean

Table 32

ANOVA Summary Data for Transfer Test Module 2

Group by Mode by Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main effects				
Group	1	3.129	0.73	0.39
Mode	1	0.549	0.13	0.72
Order	1	1.321	0.31	0.58
2-way Interactions				
Group Mode	1	1.172	0.27	0.60
Group Order	1	0.056	0.01	0.91
Mode Order	1	3.585	0.84	0.36
3-way Interactions				
Group Mode Order	1	0.243	0.06	0.81
Explained	7	1.455	0.34	0.92
Residual	38	4.251		
Total	45	3.816		

Table 33

Multiple Classification Analysis

of Transfer Test, Module 2

Grand Mean = 3.30 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-0.22		-0.24	
2 Computer Assisted Instruction	0.27		0.29	
		0.13		0.14
Mode				
1 Errorless Discrimination	0.08		0.10	
2 Paired Associate Learning	-0.10		-0.12	
		0.05		0.06
Order				
1 Module 1 then Module 2	0.17		0.19	
2 Module 2 then Module 1	-0.14		-0.16	
		0.08		0.09
Multiple R Squared				0.03
Multiple R				0.16

*Deviations of Subgroup means from the grand mean

As predicted in hypotheses 3.1 and 3.2, the transfer test scores for the CAI and individual instruction groups were not significantly different regardless of whether subjects were taught by the paired associate or errorless discrimination method. The overall mean for the module 1 transfer measure was 3.02. Similarly, subjects averaged 3.30 points on the transfer task for module 2.

On the basis of these experimental findings, it can be upheld that for the transfer tests of modules 1 and 2:

3.1 $CAI_{ED,PAL(T)} = IND_{ED,PAL(T)}$

and, 3.2 $CAI_{ED(T)} = CAI_{PAL(T)} = IND_{ED(T)} = IND_{PAL(T)}$

Retention

Three-way analyses of variance were computed separately for both the Word Recognition and Identification measures of modules 1 and 2. ANOVA summary data for these four measures are displayed in Tables 34, 36, 38 and 40.

An examination of the main effects shows that list order differences were reliable for module 1 Word Recognition ($F=4.83$, 1/45df, $p<.03$) and Word Identification ($F=6.20$, 1/45df, $p<.02$). Subgroup means about the grand mean (see Tables 35 and 37) indicate that subjects who were given list order 1 (module 1 followed by module 2) retained marginally more words than persons who received list order 2 during the training phase. However, it must be stressed that in actuarial terms this list order difference in retention amounts to $\leq$ 1 word. As can be seen from the multiple classification analyses for module 1 Word Recognition (see Table 35), two and three way interaction effects were nonsignificant ($R^2=0.25$). Similarly, multiple R squared for Module 1 Word Identification was 0.16 (see Table 37).

No significant interaction effects were found for group, mode, or presentation order of module 2. Multiple classification analysis for module 2 Word Recognition (see Table 39) indicates that the proportion of variance accounted for by interaction effects of all factors (R^2) was 0.06. Consistent with this, the multiple R squared for Word Identification of module 2 was 0.03. Overall the sample, the mean recall for module 1 and 2 Word Identification was 2.83 and 3.73 words respectively.

Table 34

ANOVA Summary Data for Module 1 Word Recognition Retention
Group By Mode By Order Effects

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	20.972	3.84	0.06
Mode	1	18.953	3.47	0.07
Order	1	26.331	4.83	0.03*
2-way Interactions				
Group Mode	1	3.741	0.69	0.41
Group Order	1	0.180	0.03	0.86
Mode Order	1	9.936	1.82	0.19
3-way Interactions				
Group Mode Order	1	0.088	0.02	0.90
Explained	7	12.786	2.34	0.04
Residual	38	5.455		
Total	45	6.596		

* Significant Effects

Table 35

Multiple Classification Analysis
of Word Recognition Retention, Module 1

Grand Mean = 2.07 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-0.88		-0.72	
2 Computer Assisted Instruction	0.81		0.66	
		0.33		0.27
Mode				
1 Errorless Discrimination	-0.55		-0.54	
2 Paired Associate Learning	0.78		0.77	
		0.26		0.26
Order				
1 Module 1 then Module 2	0.77		0.73	
2 Module 2 then Module 1	-0.84		-0.80	
		0.32		0.30
Multiple R Squared				0.25
Multiple R				0.50

* Deviation of subgroup means from the grand mean

Table 36

ANOVA Summary Data for Retention Module 1 Word Identification Group By Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	4.409	0.76	0.39
Mode	1	0.932	0.16	0.69
Order	1	35.723	6.20	0.02*
2-way Interactions				
Group Mode	1	7.932	1.38	0.25
Group Order	1	0.503	0.09	0.77
Mode Order	1	11.274	1.96	0.17
3-way Interactions				
Group Mode Order	1	4.758	0.82	0.36
Explained	7	10.250	1.78	0.12
Residual	38	5.759		
Total	45	6.458		

* Significant Effects

Table 37

Multiple Classification Analysis of Word Identification Retention, Module 1

Grand Mean = 2.83 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-0.46		-0.33	
2 Computer Assisted Instruction	0.42		0.30	
		0.18		0.12
Mode				
1 Errorless Discrimination	-0.09		-0.12	
2 Paired Associate Learning	0.12		0.17	
		0.04		0.06
Order				
1 Module 1 then Module 2	0.88		0.85	
2 Module 2 then Module 1	-0.96		-0.93	
		0.37		0.36
Multiple R Squared				0.16
Multiple R				0.39

*Deviation of subgroup means from the grand mean

Table 38

ANOVA Summary Data for Retention Module 2 Word Recognition

Group By Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	12.345	1.50	0.23
Mode	1	0.494	0.06	0.81
Order	1	3.838	0.46	0.49
2-way Interactions				
Group Mode	1	0.017	0.00	0.96
Group Order	1	2.603	0.32	0.58
Mode Order	1	2.298	0.28	0.60
3-way Interactions				
Group Mode Order	1	1.366	0.16	0.68
Explained	7	3.465	0.42	0.88
Residual	36	8.212		
Total	43	7.439		

Table 39

Multiple Classification Analysis

of Word Recognition Retention, Module 2

Grand Mean = 2.66 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-0.53		-0.51	
2 Computer Assisted Instruction	0.58		0.56	
		0.21		0.20
Mode				
1 Errorless Discrimination	-0.10		-0.08	
2 Paired Associate Learning	0.16		0.13	
		0.05		0.04
Order				
1 Module 1 then Module 2	0.34		0.32	
2 Module 2 then Module 1	-0.28		-0.27	
		0.12		0.11
Multiple R Squared				0.06
Multiple R				0.23

*Deviations of subgroup means from the grand mean

Table 40

ANOVA Summary Data for Retention Module 2 Word Identification

Group By Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	4.729	0.56	0.45
Mode	1	4.426	0.53	0.47
Order	1	0.256	0.03	0.86
2-way Interactions				
Group Mode	1	2.151	0.26	0.61
Group Order	1	11.625	1.39	0.24
Mode Order	1	1.596	0.19	0.66
3-way Interactions				
Group Mode Order	1	4.359	0.52	0.47
Explained	7	4.328	0.51	0.81
Residual	36	8.345		
Total	43	7.691		

Table 41

Multiple Classification Analysis

of Word Identification Retention, Module 2

Grand Mean = 3.73 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-0.29		-0.31	
2 Computer Assisted Instruction	0.32		0.34	
		0.11		0.12
Mode				
1 Errorless Discrimination	0.24		0.25	
2 Paired Associate Learning	-0.37		-0.40	
		0.11		0.12
Order				
1 Module 1 then Module 2	0.12		0.08	
2 Module 2 then Module 1	-0.10		-0.07	
		0.04		0.03
Multiple R Squared				0.03
Multiple R				0.16

*Deviations of the subgroup means from the grand mean

In view of the nonsignificant interaction effects for retention it can be upheld that there are no reliable differences between groups and modes of instruction. Thus, the following null hypotheses are accepted in the form:

4.2 $CAI_{ED,PAL(R)} = IND_{ED,PAL(R)}$

and, 4.3 $CAI_{ED(R)} = CAI_{PAL(R)} = IND_{ED(R)} = IND_{PAL(R)}$

In sum, failure to reject the null hypotheses leads to the conclusion that there are no statistically significant differences between the performances of subjects who were given errorless discrimination or paired associate instruction by means of the computer or individual tuition. Rather, the findings indicate that all subgroups improved to a similar extent through participation in training regardless of which teaching method was employed. Moreover, there are no reliable differences between the subgroups for either transfer or retention of learning.

Time in Training

From a practical point of view, it was considered useful to obtain some information on the relative time spent in training and attempts to mastery of the learning task. This method-time measurement (MTM) data was also analysed separately for modules 1 and 2 using a three-way analysis of variance.

ANOVA summary data on total time in training for module 1 is displayed in Table 42. An examination of the sources of variation indicates that all interaction effects were nonsignificant. No statistically reliable results were obtained between the groups, modes, and order of presentation. Despite these overall findings, there are some notable trends in the multiple classification data that warrant consideration here.

As can be seen from Table 43, the grand mean for total time spent on module 1 was 87.53 minutes. A qualitative analysis of subgroup deviations about the grand mean indicates that, in general terms, the individual instruction group took less time to complete their training sessions than was the case for the CAI group. Deviations from the grand mean were -11.48 minutes for individual teachers and +8.27 minutes for the computer bases programmes. Moreover, the paired associate method appears to be slightly more time efficient (-6.58

Table 42

ANOVA Summary Data for Module 1 Total Time

Group By Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	3603.295	2.76	0.10
Mode	1	1724.913	1.32	0.25
Order	1	56.172	0.04	0.84
2-way Interactions				
Group Mode	1	193.164	0.15	0.70
Group Order	1	261.506	0.20	0.66
Mode Order	1	289.829	0.22	0.64
3-way Interactions				
Group Mode Order	1	240.353	0.18	0.67
Explained	7	1024.651	0.78	0.60
Residual	35	1304.633		
Total	42	1257.969		

Table 43

Multiple Classification Analysis

of Total Time, Module 1

Grand Mean = 87.53 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-11.48		-11.04	
2 Computer Assisted Instruction	8.27		7.95	
		0.28		0.27
Mode				
1 Errorless Discrimination	6.28		6.24	
2 Paired Associate Learning	-6.58		-6.53	
		0.18		0.18
Order				
1 Module 1 then Module 2	2.33		1.15	
2 Module 2 then Module 1	-2.44		-1.21	
		0.07		0.03
Multiple R Squared				0.11
Multiple R				0.33

*Deviations of subgroup means from the grand mean

Table 44

ANOVA Summary Data for Module 2 Total Time

Group by Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	8748.424	7.83	0.01*
Mode	1	9943.914	8.90	0.01*
Order	1	11.574	0.01	0.92
2-way Interactions				
Group Mode	1	429.589	0.38	0.54
Group Order	1	69.444	0.06	0.80
Mode Order	1	277.378	0.25	0.62
Explained	6	3561.774	3.18	0.01*
Residual	30	1117.516		
Total	36	1524.892		

Table 45

Multiple Classification Analysis

of Total Time, Module 2

Grand Mean = 90.68 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	-16.29		-15.88	
2 Computer Assisted Instruction	15.43		15.05	
		0.41		0.40
Mode				
1 Errorless Discrimination	17.01		16.47	
2 Paired Associate Learning	-17.95		-17.39	
		0.45		0.44
Order				
1 Module 1 then Module 2	-4.25		-0.74	
2 Module 2 then Module 1	2.59		0.45	
		0.09		0.02
Multiple R Squared				0.36
Multiple R				0.60

*Deviations of subgroup means from the grand mean

minutes) than was the errorless discrimination approach (+6.28 minutes).

ANOVA summary data on total training time for module 2 is presented in•Table 44. Trends in the time analysis were similar to module 1 results. An examination of the main effects indicates that group and mode differences were both reliable at the $p < .01$ level (Group: F=7.83, df= 1/36; Mode: F=8.90, df= 1/36). The grand mean for training time on module 2 was 90.68 minutes (see Table 45). Subjects instructed by individual teachers tended to complete the sessions at a more rapid pace (-16.29 minutes) whereas the computer programmes required an average of +15.43 additional minutes in relation to the grand mean. Similarly, the paired associates approach was time efficient (-17.95 minutes) in contrast to the errorless discrimination method (+17.01 minutes). Trends in the time data for module 2 are clear cut, favouring the individual tuition and paired associate method.

Attempts to Mastery

Data concerning the total number of attempts recorded for each subject was tabulated separately for modules one and two. A three-way analysis of variance was then performed to identify any interaction effects between the groups, modes, and orders of presentation with regard to total attempts required to master the learning steps for the 5 sessions contained in each module.

ANOVA summary data on total attempts for module 1 is displayed in Table 46. These results indicate that there were no reliable differences between the independent variables in terms of computer assisted instruction, individual tuition, modes or orders of presentation. In general, it can be stated that the subgroups were similar with respect to overall attempts recorded for module 1. There were, however, some qualitative aspects of the data that should be considered when interpreting these findings.

An inspection of the multiple classification analysis in Table 47 shows that the overall mean number of attempts for module 1 was 239.41. By way of contrast it can be seen that the individual instruction group required a slightly greater number of attempts (+5.47) than was the case for the computer assisted instruction group (-5.25). Deviations from the grand mean also indicate that subjects given the errorless discrimination mode tended to register fewer

Table 46

ANOVA Summary Data for Module 1 Total Attempts

Group By Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	1771.116	0.17	0.68
Mode	1	7599.603	0.74	0.39
Order	1	43.618	0.00	0.95
2-way Interactions				
Group Mode	1	590.217	0.06	0.81
Group Order	1	9586.661	0.93	0.34
Mode Order	1	7142.594	0.69	0.40
3-way Interactions				
Group Mode Order	1	261.502	0.02	0.87
Explained	7	4132.510	0.40	0.89
Residual	41	10273.372		
Total	48	9377.830		

Table 47

Multiple Classification Analysis

of Total Attempts, Module 1

Grand Mean = 239.41 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	5.47		6.18	
2 Computer Assisted Instruction	-5.25		-5.93	
		0.06		0.06
Mode				
1 Errorless Discrimination	-10.93		-11.27	
2 Paired Associate Learning	13.41		13.83	
		0.13		0.13
Order				
1 Module 1 then Module 2	-1.52		-0.86	
2 Module 2 then Module 1	1.86		1.05	
		0.02		0.01
Multiple R Squared				0.02
Multiple R				0.14

*Deviations of subgroup means from the grand mean

Table 48

ANOVA Summary Data for Module 2 Total Attempts

Group By Mode By Order Interactions

Source of Variation	df	M.S.	F-Ratio	Probability
Main Effects				
Group	1	2063.589	0.27	0.60
Mode	1	7566.955	0.99	0.33
Order	1	8856.375	1.16	0.29
2-way Interactions				
Group Mode	1	71.002	0.00	0.92
Group Order	1	6144.072	0.80	0.37
Mode Order	1	8484.262	1.11	0.29
3-way Interactions				
Group Mode Order	1	1851.498	0.24	0.62
Explained	7	4689.049	0.61	0.74
Residual	36	7645.099		
Total	43	7163.882		

Table 49

Multiple Classification Analysis

of Total Attempts, Module 2

Grand Mean = 239.45 Variable and Category	*Unadjusted Deviation	Eta	Adjusted for Nonmetric Factors Deviation	Beta
Group				
1 Individual Instruction	4.43		6.00	
2 Computer Assisted Instruction	-5.82		-7.89	
		0.06		0.08
Mode				
1 Errorless Discrimination	-10.61		-11.47	
2 Paired Associate Learning	13.97		15.09	
		0.15		0.16
Order				
1 Module 1 then Module 2	-14.65		-15.58	
2 Module 2 then Module 1	12.21		12.98	
		0.16		0.17
Multiple R Squared				0.05
Multiple R				0.23

*Deviations of subgroup means from the grand mean

responses (10.93) in contrast to the larger number of attempts recorded by persons who participated in the paired associate method (+13.41). Multiple R squared for the above interaction effects was not significant (0.02) with regard to total attempts required to complete module 1.

ANOVA summary data for total attempts on module 2 is displayed in Table 28. These results are consistent with the module 1 findings and reveal that no significant interaction effects occurred between groups, modes, or presentation order. An examination of the multiple classification analysis in Table 49 shows that the grand mean for total attempts on module 2 was 239.45. A qualitative examination of the data indicates that subjects who were taught by individual teachers recorded a slightly greater number of attempts (+4.43) than persons who received computer assisted instruction (-5.82). It should also be noted that relatively fewer attempts were registered by the errorless discrimination group (-10.61) than was the case for subjects participating in the paired associate method (+13.97). It must be stressed however, that these trends are not statistically reliable (R^2 = .06). Rather, the findings are presented here as a general indication of deviations found amongst the subgroups that may have some practical importance for gauging the efficiency of the different forms of instruction provided.

To summarise, no significant main or interaction effects were observed between groups, modes, or order of presentation with regard to total number of attempts. For module 2 it was found that persons participating in the individual instruction group completed their training at a significantly faster pace than the computer based group. There was also an indication that the errorless discrimination method was less time efficient than the paired associate procedure. Persons given computer assisted instruction tended to require slightly fewer attempts to master the training sequences than was the case for subjects receiving individual instruction from teachers. Practical implications arising from these methods-time measurement analyses will be discussed in the following chapter.

CHAPTER VIII
DISCUSSION

This study has been designed to answer specific hypotheses concerning the utility of contrasting approaches for teaching word recognition. Additionally, the findings offer some practical information on cognitive characteristics of the mentally retarded learner. In order that the results might be discussed within a theoretical framework, this section has been organised to integrate the experimental findings with previous work undertaken on acquisition, retention, and transfer of learning. The major focus of this Chapter is upon the translation of theory into practice. An attempt has been made to highlight some principles of learning which were found to be important for teaching word recognition to mentally retarded learners.

Acquisition of Learning

The major findings of this research demonstrate that microcomputer based instruction and more conventional tuition result in similar learning outcomes despite procedural variations arising from the two different methods of instruction provided. As predicted, there were no reliable differences between the two groups and modes of instruction in terms of performance on the criterion measures of Word Recognition, Identification, and Picture-Word Matching. The fact that all subjects recorded significant gains as measured by a comparison of pre- versus post-test change scores, leads to speculation as to which underlying processes account for these consistent improvements in learning.

The results of this study are in accordance with the findings of Parmenter et al. (1979) who demonstrated that mildly retarded adolescents learned a short list of words equally well under two conditions of instruction. Similarly, Vergason (1966) found that both automated and traditional methods of instruction resulted in similar learning outcomes as measured by a test of retention administered one day after completion of training. The main point that must be considered in this study and preceding research is the extent to which treatment conditions were different from one another. It may be that a number of common elements were operating under both conditions despite more obvious variations in the methods of instruction.

In the present study, a paired associate (picture-word) method, as used by Vergason (1964) and Holz (1976), was compared with an errorless discrimination technique in which no pictures were used such that the stimulus word to be learned serves as the sole focus of the learner's attention (Walsh and Lamberts, 1979; Vandever and Stubbs, 1977). If, as Samuels (1970) has argued, the effect of pictures on acquisition of a social sight vocabulary is minimal, then one is left to question whether or not subjects were shifting attention across dimensions from picture to word. Indeed, the word's relation to a referent picture may have been perceived as almost coincidental by subjects participating in the paired associate mode. This assumption is in line with Duell's (1968) observation that a desired shift in stimulus control is more likely to occur when subjects are forced to notice a cue while responding. In practical terms, failure to attend to extra stimulus dimensions (pictures) may mean that subjects in the paired associate mode were, in effect, focusing most of their attention on the printed material and receiving a similar form of training to that offered in the errorless discrimination mode of instruction. Thus, the essential difference between the two modes may have been simply the order and number of multiple choices that were presented for each of the four trials in a given training sequence.

Subjective impressions suggested that while trainees taught by the paired associate method attended to pictorial material at the beginning of each sequence, they rapidly shifted to a straight word focus and took less notice of the picture during the training phase. The fact that no further reference was made, either by the instructor or computer, to the picture following introduction of the word, leads to the observation that the extra stimulus material was optional (not essential) for successful completion of each of the word items and trials. By implication, the photographs may have played a passive role in the learning process such that the two modes of instruction operated in a similar manner to one another.

The results of the experiment clearly demonstrate that the two groups and modes of instruction were equally effective for teaching a word recognition task. In view of the nonsignificant interaction effects, it seems likely that a common set of factors, independent of the treatment variables, contributed to the changes in learning. Firstly, the use of individual instruction in a highly interactive setting resulted in high levels of attention and motivation. The effect of being singled out for training was apparent in the subjects' behaviour. They usually anticipated their turn on the computer or with individual instruction and eagerly came to the sessions. Secondly, the relative lack of extraneous stimuli in the training rooms (e.g. the absence of windows, other trainees and industrial noises) probably aided concentration on the learning task. In terms of the Zeaman and House (1963) theory of attention it can reasonably be assumed that the focus on a structured set of dimensions (e.g. target words and referent pictures) assisted the learner to sort out relevant learning cues. The logical sequence of instruction provided a concrete learning set in which the subject could organise input materials.

Thirdly, there are a number of principles of learning that are operating under both conditions of instruction. These factors are a function of programmed instruction in general rather than computer assisted instruction in particular, and have previously been shown to assist the learning process (Clarke and Clarke, 1973; Brown, 1975):

1. Active participation
2. Self-pacing instruction
3. Overlearning of materials
4. Reduction of emotional dependence
5. Immediate reinforcement.

Active participation was an essential part of the learning process. Subjects were encouraged to make their own decisions and to work independently. This was consistent with Skinner's (1968) view that every attempt should be made to ensure the student does not become a passive recipient of new information. Rather, opportunities for exploration and self direction need to be offered within a structured learning medium. In both the computer assisted instruction and individual tuition groups, subjects had full control of the speed of presentation. The longest response time measured for completion of a module (5 sessions) was 203 minutes while the shortest time interval was 24 minutes. The time generally decreased markedly for all subjects as they became familiar with the procedures. However, it was noted that subjects receiving computer assisted instruction required slightly more time to complete their training sessions than persons who were given individual instruction. This trend could be attributed to the fixed sequence of time delays programmed into the computer.

The empirical nature of this study predisposed prime attention to the more objective and measurable aspects of behaviour and learning.

The shortcoming of this approach was that many important situational factors and descriptive features of the subjects' response to the teaching programmes tended to be overlooked. A variety of noticeable changes in behaviour that were subsequently noted by the teachers and experimenter were not amenable to measurement in the pre- and post-test situations. These qualitative aspects of behaviour were based upon observations and anecdotal recordings completed by the examiner at the time of each session.

Informal observations suggest that computer based instruction can be of particular value to subjects who are overly distractable or inclined to engage the teacher in off-task verbal interactions. One participant, previously considered incapable of benefiting from individual instruction due to aggressive behaviour (e.g. abusive language, inappropriate physical contact) was observed to follow instructions and presumably learn through interaction with the computer. Another subject who demonstrated grotesque personal manners (e.g. loud burping noises, gazing into space, and verbal imitation of background noises) could operate the computer system and eagerly attend to the requirements of the learning task. Many other examples could be cited to support the view that computer assisted instruction, while not attempting to modify difficult behaviours, may offer a suitable learning environment for persons who are less able to attend and interact in an interpersonal teaching situation.

A major obstacle in providing practical social education for mentally retarded adults is the inappropriate use of child oriented materials. Commonly, the teaching of early learning concepts involves the use of objects (e.g. blocks, flashcards, children's stories) that are not in keeping with regular adult interests. It was notable that several of the teachers who administered the individual instruction programmes, commented afterwards that they felt the teaching of word recognition by traditional pictorial and flashcard methods was a rather undignified and regressive approach not suited for use with adult subjects. By way of contrast, the same materials presented under computer control give the outward appearance of an adult learning medium that incorporates elements of new technology and skillful operation by the user.

It is generally the case that mentally retarded adults are exposed to sheltered lifestyles and have a limited range of opportunities for decision making (Ryba, 1979). Within the context of this present research, it was possible to offer an independent learning experience such that subjects interacted with the computer at their own pace and were required to take initiative and responsibility for solving problems. Indeed, many subjects preferred to work independently and would wait for the experimenter to leave the room before proceding with their lesson.

Subjective impressions by teachers suggested that participants receiving individual tuition were aware of failure experiences when these occurred and that perceptions of error by both the student and teacher would impede performance on subsequent items. Despite the use of neutral feedback (e.g. "Okay", "Try again") there was a need to provide verbal encouragement to help overcome these failure experiences. Conversely, it was noted that trainees who were given computer assisted instruction responded actively to the feedback provided throughout the training sequences. It was noticed, for example, that subjects would often verbalise the flashing messages (e.g. *** IS RIGHT ***, ***TRY AGAIN ***) and nod their heads in response to 'Happy Face' illustrations displayed on the video screen. Repetition of the items when errors were made did not appear to result in negative perceptions of failure though subjects were aware that they had recorded an incorrect response. Such observations are in agreement with a study by Holz (1976) who noted the willingness of mentally retarded children to proceed with computer assisted instruction despite frequent repetition of items when errors occurred. In sum, it would seem that the relatively impersonal nature of the computer can provide direct and meaningful feedback without triggering negative perceptions of failure that tend to have an adverse effect on performance in more conventional forms of individual instruction which involve direct interpersonal feedback.

Contrary to expectation, it was found that list order effects were significant for the Word Recognition Test of Module One. An examination of the subgroup means indicated that subjects who were given list order one (module 1 followed by module 2) tended to achieve marginally higher post-test scores than was the case for subjects receiving list order two (module 2 followed by module 1). Several different interpretations may be advanced to account for this finding. It may be that the tool names contained in Module One formed a more discernible and conceptually meaningful stimulus class (e.g. HAMMER, SPANNER) than the varied information items of Module Two (e.g. BREAD, RAILWAY). If this was the case, then there is reason to believe that the initial clustering of common elements facilitated input organisation and generally resulted in improved performance by subjects given list order one. Support for this assumption is available from previous research by Bilsky and Evans (1970). These experimenters found that when mentally retarded adolescents were first trained on a clustered list of words, their performance on subsequent lists of random items improved to a significant extent. The educational implications of the present results are that it may be possible to facilitate performance on educational tasks such as word recognition by remediating specific deficiencies in input organisation using associative clustering techniques.

It should be mentioned here that unfamiliarity with the test situations may have adversely affected subjects' performance. Other researchers (Brown and Semple, 1970; Brown, 1967) have demonstrated that when slow learners are subjected to unfamiliar social and physical conditions, their overt verbalisation and motor performance are likely to be inhibited. Moreover, unfamiliar stimulation may appear unstructured and presumably less meaningful to the learner than events occurring in a familiar environment. Within the context of this present study, it may be that subjects were susceptible to the unfamiliar test circumstances and individual instruction sessions especially since these were an irregular component of their ongoing training programmes. Assuming this is the case, it seems important to provide social and environmental preparation prior to attempting any formal assessment or teaching. To some extent, initial meetings with trainees were used as an opportunity to establish rapport though this may not have been sufficient to overcome the effects of introducing a structured test sequence. One practical suggestion for overcoming the effects of unfamiliarity with the materials and procedures would be to carry out a trial assessment and training programme prior to the experimental phase.

Despite the statistical significance of the gains in pre- versus post-test performance, there is a need to consider the actual changes in learning that occurred as a result of training. For Module One it was observed that the mean increase in Word Recognition for the combined groups was 2.51 words. Similarly, the average gain for Module Two was 2.76 words. By way of comparison, average increases for Word Identification were 1.11 and 1.78 words for Modules One and Two respectively. On the Picture-Word Matching Test it was found that training on Module One resulted in a mean increase of 1.84 words while Module Two gains averaged 2.47 words. These modest improvements in word recognition ability are consistent with findings from other related studies (e.g. Walsh and Lamberts, 1979; Dorry and Zeaman, 1975) that have employed a similar number of items and amount of training time.

The relatively minor improvements in word recognition knowledge measured by this study may indicate that a longer period of training with more frequent sessions is necessary to ensure acquisition and retention of learning. It might also be the case that fewer training items within each of the modules would have resulted in improved levels of performance. Practitioners can rightfully question whether such gains are meaningful in a psychological or behavioural sense. Notwithstanding this limitation, there is evidence to indicate that training programmes which make use of well known principles of learning (Brown, 1975) and programmed instruction (Beasely, 1974) will enhance learning outcomes.

The results of this study support the findings of Vandever, Maggart, and Nassar (1976) and Walsh and Lamberts (1979) concerning the utility of errorless discrimination procedures that make use of a whole-word approach for teaching word recognition. In particular, it is conjectured that the photographs used in the paired associate teaching method played a passive role in training with the effect that attention was primarily directed at printed words. There is no evidence in this present research to favour the use of pictorial materials when teaching recognition of common words. However, this may not be true with more abstract concepts that can meaningfully be presented in a visual form. The findings appear to indicate that a straight word focus is likely to be beneficial for fostering rapid initial learning. The main advantage of the errorless discrimination approach is that the programme forces the subject to make discriminations on the whole word by eventually using distractors with the same initial and final letters as the target word.

The techniques of errorless discrimination and matching to sample can be traced back to the early work of Itard (1807/1962) who, over 180 years ago, demonstrated that principles of gradualism and stimulus shaping can be applied to the successful teaching of a mentally retarded child on functional aspects of social sight reading and writing. In terms of research by Sidman and Stoddard (1967) it seems probable that a restricted stimulus-response relation using an exclusive word focus and discrimination procedures may be particularly suited to the teaching of word recognition with mentally retarded learners. As Samuels (1970) has pointed out, training which is designed to force students to pay attention to printed word stimuli appears to be more successful than programmes which do not force such attending. Relating these findings to this present investigation, it is contended that the shaping procedures used were instrumental in training handicapped adults toward a cognitive learning set.

It is probable that the strength of associations between auditory and visual representations of the printed word was enhanced by the nature of the learning task provided. Specifically, the principles of gradualism and stimulus shaping used in these teaching programmes appeared to facilitate acquisition of a stimulus-response relationship through repetition and overlearning of the target words. There is evidence from other research (Bilsky and Evans, 1970) to support the contention that mentally retarded people demonstrate a deficit in their ability to organise input materials. It would seem that the structured and sequential nature of the teaching programmes used in this investigation lend themselves to increasing the effectiveness of organisational skills with slow learners.

In discussing the problem of attention, Zeaman and House(1963) have noted that distraction may be closely tied to inability to ignore irrelevant dimensions of the learning task. The practical implication of this is that learners should be exposed to those teaching aids which tend to direct their attention and provide active participation in the teaching situation. This can clearly be accomplished through the use of audiovisual aids, certain teaching machines, and computer assisted instruction.

An ongoing controversy in the field of mental retardation concerns whether or not the handicapped individual is merely demonstrating a developmental lag or possesses some underlying cognitive deficit that precludes the processing of certain types of information. Luria (1963) has demonstrated that there is considerable dissociation of speech and action in mentally retarded children. He contends that defects such as inertia, dissociation, and generally weak integration of the central nervous system (CNS) affect performance on retention and memory of verbal conditioning tasks. However, it is felt that these deficits can be overcome to some extent by specific remedial strategies that take account of the characteristic nature of the impairment. Das (1972) also alludes to the functional cognitive differences between retarded and nonretarded children and recommends the use of specialised remedial methods to improve information processing in these children.

Consistent with the above research, this present study has demonstrated that handicapped learners can benefit from a programmed instruction approach that makes use of gradualism and stimulus shaping to teach a restricted stimulus-response pattern required of a word recognition task. Intuitively, it seems probable that the training procedures were effective in increasing new cognitive structures that promote more efficient learning. This is a matter of inference and clearly requires more research to identify ways in which a learning set is developed by mentally retarded learners. At this time it is not possible to separate the differences in performance from what is postulated as learning or retention. Obviously, it must be concluded that only performance can be measured in objective terms while learning and memory processes must be inferred as second order factors or underlying constructs not amenable to measurement. In sum, acquisition of a given task must be considered with regard to both mastery of learning objectives and more elusive cognitive strategies that account for the learner's method of processing new information.

The fact that computer assisted instruction was able to approximate learning outcomes achieved through more traditional forms of tuition leads to speculation as to the usefulness of this new technology for enhancing the cognitive abilities of mentally retarded learners. The capability to control precisely the manner in which new information is presented to the learner has important implications for studying patterns of cognitive processing under varied modes of interaction in the teaching situation. Very little is known about the learning process per se, but it is widely recognised that extraneous stimulation which is commonly found in conventional teaching programmes can interfere with acquisition of a learning set. Teaching procedures generated by a computer can be designed to maximise on-task behaviour and thus overcome some interfering environmental factors that may inhibit learning of a specific operation or concept. The principle is advanced that computer related learning environments give the learner considerable control of the teaching situation and provide consistent feedback that is not so readily administered by conventional forms of instruction. Motivation can be a strong determinant as far as the performance of retarded learners is concerned and there are indications from this study and other related research to demonstrate that computer assisted instruction can be used to enhance interest and purposeful interaction within the learning process. Similarly, the point can be made that computer assisted instruction is an important teaching aid that incorporates well known principles of programmed learning and perhaps more importantly, offers a self directed instructional mode.

Transfer of Learning

As predicted there were no significant interaction effects between groups or modes of instruction on the transfer test measures for Modules One and Two. The overall results indicate that subjects recorded similar gains in learning on the transfer measures (Combined Group Mean: Module One = 3.02; Module Two Mean = 3.30) to that recorded on the post-tests of Word Recognition and Identification. Contrary to expectation, however, it was found that subjects who were given list order one (Module One followed by Module Two) achieved slightly higher transfer test scores than persons placed in list order two (Module Two followed by Module One). The significance of this order effect is unclear but may be related to the type of stimulus class provided during initial training. It is possible that instruction on a common set of elements (tool names) at the outset of training may have aided subjects' performance with regard to organisation of input materials and development of an efficient learning set. This is also in agreement with earlier work by Bilsky and Evans (1970) who demonstrated that the effects of increased organisational skills will transfer from one situation to another.

The ability of subjects to transfer their learning is in line with the theoretical proposition of Zeaman and House (1963) who predict that an intradimensional shift (ID) will arrange for positive transfer of the attention response since the same stimulus dimension is relevant in both original learning and transfer. In the conceptual terms of this investigation, it can be assumed that trials one and two of the errorless discrimination procedure involved intradimensional shifts in the sense that the relevant aspect of the task was length of word; whereas in trials three and four the comparison stimuli are all of similar length and the beginning letter of the target word (previously irrelevant) becomes the relevant task dimension. Thus, ID shifts arrange for transfer of the attention response at several points in the training programme. It can be stated that during the training phase subjects received instruction on both intradimensional and extradimensional shifts regardless of whether they were given paired associate or errorless discrimination modes.

Research by Switzky (1973) supports the view that ID shifts are learned at a significantly faster rate than ED shifts when subjects are trained on relevant dimensions of low distinctiveness in original learning. Moreover, the results suggest that when subjects are trained in original learning on problems where the relevant dimension is of low distinctiveness, they appear to learn a dimensional mediator which assists with transfer to a new task. In terms of this present investigation, support is obtained for the ability of subjects to generalise their learning to new, though related, situations in which the same stimulus dimension is relevant for both original learning and transfer. However, some caution must be exercised in making this interpretation as the word recognition task involved very basic concepts and similar levels of transfer may not have been obtained with less familiar vocabulary items. The practical implication of previous work by Switzky (1973) and the present findings is that it seems important to diminish the distinctiveness of cues progressively during training to help ensure that the learner is able to develop some dimensional mediators which will assist the transfer of information to new situations.

It is important to note that both the computer assisted instruction group and subjects taught by conventional individual programmes attained similar levels of transfer. This, in part, supports the view that when subjects are taught by an automated procedure they are able to generalise their learning to other real life events. Most previous research on computer assisted instruction for teaching social sight reading (e.g. Atkinson, 1974; Holz, 1976) has tended to make use of the computer for both assessment and training. Hence, little evidence is available concerning the ability of subjects to transfer their learning to other more crucial situations. The practical implication of this finding is that computer assisted instruction can successfully be used to simulate conventional approaches to learning.

There are many observational aspects of the present study that warrant consideration here. It was noted, for example, that subjects quickly learned to operate the computer equipment and began to anticipate each subsequent step in the teaching programme. It is felt that the development of a consistent learning set was an important factor in the acquisition and transfer of learning by subjects who received instruction on the computer. Subjects would frequently verbalise the visual information presented to them on the video display and slide projection screens and attempt to predict the likelihood of their responses being correct. Previous research (e.g. Wolff, 1967; Brown, 1975) has demonstrated that overt verbalisation can facilitate concept attainment. Available evidence suggests that overt verbalisation can increase the salience and discriminability of the verbal cue which is needed for attainment of a concept. This leads to speculation that an automated interactive system such as the computer used in this investigation is useful for aiding the development of mediation processes or assisting the learner to organise input materials and respond on cue to relevant dimensions of a task.

The training procedures used in this study made use of highly distinctive printed word stimuli presented in upper case letters on flashcards or a video display screen. It was considered that these distinctive features would assist the learner to perceive relevant dimensions of the task. This approach is in agreement with previous research by Guralnick (1975) who showed that techniques designed to teach retarded children to attend to distinctive within-stimulus features of certain alphabet letters facilitates later discrimination of those forms. In comparing several methods of instruction, it was found that groups who were given pre-training on distinctive features (e.g. horizontal-slant line drawings) and highlighting of letter discrimination cues (e.g. differential colouring of important segments) were able to transfer their learning to a new discrimination task. Conversely, subjects who were given training on distinctive features followed by fading-in of nonessential elements of letters and forms were less able than the other groups to generalise their learning. Previous work by Gollin and Savoy(1968) also found that fading procedures were not successful for facilitating transfer to a conditional discrimination problem. These authors suggested that fading procedures may not encourage subjects to identify and attend to relevant dimensions, especially when a wide range of cues is available. Rather, responding may come to be controlled by certain stimulus dimensions which are established early in training such as length of the target word or shape of the beginning letter. Relating these research findings back to this present investigation, it appears that the effect of the training procedures was to increase the likelihood of subjects attending to relevant distinctive features of the target words. Moreover, the distinctiveness of the printed material seemed to facilitate transfer of training.

The practical implication arising from this investigation and previous research is that transfer of learning is directly linked to ability of subjects to identify and respond to relevant letter and word cues. There is considerable evidence to favour the use of within-stimulus prompting (accentuating critical features of the stimuli themselves) as opposed to extra-stimulus prompting (additional colour and form cues) to guide performance on letter and word discrimination tasks. Earlier work by Wolfe and Cuvo (1978) suggests that since mentally retarded persons tend to be overselective and attend to relatively few cues in a stimulus array, within-stimulus prompting may be more effective than the addition of extra cues which are intended to aid task performance. Further support for this idea comes from the work of Duell (1968) who noted that only when the subject is forced to notice a relevant cue while responding, does the desired shift in stimulus control take place.

In summary, it is stressed that the effectiveness of training is likely to be enhanced by encouraging mentally retarded subjects to respond to within-stimulus cues that will remain relevant under varying transfer conditions. Directing the attention of subjects to a few important cues during the early stages of training would appear to promote acquisition and transfer of learning. There is evidence to suggest that extra-stimulus prompts can impede generalisation of correct responses, especially when these additional cues (e.g. colour and form coding) are made redundant in the transfer situation.

Retention of Original Learning

The results of this study indicate that there are no reliable differences between groups or modes of instruction as measured by the tests of retention for Module One and Module Two. In general, this supports the view that both the computer assisted instruction and more conventional interpersonal tuition result in similar amounts of retention by subjects one month after completion of the training programmes. The overall results show that retention test scores were similar to those obtained on the immediate post-tests of Word Recognition and Word Identification. The practical implication of this finding is that subjects were able to recall their learning at a later time following a four week interval in which no individual instruction was provided. In terms of the present study, it would appear that subjects could retain information on the concrete word items presented during the training phase.

Significant effects were found for list order of Module One on the Word Recognition and Identification retention measures. Two possible explanations can be advanced for this specific finding. First, it should be noted that all subjects were given Module One then Module Two tests of retention. This test sequence might have inadvertently favoured subjects trained on list order one since this was consistent with their original order of instruction. Thus, a serial recall effect may have occurred. Alternatively, subjects given initial training on a common set of elements (tool names) might have developed a more effective learning set that persons who first received instruction on the wider range of items contained in Module Two. This latter interpretation is in agreement with research evidence from Bilsky and Evans (1970) noting the advantages of associative clustering on reading comprehension.

The finding that subjects could recall their original learning is consistent with previous research by Vergason (1966) who compared retention in educable retarded subjects on conventional and automated methods of word recognition training. It should be noted, however, that in the Vergason study subjects taught by the automated approach could retain information over a longer time period than persons taught by conventional tuition. In sum, the present investigation indicates that computer assisted instruction and individual tuition are equally effective with regard to recall of information one month after completion of training.

It is notable that there are no reliable differences between the two modes of instruction with regard to retention of original learning. The practical implication of this finding is that similar levels of retention can be anticipated regardless of which teaching method is employed. As discussed previously, however, some doubt can be cast upon the fundamental differences between the two teaching approaches, especially since the pictorial materials may have played a minor role in the learning process. The practical suggestion arising from this is that a straight word-focus should be sufficient for ensuring acquisition and retention of learning. This is in agreement with earlier work by Vandever and Stubbs (1977) who demonstrated that moderately retarded children can retain over a five month period what they have learned and show some transfer to untaught words as well. Research findings of the present investigation and previous studies suggest that a whole-word method will enable mentally retarded persons to learn some words rather more quickly than a phonics approach. In a practical sense, it would appear that the errorless discrimination procedure with a straight word focus is an efficient means of teaching a basic social sight vocabulary. This would seem particularly true with mentally retarded adults who have received little formal schooling and are unlikely to benefit from a phonics approach that attempts to develop a stock of letter sounds prior to teaching word recognition. It may be, however, that a systematic phonics programme can promote greater amounts of transfer and retention of learning but that this form of instruction would need to be provided over a long term and geared to meet individual differences in learning abilities.

It is commonly recognised that overlearning is likely to result in improved retention of information over time. In general, repetition of the task after perfect performance has been attained is to be encouraged. This is particularly important with handicapped learners who frequently demonstrate difficulties in their ability to transfer learning to new physical environments and social circumstances. While it is beyond the scope of this present investigation to examine the role of overlearning on retention of word recognition, some general comments of an observational nature can be made.

It was noted that many of the subjects in both the computer and individual tuition groups attained a maximum criterion of four errorless trials on each item early in the training period so that subsequent trials afforded an opportunity for overlearning to take place. Even when subjects made errors at various points in the programme there were additional trials on which material could be overlearned. This leads to the speculation that the number of overlearning trials that occurred in the experimental teaching programmes may have largely contributed to the results obtained. This is in line with a study by Vergason (1964) which demonstrated that mentally retarded and 'normal' subjects showed equal retention after thirty days on paired associate material which had been considerably overlearned. The Vergason study pointed out that retarded subjects were highly inferior on retention immediately following a minimum level of learning but that they equalled 'normal' subjects when afforded overlearning trials. The real importance of overlearning has been noted in the remarks of Spicker (1966):

> "... acquisition of knowledge depends on the complexity of the task to be learned, while retention of knowledge is determined by the amount of overlearning that takes place."
>
> (p. 92)

The microcomputer used to teach word recognition in this investigation was ideally suited for providing overlearning trials to mentally retarded subjects. It also offers a highly consistent and non-variable form of instruction which calls for active participation and attention on the part of the learner. Unlike more conventional individual and classroom instruction, the computer is infinitely patient and can be used to ensure that overlearning takes place. At a most basic level, the computer can be used for repetitive drill and practice procedures as required for individual subjects thus freeing the teacher to engage in a tutorial role with other students.

In summarising the findings for the retention measures, several conclusions can be drawn together. Firstly, levels of retention appear to be enhanced by the large number of overlearning trials provided to both the computer and individual instruction groups. Secondly, the highly structured and consistent training format provided a conceptually meaningful framework for later recall of information. Finally, computer assisted instruction offers a practical alternative to conventional drill and practice procedures that can easily be geared to operate at each learner's pace.

Methods-Time Measurement

Data concerning both the total number of attempts to attain criterion and time in training for both modules was used to gauge the efficiency of the experimental teaching procedures. Analysis of methods-time data for Module Two indicated that there were significant interaction effects between the groups and modes. Similar effects were found for the Module One data as well, though these results did not reach a statistically significant level.

Subjects who were given individual tuition tended to complete their programmes at a more rapid pace than did persons who were trained on the computer. The reason for this apparent greater efficiency of the conventional instruction group is due largely to the fixed mode of operation governing the sound-on-slide projector. A major disadvantage of the computer system was that the audio messages had to be contained in a linear sequence on the tape so that even when a subject recorded a correct response and did not require additional verbal cues, it was necessary to play the cassette (with the speaker switched off) in order to bypass extra error messages. While no precise records were maintained concerning the time required to advance audio messages, it is estimated that ten seconds per trial or approximately 6.6 minutes per session was required for the tape to be correctly positioned prior to each presentation. This was a technical limitation that could have been avoided with the use of a vocal synthesizer or random access audio cassette player. It should be mentioned, however, that the use of less sophisticated equipment was in keeping with the applied nature of this investigation. A prime consideration was that the microcomputer and automatic slide projector used in this research are commercially available to training centres at a reasonable cost.

Subjects in the errorless discrimination mode required a significantly longer period of time to complete their training than persons taught by the paired associate method of instruction. This additional time component was probably a function of the task requirements. The physical arrangement of a larger number of flashcards in the errorless discrimination method required more time, especially with regard to the tutor condition. It might also be the case that since the errorless discrimination mode made use of a wider range of multiple choices than the paired associate procedure, subjects needed more time to respond. On the surface at least, it would appear that the paired associate mode is procedurally more time efficient since less manipulation of materials is necessary.

Most previous studies which made use of automated procedures for teaching a social sight vocabulary (e.g. Vergason, 1964; Beasely, 1974) have provided little or no information on the amount of time required to complete a training sequence. The increasing application of microcomputers in education, however, should offer a practical tool for precisely gauging response patterns and time spent in solving problems. Measurement techniques for study of efficiency of instruction along with the more obvious learning outcomes need further refinement. This technical approach to teaching and measurement of learning is consistent with the original recommendations of Skinner (1953, 1961) concerning the use of teaching machines for enhancing the efficiency of programmed instruction.

CHAPTER IX
CONCLUSION AND EDUCATIONAL IMPLICATIONS

It is apparent that there are many difficulties associated with the development of new technology and determination of the practical role that innovations such as microcomputer assisted instruction might play in the training of handicapped persons. One of the major concerns facing special education today is that of the under-utilisation of potentially useful new ideas. The basic problem is not the generation of technology and media for exceptional learners, but rather getting these innovations into a system where they can be implemented. Despite a wealth of information regarding the efficacy of educational technology in remedial instruction, there has been a general failure to organise these resources so that they reach the classroom. While there is universal awareness of important advances in space and medical technology, the state of the art indicates that innovation in education is a slow and complex process. The difficulties are such that it could be asserted that a serious gap exists between invention and the utilisation of new technology.

This chapter discusses some reasons for the present gap between development and implementation of new technology. Attention is given to some practical solutions that might foster greater awareness and acceptance of recent innovations. In particular, the current trend toward widespread usage of microcomputers in education is considered as a significant factor that could potentially alter the future direction of special education services. Increasing emphasis upon individual programme planning will require the augmentation of human efforts by technology. Finally, the limitations of this study have been noted along with possible directions for future research.

Bridging the Gap Between Invention and Innovation

There is a tendency amongst researchers to underestimate some of the problems that can arise with utilisation of alternative instructional media. All too often it is the case that new technology is viewed as a simple process that requires merely making others aware of recent developments so that they can immediately accommodate these new tools. But actual experience, including this present research, has demonstrated time and again that innovation is a complex proposition both in terms of implementation and evaluation of new technologies. Lance (1977) has pointed out some possible reasons that might account for the present gap between invention and innovation.

1. Education is essentially a conserving institution. There is a definite tendency for educators to reject advances or avoid making changes in an institution so open to public view.
2. There is a tendency for educators to perceive new technology as a threat to both their jobs and their personal interactions with students.
3. The costs of innovation are high, especially with regard to initial implementation and evaluation of a new technology.

In this present investigation, it has been demonstrated that microcomputer based instruction and more conventional forms of individual tuition result in similar learning outcomes regardless of procedural variations arising from the two different methods of instruction provided. This has rather profound implications for future advances in the teaching of mentally retarded persons and lends support to a growing body of knowledge concerning the effectiveness of computer assisted instruction. The significance of this finding takes on real meaning when it is recognised that the special purpose equipment used in this study is commercially available at a reasonable cost. Prior to the advent of the microprocessor era, the practical applications of computer based instruction were considered to be a rather academic matter since large, sophisticated, and expensive equipment would be required to provide this form of instruction. This is no longer the case, however, and microcomputers are very rapidly finding their way to classrooms and training centres for use in the assessment and training of handicapped people.

It was observed in this study that computer assisted instruction can be of particular value with persons who find it difficult to attend and interact in regular teaching environments. Examples were given of individuals who, because of aggressive behaviour or undesirable personal habits, were considered unlikely to benefit from participation in individual instruction. Yet it was found that these persons could operate the computer and learn through interaction with the system. While not attempting to modify difficult behaviours, it appears that the computer may offer an alternative learning environment which may be preferable for some students. There is also some anecdotal information to suggest that the relatively impersonal nature of the computer can provide direct and meaningful feedback without triggering perceptions of failure that tend to have an adverse effect on performance in more conventional kinds of instruction.

A large amount of evidence from previous research and the present study has been presented to support the view that mentally retarded persons experience difficulty in organising input material and sorting out the relevant cues of a learning task. This is in line with theoretical propositions advanced by Zeaman and House (1963) and Bilsky and Evans (1970). It is interesting then to speculate as to the usefulness this new technology may have for enhancing the cognitive abilities of mentally retarded learners. The consistent and nonvariable instruction provided by a microcomputer tends to optimise on-task behaviour while providing active participation and self-directed instruction to the learner. It was also noted that the computer is ideally suited for offering overlearning experiences through drill and practice which has been shown to improve retention of information by handicapped persons. The general availability of the microcomputer should provide an opportunity to place the mentally retarded person in control of the teaching environment so that he can learn in ways that have, until recently, not been possible.

In order to be effective, these technical innovations require materials that have been produced by teachers who are aware of ways in which microcomputers can be used in special education. Obviously, the computer programmes will only be as good as the skills of the person who prepares them. This will require increasing involvement by teachers in both the implementation and evaluation phases of computer assisted instruction. Developments in the technology and in the creative skills required for production of computer-based learning materials could provide the opportunity to move away from institutional learning. The extent to which special education should take hold of this opportunity and what they should make of it are important questions for future development.

In view of the growing commitment to provide appropriate educational experiences to more severely handicapped persons, there will be a need to take advantage of advances in instructional technology that show promise for ameliorating the conditions of learning that have to this point hindered the achievement of this population. The potential of microcomputers for providing remedial instruction tailored to meet individual needs has been well documented. There is an increasing awareness that this technology can be used to compensate for learning and sensory impairments. The translation of sound to visual mode and print to tactual mode are two examples that can be mentioned. Perhaps most importantly, the fear that computers will replace teachers, administrators, and educational support staff has largely been alleviated.

It must be recognised that the development of this educational technology will depend to a significant extent on the coordination of research efforts and the availability of support services. Several aspects need to be considered with regard to current and future needs. (Ryba and Christiansen, 1980). These include:

1. Advice of selection of equipment: Not all microcomputers are appropriate for educational applications. Some systems are better than others and there are large differences in the cost of equipment. Advice needs to be available on the most practical and economic systems for use in schools and training centres.

2. Programming the computer: Teachers need to learn how to programme the computer and methods for effective use of this tool with handicapped learners. It has been the case in other countries that Universities and Technical Institutes offer courses that assist teachers in gaining these skills. Inservice training is needed to provide teachers with an appreciation for ways in which computers can be programmed for instruction in special education settings.

3. Development and dissemination of teaching resources: It is desirable to have a 'network' of resources that will minimise duplication of effort and help ensure that teachers have knowledge about and access to as much teaching material as possible.

4. Administration and scheduling of microcomputer: Advice is required to assist educators with making decisions about the physical arrangement and location of CAI study areas in schools and training centres. Problems of timetabling need to be dealt with to help ensure that the most effective use is made of the microcomputer for individual tuition and computer managed instruction.

An attempt has been made in this present study to provide a practical account of the procedures used to evaluate the utility of computer assisted instruction for teaching recognition of words to mentally retarded persons. The finding that subjects taught by the computer and those given more conventional tuition achieved similar learning outcomes suggests that a set of common factors were operating under both conditions. It has been proposed that several principles of learning and features of programmed instruction (e.g. active participation, selfpacing, overlearning, immediate reinforcement) may have accounted for these gains in performance.

In sum, it is stressed that the major advantage of computer assisted instruction appears to rest with the utility it has for systematically applying principles of learning. The computer offers an alternative instructional medium that, while perhaps not suited to all persons' needs, can provide a highly structured learning experience and potentially increase the effectiveness of organisational skills in mentally retarded persons. The results of this investigation and previous related research uphold the view that retarded learners experience difficulty in identifying relevant dimensions within a learning task and are easily distracted by extraneous stimulation (Zeaman and House, 1963). It is advanced that the consistent stimulus-response patterns developed by the learner through interaction with the computer system may assist with the development of cognitive strategies that improve problem solving abilities in various types of situations. There is reason to believe that the use of computers in special education will help develop a clearer understanding of some underlying processes that must ultimately govern the conditions under which learning takes place.

Limitations of the Study

Due to the design of the study, it was necessary to compare relatively small sample sizes to examine whether any interaction effects were present between groups and modes of instruction. While the sample size was statistically manageable, a larger one would have been used had more eligible subjects been available.

In view of the fact that only one microcomputer system was available for use in the study, it was necessary to offer two consecutive terms of instruction at each of the training centres. This also imposed some practical limits on the amount of training that could be given to subjects.

Because of time limits imposed by the participation of student teachers and scheduling of subjects, it was necessary to restrict the number of teaching sessions to two per week for each subject. It is felt that more frequent sessions are required to maintain continuity of training and help maximise recall of new information. Thus, it is recommended that future research efforts employ daily sessions over a longer time period to optimise retention and overlearning of information.

Duration and content of the teaching sessions is an important consideration in programme development. Informal observations suggest that thirty minutes is a maximum duration for a session and that in some cases, where subjects have attention difficulties, no more than fifteen minutes should be spent. Similarly it is felt that the number of training items should be reduced substantially. It may be more efficient, for example, to teach four items in a given module as compared with the eight training items used in each module for this study.

It appears that the pictorial material used in the paired associate mode did not constitute as active a part of the training sequence as was initially assumed. Once a word had been introduced and paired with its referent picture, no further attempt was made to direct the subject's attention to the photograph. This casts some doubt as to whether or not subjects were shifting attention across dimensions from picture to word. In effect, the paired associate method used may have been akin to the straight word focus of the errorless discrimination procedure.

Finally, there are grounds for believing that direct behavioural observation and related anecdotal data were an important addition to the more objective forms of assessment used in this study. Clearly, much useful information can be derived from informal evaluations that take account of the quality of interaction between the student and computer along with situational and environmental factors that appear to exert an influence on learning outcomes.

Suggestions for Future Research

One of the most obvious barriers in studying human information processing is the reality that many events of potential interest to the cognitive research occur within the human organism. It is notable that the behaviouristic tradition has emphasised simple functional analysis concerning only input stimulus and output responses. Yet there is almost universal agreement that, with the exception of a few simple models, there is a need to postulate the presence of internal mechanisms that account for the amount and type of learning which takes place under varying conditions of instruction. The increasing availability of microprocessor systems (e.g. minicomputers, microcomputers) suggests that much future research on cognitive processes will be characterised by highly controlled stimulus input as well as very specific response measurements. The computer is ideally suited for cognitive research, as it allows for a great deal of variation in the presentation of stimulus and specific evaluation of performance outcomes with high levels of accuracy. Moreover, computer systems are capable of dealing with a given stimulus in many different ways and this flexibility permits the introduction of very precisely controlled experiments (Millward, 1978).

Cognitive researchers are often required to deal with an extremely large range of complex stimuli. For example, visual presentation of a simple stimulus like the word "FORK" comprises four out of twenty-six possible letters which are arranged in a row in some kind of format for some specific duration of time at some light intensity in varying contexts of comparison stimuli which may or may not be meaningfully related. The subject is required to encode the stimulus, producing a phonological internal code, a meaning, and perhaps some associations or information about the word "FORK" to other words contained in a learning set. It is important to recognise that these physical dimensions of the stimulus cannot be completely ignored since they obviously introduce variation into subjects' responses that may account for the type and amount of learning that occurs.

Within the context of this present research it can be seen that the microcomputer system has the capability to control many of these physical parameters so that research can be undertaken to examine the optimal conditions under which learning is likely to take place. It may be, for example, that performance on a word recognition task can be improved by increasing the number of trials or increasing duration of exposure to the target word at the commencement of training. Wide variations in conventional forms of instruction give rise to intervening variables that cannot be measured but have a subtle and significant influence on performance outcomes. There is clearly a need to explore the effect of these physical parameters to identify ways in which the teaching method can be modified to result in improved learning. Evidence from previous research (e.g. Bilsky and Evans, 1970) supports the view that mentally retarded persons have a deficit in their ability to organise input materials. The flexibility of the microcomputer to introduce and control new teaching procedures may lead to more substantial research concerning the remediation of specific deficiencies in input organisation.

There is evidence that 'soft' evaluation data is a useful means of obtaining more information on microcomputer based instruction.

The aim should be to provide the best possible description of the ways in which students respond and presumably learn through interaction with the computer system. This would involve informal evaluation using interviews and observational data along with formal psychometric evaluation. Both teachers and administrators should be able to gain a meaningful picture of the advantages and limitations of automated instructional systems from a study that is sufficiently broad based. This should include as clear a picture as possible of what was done, what was achieved and what constraints were imposed.

A recent major working conference on computer assisted instruction (Lewis and Tagg, 1980) noted that there are three major dilemmas with current practice:

1. Evaluators measure what they can measure rather than what they should measure;
2. They present results which no one can interpret e.g. experimental group = 12.6, control group = 11.8, significant within < 0.05;
3. They do not control the most critical variables that can swamp any other effects e.g. the range capability and the effect of out-of-school environment.

A desirable step in microcomputer based research would be to assess the general acceptability of both methods and materials. The recent proliferation of poor quality educational software highlights the current trend toward rapid development and marketing of substandard teaching programmes. In many cases these materials are apparently being prepared by persons with little or no training in education in order to take advantage of the commercial market. In many respects this trend is similar to the earlier, often ill-advised, adoption of programmed textbooks during the 1960's era. By implication, it would be advisable to exercise some caution through evaluation of the current range of educational products.

Difficulties with the evaluation of computer assisted instruction materials are very much akin to the assessment of more conventional teaching methods. The presence of extraneous variables such as teacher personality and environmental factors have been known to exert a powerful influence on learning outcomes. Similarly, it can be assumed that some secondary, and perhaps less obvious, features of computer assisted instruction (e.g. imaginative graphics presentation, novel audio feedback) influence performance; but in fact this contribution to the learning process is often difficult to assess. Decisions also need to be made on the criteria for evaluation. Cost efficiency, ease of administration, programme content, acquisition and retention of learning, are but a few examples of possible evaluation objectives. It also seems likely that the form of evaluation will be influenced by the nature of the audience to whom it is directed (parents, teachers, decision makers and funding agencies).

In conclusion, two main lines of enquiry appear to emerge. The first of these concerns the further development and refinement of microprocessor based programmes in special education. At present, there is a serious lag between this new technology and the availability of suitable instructional materials. With recent advances in cost-effective computer assisted instruction and the world-wide proliferation of microcomputers in schools, rapid increases in future educational applications are foreseen. With the movement toward providing a truly appropriate education for each learner, teachers will need to be supported by a technology that enables them to deal with a wide range of individual differences. High quality teaching programmes which are generated by microcomputer based systems can effectively augment human resources. Finally, the recent availability of powerful microprocessing systems can be directly applied to theoretical work which seeks to understand some underlying processes that must ultimately govern human learning. The widespread application of microcomputers in special education should enable many divergent paths of cognitive research to be followed.

APPENDIX A

STAFF SURVEY OF SOCIAL SIGHT WORDS

I need your assistance to identify a group of words that might be taught in our reading programmes at Cook St. and Aokautere Centres.

Your ideas are important because it is necessary to identify words that will be of practical value in community life.

For each of the following four categories please list a set of words that you consider useful for trainees to know.

Please complete this list on your own. There are no right or wrong answers - only what you think is important.

	Community Information	Traffic Safety	Tool Names	Grocery/Food Items
1.	(e.g.) Toilet	(e.g.) Danger	(e.g.) Hammer	(e.g.) Milk
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

Thanks for your help. Later on we will all meet together to select a list of words for the teaching programmes.

Ken Ryba.

THE CLIFTON AUDIO VISUAL READING PROGRAMME

by

R. I. BROWN, B.Sc., Dip.Psych., Ph.D.
Research Unit, Institute of Education, Bristol

and

G. E. BOOKBINDER, B.A.
Supervisory Remedial Teacher
Salford Education Committee, Lancashire.

DIAGNOSTIC MATERIAL

NAME

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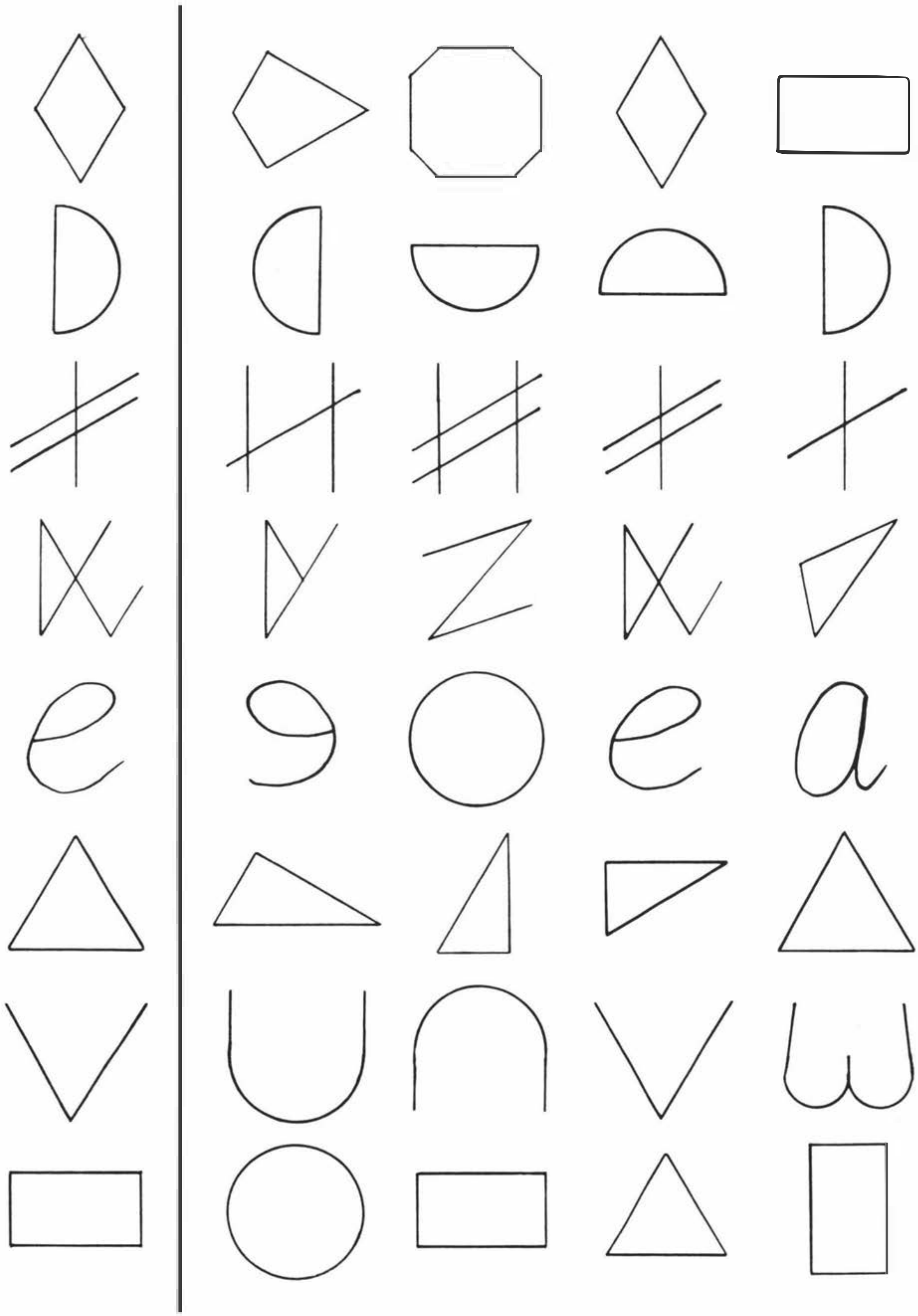
VISUAL DISCRIMINATION

SHAPES TEST



LETTER DISCRIMINATION TEST

a	u	e	o	a
b	d	p	b	q
m	n	m	w	v
i	j	i	l	e
uz	vs	uz	nz	us
mm	mn	mw	mm	ma
gg	qg	gp	qp	gg
oo	ou	oa	oo	oe
ea	eo	ec	ea	ee
th	tb	lh	ht	th
oa	ca	oa	oe	on
ay	ag	aq	au	ay
ph	qh	pb	ph	gh
au	ou	au	aa	ua

LETTER DISCRIMINATION TEST (continued)

igh	iqh	igh	igb	iph
tion	toin	tion	ticn	tiom
pqf	pqf	pgf	pfq	pyf
eoa	eea	esa	eoa	eao
Per	ber	Pre	Der	Per
dis	pis	dis	qer	diz
ing	igh	ign	ihg	ing
lwn	tmn	Ivu	lmn	lwn
acei	icae	aaee	acei	acie
aeow	eaow	aeom	eoan	aeow
piece	peice	paeic	piece	quiece
ation	atiam	alaen	ation	atoin
sboes	sbeos	shoes	sboez	sboes
gaien	qaien	gaien	qoeim	paien
occas	oooaz	occas	occen	ocoas
spoon	sqoon	spone	spoon	sboon
down	brown	domn	down	dome
think	tkink	thank	tbink	think
coming	cuming	comming	comeing	coming
November	Novenbre	November	Novenber	Novemder
station	station	satation	straton	shation
Electrical	Electricle	Electric	Electrikal	Electrical
necessary	neseccary	neccessary	necessary	necessery

PHONIC UNITS TEST
(presented in Audio-Visual Programme)

a	e	b	t	c	n	o	l	i	f	r	
u	p	m	s	w	d	h	g	y	j	k	v

ee	oo	ea	th	ch	ai	oa
ing	sh	ur	ir	er	igh	ar
ow	ou	oi	ay	ey	st	tion
oy	all	ed	wh	ce	sp	age
ly	au	ew	ph	dis	con	qu

APPENDIX C

SCREENING PROCEDURES

WORD RECOGNITION AND IDENTIFICATION

Name of Trainee:	Date:
Name of Examiner:	
Training Centre:	

Instructions: Select any one of the 5 random word sets. Place the 8 cards in a 4 x 2 matrix arrangement on desk directly in front of trainee. Spacing between cards should be 5 cm.

Say, "Do you know any of these words? Please point to any word that you know." If T points to a word, say, "What does this word tell us." Repeat procedure for any other words T points to and record responses.

Word Recognition: For each of the 8 words, point to the flashcard and say, "What does this word tell us?" Record response or go on to next word if no response is made within 10 seconds.

Word Identification: Say, "I'm going to say a word and I want you to point to the card which tells about the word." (e.g. The word is DANGER ... You find DANGER). Follow procedure and record responses for each of the 8 words.

RANDOM SET 1

Item	Initial Response	Word Recognition	Word Identification
Exit			
Hammer			
Milk			
Spanner			
Butter			
Sugar			
Fork			
Shovel			
SCORE			

-2-

RANDOM SET 2

Item	Initial Response	Word Recognition	Word Identification
Push			
Pull			
Police			
Open			
Knife			
Danger			
Eggs			
Bread			
SCORE			

RANDOM SET 3

Item	Initial Response	Word Recognition	Word Identification
Coffee			
Tea			
Meat			
Vegetables			
Cheese			
Give Way			
Cross			
Stop			
SCORE			

-3-

RANDOM SET 4

Item	Initial Response	Word Recognition	Word Identification
Entry			
Womens			
Go			
Railway			
Road Works			
No Entry			
Wait			
Walk			
SCORE			

RANDOM SET 5

Item	Initial Response	Word Recognition	Word Identification
Chisel			
Drill			
Pliers			
Saw			
Bank			
Bus Stop			
Mens			
Screwdriver			
SCORE			

APPENDIX D

PRE-TEST PROCEDURES
WORD RECOGNITION AND IDENTIFICATION

Name of Trainee:	Date:
Name of Examiner:	
Training Centre:	

MODULE 1

Instructions: Start with the 2 practice items (BUS STOP, GO). Place the 2 cards vertically on desk directly in front of trainee. Spacing between cards should be about 5 cm. Follow directions as noted below then repeat procedure with all 8 cards of module 1. 8 cards should be arranged in 4 x 2 matrix directly in front of trainee.

Say, "Look at these words and point to one if you know what it says." If T points to a word, say, "What does this word say?" Repeat procedure for other word(s) if T points to another card. (Go on to the next step if no response within 10 seconds.)

Word Recognition: For each of the 2 words (practice) or 8 words (test) point to the flashcard and say, "Tell me what this word is." Record response or go on to next word if no response is made within 10 seconds.

Word Identification: Leave the 2 cards (practice) or 8 cards (test) on the table as above. Say, "I'm going to say a word then I want you to point to the word which tells about (shows) the word." (e.g. "The word is BUS STOP... Point to BUS STOP.") Follow the same procedure for all words in the sequence.

Item	Initial Response	Word Recognition	Word Identification
BUS STOP (P)			
GO (P)			
HAMMER			
SPANNER			
FORK			
SHOVEL			
DRILL			
PLIERS			
SAW			
SCREWDRIVER			
SCORE			

PRE-TEST PROCEDURES
WORD RECOGNITION AND IDENTIFICATION

Name of Trainee:	
Name of Examiner:	
Location:	Date:

MODULE 2
Instructions

Start with the 2 practice items (BUS STOP, GO). Place the 2 cards vertically on desk directly in front of trainee. Spacing between cards should be about 5 cm. Follow directions as indicated below then repeat procedure using all 8 cards of module 2. 8 cards should be arranged in a 4 x 2 matric directly in front of trainee.

Say, "Look at these words and point to one if you know what it says." If T points to a word, say, "What does this word say?" Repeat procedure for other word (s) if T points to another card. (Go on to next step if no response within 10 seconds.)

Word Recognition: For each of the 2 cards (practice) or 8 words (test) point to the flashcard and say, "Tell me what this word is." Record response or go on to the next word if no response is made within 10 seconds.

Word Identification: Leave the 2 cards (practice) or 8 cards (test) on the table as above. Say, "I'm going to say a word then I want you to point to the word which tells about (shows) the word." (e.g. "The word is BUS STOP ....Point to BUS STOP.") Follow the same procedure for all words in the module.

	1	2	3
Item	Initial Response	Word Recognition	Word Identification
BUS STOP (P) GO (P)			
SUGAR PUSH BREAD PULL COFFEE MEAT CROSS RAILWAY SCORE			

PRE-TEST PROCEDURES
PICTURE RECOGNITION AND MATCHING

Name of Trainee:	
Name of Examiner:	
Training Centre:	Date:

MODULE 1
Instructions

A. Picture Recognition Pre-Training: Each trainee is shown the 8 words from module 1 and two practice photos (BUS STOP, GO). The photos are then identified 1 at a time. Present each photo in turn and say, "This is ("This shows") ...." Ask the trainee to repeat the word out loud. Following this practice, present each photo in turn and say, "What is this ..." (or) "What does this tell us?" Repeat this procedure until each photo is identified correctly at least once. No marks for this section but check each item to show that it has been practiced (column 1 below).

B. Picture-Word Matching Test: 3 photos are placed vertically on table directly in front of the trainee. (1 picture refers to the target word and 2 photos are distractors selected at random. Give trainee a word card and say, "Put this word beside (with) it's picture." Use the 2 practice items (BUS STOP, GO) first. Then for each of the 8 test items in turn, present 3 photos (including target word and 2 distractors) and repeat above procedure. Because the chance probability of getting an item correct is high (1-3) it is necessary to administer the test a second time. Simply shuffle the photos and say, "Okay, let's try this one more time." (Record responses under Trial 2.)

	1	2	3
Item	Practice Recognition	Trial 1 Test	Trial 2 Test
BUS STOP (P)			
GO (P)			
HAMMER			
SPANNER			
FORK			
SHOVEL			
DRILL			
PLIERS			
SAW			
SCREWDRIVER			
SCORE			

PRE-TEST PROCEDURES
PICTURE RECOGNITION AND MATCHING

Name of Trainee:	
Name of Examiner:	
Training Centre:	Date:

MODULE 2
Instructions

A. Picture Recognition Pre-Training: Each trainee is shown the 8 words from module 2 and two practice photos (BUS STOP, GO). The photos are then identified 1 at a time. Present each photo in turn and say, "This is ("This shows") ...." Ask the trainee to repeat the word out loud. Following this practice, present each photo in turn and say, "What is this ..." (or) "What does this tell us?" Repeat this procedure until each photo is correctly identified at least once. No marks for this section but check off each item to show that it has been practiced (column 1 below).

B. Picture-Word Matching Test: 3 photos are placed vertically on table directly in front of the trainee. (1 picture refers to the target word and other two photos are distractors selected at random.) Give trainee a word card and say, "Put this word beside (with) it's picture." Use the two practice items (BUS STOP, GO) first. Then for each of the 8 test items in turn, present 3 photos (including target word and 2 distractors) and repeat above procedure. Because the chance probability of getting an item correct is very high (1-3) it is necessary to administer the test a second time. Simply shuffle the photos and say, "Okay, let's try this one more time." (Record responses under column 3.)

	1	2	3
Item	Practice Recognition	Trial 1	Trial 2
BUS STOP (P)			
GO (P)			
SUGAR			
PUSH			
BREAD			
PULL			
COFFEE			
MEAT			
CROSS			
RAILWAY			
SCORE			

APPENDIX E

MODULE 1: TOOL NAMES
TRANSFER TEST PROCEDURES

This assessment is carried out to determine the extent to which trainees are able to transfer their learning to new situations.

Please administer the test in the workshop. Contact persons for equipment are:

Aokautere - Alan Parry
Cook Street - Ken Ryba

Equipment:
1. A box of tools has been prepared for your use. This should contain all of the 8 items listed below.
2. 8 flashcards of tool names (Use the cards from the 'kitsets).

Procedure: Place all 8 tools out on a bench in the workshop. These can be placed in any order but should be within easy reaching distance of the trainee.

Give trainee the first card and say, "Tell me what this word says T?" "Now I want you to take this card and put it down next to the tool it tells (shows) us about."

Repeat the above direction for each of the 8 tool names. Record both what the trainee says and whether he placed the card with the correct tool.

MODULE 1

Item	Verbal Response	Word-Tool Matching
1. HAMMER		
2. SPANNER		
3. FORK		
4. KNIFE		
5. DRILL		
6. PLIERS		
7. SAW		
8. SCREWDRIVER		
SCORE		

MODULE 2: GROCERY/INFORMATION TRANSFER TEST PROCEDURES

This assessment is carried out to determine the extent to which trainees are able to transfer their learning to new situations.

Please administer Part A of this test in the coffee lunchroom or kitchen. Contact persons for equipment are:

Aokautere - Carla Van Brun Schott
Cook Street - Ken Ryba

Equipment: 1. A food box has been prepared for your use in assessing items 1 - 4. This should contain sugar, bread, coffee, meat, milk, butter, cheese, crackers or biscuits.

2. 6 flashcards as listed below (No railway or cross).

Part A Procedure: Place the food items out on a bench in the kitchen. These can be arranged in any order so long as they are within easy reaching distance of the trainee. Give trainee the first flashcard and say, "Tell me what this word says?" "Now I want you to take this card and put it down with the tool it tells (shows) us about."

Repeat this direction for each of the 4 food items.

Part B Procedure: Take trainee to location of a conventional door (not sliding or swinging door). Be sure that the door is open to about 45 degrees or so (halfway). Place flash card immediately above handle on door with cello tape. Say, "Now T, tell me what this word says." "You go ahead and do what the sign says. Go ahead."

Repeat directions for both PUSH and PULL.

Please record below both what the trainee says and whether he/she placed the cards with the corresponding items or acted in response to the word.

Module Two

Item	Verbal Response	Word/Item Matching
1. Sugar		
2. Push		
3. Bread		
4. Pull		
5. Coffee		
6. Meat		
SCORE		

APPENDIX F

TRAINING PROCEDURES

Individual Instruction Timetable

The teaching phase of this project will be carried out over a five week period from July 7th through August 8th - end of term. During this time you will need to complete both assessment and teaching of the 2 modules.

There are always factors that make it difficult to follow a schedule (e.g. sickness, timetable clashes). All that can be asked is for you to attempt to complete the programme by the end of this second term.

Following is an itinerary for the balance of the term:

June 26	Group meeting to practice pre-test and training procedures. Work in teams to learn how to use the materials and follow instructions.
July 3	Group meeting to continue with practice on use of materials. Videotaping of each person administering the teaching method.
July 7 - 11	Administer pre-test for module 1 Teaching session 1 Teaching session 2
July 14 - 18	Teaching session 3 Teaching session 4
July 21 - 25	Teaching session 5 Post-test Module 1 Transfer Test Module 1 Pre-test Module 2 Teaching session 1
July 28 August 1	Teaching session 2 Teaching session 3
August 4 - 8	Teaching session 4 Teaching session 5 Post-test Module 2 Transfer Test Module 2

Each teaching session should take a maximum of 30 minutes to complete. Please ensure that you teach all 8 words of the module in each session noting number of attempts on each trial and time spent on each target word. Charts are provided to record responses for each session. The charts should be included in your final report

Note 1: Testing and teaching materials are available from:
Glyn Robinson - Cook Street Centre
Carla Van Brun Shot - Aokautere Centre

Note 2: I would like to be with you during your first session to answer any questions you might have and provide support as required. So please let me know when you would like to meet for the pre-test and teaching session 1. If you have any questions or concerns about your programme then please phone me at: 69099 Ext. 2509.

Pre-Test Phase

The purpose of this pre-test phase is to obtain a baseline measure of the trainee's word recognition ability prior to commencement of training. Then it is possible to measure any changes in learning that might occur through participation in the teaching programme.

In order that a meaningful comparison can be made, it is essential for all teachers to follow a standard set of directions when administering the pre- and post-tests for each of the two word modules.

Following in a description of the pre-tests and list of directions for administration. You should follow these directions precisely and give the tests in the sequence presented.

Instructions

A. Word Recognition and Identification (Practice)

This procedure is identical to the test that follows but provides an opportunity for the trainee to gain familiarity with the material. This section is not scored but you should make a note of responses. (· = incorrect and ✓= correct response).

Place the 2 practice words (BUS STOP and GO) vertically on desk directly in front of trainee. Spacing between the cards should be 5 cm.

BUS STOP

GO

Say, "Look at these words and tell me if you know one." "Please point to any word that you know." If T points to a word

Say, "What does this word say?" Repeat procedures for other word if T points to the second card (Go on to next step if no response within 10 seconds)

Word Recognition: For each of the 2 words point to the flash-card and say, "Tell me what this word is." Record response or go on to next word if no response is made within 10 seconds.

Word Identification: Leave the 2 cards on the table as above. Say, "I'm going to say a word and I want you to point to the card which tells about (shows) the word (e.g. "The word is BUS STOP ... Point to BUS STOP"). Follow the same procedure for both words.

Note: Use neutral verbal feedback, e.g. okay, good, uh hum, lets try again. If T asks for advise say, "You are doing well, let's try some more.

1. Word Recognition: Place the 8 cards of the module in a 4 x 2 matrix directly in front of trainee. Put cards down randomly (any way you like) with spacing of about 5 cm. between cards.

e.g.

HAMMER	SPANNER
FORK	KNIFE
DRILL	PLIERS
SAW	SCREWDRIVER

Follow the same procedures as in the practice session. Say, "Do you know any of these words?" "Please point to any word that you know." If T points to a word, say, "What does this word say?". Repeat procedure for any other words T points to, if no response after 10 seconds then say, "Okay, let's go through them together."

For each of the 8 words in turn, point to the flashcard and say, "Tell me what this word is." Record response or go on to next word if no response is made within 10 seconds.

2. Word Identification: With the cards still on the table as above, say, "Now I'm going to say a word and I want you to point to the card which tells about (shows) the word." (e.g. The word is HAMMER ... Point to HAMMER). Follow the same procedure for each of the 8 words.

3. Picture Recognition Pre-training: Each trainee is shown the 8 photos from Module 1. or 2. (whatever you are working on) and 2 practice photos (BUS STOP and GO). The photos are then identified 1 at a time. Present each photo in turn and say, "This is)"This shows") ..." Ask the trainee to repeat the word out loud.

Following this trial, present each photo in turn (any order you choose). Say, "What is this ..." (or) "What does this tell us?" Repeat this procedure until each photograph is identified correctly at least once. No marks for this section but check each item to show that it has been practiced.

4. Picture-Word Matching Test: 3 photographs are placed vertically on the table directly in front of the trainee. (1 picture refers to the target word and 2 photos are distractors selected at random).

Note: Follow the word order provided but select and arrange photos randomly.

e.g.

Photo 1 BUS STOP	Photo 2 HAMMER	Photo 3 DRILL

Give trainee a word card and say, "put this word beside (with) its picture." Use the 2 practice items (BUS STOP and GO) first so that the trainee knows what is required. These 2 practice items are not scored but please record responses.

For each of the 8 words in turn, present 3 photos (including target item and 2 distractors) and repeat above procedure.

Because the chance probability of getting an item correct is high (1-3) it is necessary to administer this test a second time. Simply shuffle the photos and say, "Okay, lets try this one more time".

Place down 3 photos and give trainee the flashcard. Repeat same procedure with all 8 words.

Note: Because this is a standard test it is not a good idea to give strongly positive and negative feedback. But obviously some verbal reassurance and communication is necessary. You can use the following types of verbal feedback for this purpose:

1. "You are doing well"
2. Neutral Descriptions - Okay, uh hum
3. "Lets try again, okay"
4. "That was easy for you"

It is important to strike a balance between being objective and yet personal in your approach. This is especially important when we are working with adults.

Within the teaching sessions please feel free to give an appropriate amount of verbal feedback - e.g. you are doing well, that is right, lets try again - but please don't "overload" the use of reinforcers. Be "normal" in the extent to which you use verbal feedback bearing in mind that you want the trainee to attend to the materials and teaching session. Over-use of verbal reinforcers can be distracting.

ERRORLESS DISCRIMINATION METHOD

Overview

This approach makes use of a straight word focus and no pictorial material is presented. With the errorless discrimination or word shaping technique, the teacher initiates learning by reinforcing a stimulus-response relationship that the subject can easily acquire, and progressively alters the complexity of discriminations until a restricted stimulus-response relation (the terminal teaching objective) is attained. The Edmark Reading Program (1972) is perhaps the most well documented application of this teaching method.

In the discrimination approach, the word to be taught is first presented and identified by the presenter who says "Point to the word _____." Over a series of four trials, the pointing response is shaped by displaying distractor items along with the target word. Each trial is intended to provide a more difficult discrimination. Comparison stimuli are initially very dissimilar but eventually become similar to the target word with only subtle differences between the words or word-like configurations.

For example, look at this item:

Trial 1	Trial 2	Trial 3	Trial 4
???	Horse	Could	Horse
Horse	In	While	House
???	A	Soil	Hound
???	So	Horse	Hunt

Note how each trial provides a more complex discrimination. Also, it may be necessary to repeat trials to ensure that a trainee has mastered a level before moving on to the next.

Specific Instructions

Following is a very precise set of procedures to follow. We will be practicing these together to ensure that all of us are using the same procedure.

1. Present flashcard containing word to be taught.
   Say, "This word says _____." "Now you say _____."
   (Display word for 5 seconds)
2. Remove card
3. Present word and 3 distractors for trial 1 in random order
   "Say, "Now you find _____."
   e.g. ???
   STOP
   ???
   ???
4. If T correctly identifies the word then advance to trial 2 or else remove all cards and then place down target word and two distractors in random order.
5. Say, "Find _____."
   (If T correct then present word and three distractors)
   e.g. ???
   STOP
   ???

6. If T is wrong then remove all cards.
   Place down target word and 1 distractor. e.g. ??? STOP
   Say, "Try again".

   (If T correct then present word and 2 distractors - then word and 3 distractors)

7. If T is wrong in 6 above then display target word only.
   Say, "Point to the word." e.g. STOP

8. Present the target word and 3 trial 1 distractors in random order. e.g. ??? STOP ??? ???

   (If T correct then go to trial 2)

9. If T is wrong then remove cards and place down target word and 2 distractors. e.g. STOP ??? ???
   Say, "Find _____."

10. If T is wrong then remove all cards.
    Place down target word and 1 distractor. e.g. ??? STOP
    Say, "Try again."
    (If T is correct then present word and 2 distractors - then word and 3 distractors.)

11. If T is wrong in 10 above then display target word only. e.g. STOP
    Say, "Point to the word."

12. Present the target word and 3 distractors. e.g. ??? STOP ??? ???
    Say, "Try again."

13. If T is still wrong then advance to trial 2 by default.

14. Trial 2 - Present target word and 3 distractors for trial 2 IN AT STOP ON

15. If T is correct then advance to trial 3 or else repeat breakdown steps 5 - 12.

In summary, the task is broken down twice to presentation of the single word only. The trainee is given a maximum of 3 attempts at the full list - i.e. word and 3 distractors - else he is automatically advanced to the next trial.

The task is errorless in the sense that it is broken down so that the trainee need only point to the target item being taught (e.g. STOP).

Following is an example session:

Trial 1

??? STOP ??? ???	(Trainee points to target word so we go to trial 2 - no breakdown is given)

Trial 2

IN STOP AT ON	(T makes an error so we remove distractor and present breakdown)	STOP IN AT	(T is correct so we present word and 3 distractors)	STOP IN AT ON

(T is correct on second presentation of 4 words so we then go on to trial 3)

Trial 3

STOP WIFE BEAT ROOT	(T makes an error so we remove distractor and present breakdown)	STOP WIFE BEET	(T makes an error so we remove another distractor and breakdown task)

STOP BEET	(T is correct so we present target word and 2 distractors)	STOP BEET WIFE	(T is correct so we present word and 3 distractors)

STOP BEET WIFE ROOT	(T is correct so we proceed to trial 4)

Trial 4

STOP START SUN SEAT	(T is correct so we go on to next word item)

NOTE: Maximum number of attempts for any trial is 9. Even if the trainee has not mastered the trial we proceed to the next item after 9 attempts.

Follow the verbal directions carefully. When T is wrong use neutral feedback - e.g. "Okay, let's try a new one."

PAIRED ASSOCIATE METHOD

Overview

In this method, a picture and corresponding word are presented simultaneously with the result that responses to the printed word are learned with repeated pairings. The paired associate items each contain two elements: (1) a stimulus element (picture)
(2) a response element (word)

Photographs and flashcards will be provided. There will be one set of materials at Cook Street and another set at Aokautere Centre so these will have to be shared. But because some of you will be working on module 1 while others are working with module 2 there should be little difficulty in coordinating use of the materials.

The word to be taught is presented along with a referent photograph. The photograph provides a contextual cue only (i.e. does not show a word) and can remain in view throughout the teaching session. Over a series of four trials, the trainee is asked to make increasingly more difficult discriminations. In the first trial the trainee need only point to the target word. A new distractor word is added for each subsequent trial.

For example, if we were teaching the item STOP:

Trial 1	Trial 2	Trial 3	Trial 4
STOP	STOP	EXIT	WAIT
	ENTRY	STOP	STOP
		CROSS	RAILWAY
			WALK

Note how each trial provides a more complex discrimination. Also, it may be necessary to repeat trials to ensure that a trainee has mastered a level before moving on to the next.

Specific Instructions

Following is a very precise set of procedures. We will be practicing these together to ensure that all of us are using the same method.

1. Present photo showing cue of word to be taught.
   Say, "Have a look at this picture. It means _____."
2. Present flashcard containing word to be taught.
   Say, "This word says _____." "Now you say _____."
   (Display word for 5 seconds)
3. Remove card.
4. Present card containing target word and say,
   "Now you point to _____." (Trial 1)
5. Remove card.
6. Trial 2 - Present the target word and 1 other distractor word selected at random from pool of items. Say, "Find ___."
   (If T is correct then go to trial 3 else follow next step.)

7. If T is wrong then remove cards and present target word alone. Say, "Point to _____."
8. Present the target word and 1 distractor. Say, "Try again." (If T is correct then go to trial 3 else follow next step.)
9. If T is wrong then remove cards and present target word alone. Say, "Point to _____."
10. Present the target word and 1 distractor. Say, "Try again." (If T is correct then go to trial 3 else follow next step.)
11. If T is wrong then remove cards and present target word alone. Say, "Point to the word."
12. Present target word and 1 distractor. Say, "Point to the word." (If T is correct then go to trial 3.)
13. If T is wrong then remove cards and present the target word alone. Say, "Point to the word."
14. Present the target word and 1 distractor. Say, "Find the word."
    (If T is still wrong then go to trial 3 by default)
    Maximum number of attempts for any trial is 9.
15. Trial 3 - Present the target word and 2 other distractors selected at random from pool of items. Say, "Find ____."
16. If T is wrong then remove 1 of the distractors (the one he made an error on) and say, "Find _____."
    (If T is correct then present target word and 2 distractors.)

    If T is wrong then remove cards and present the target word only. Say, "Point to the word."
17. Present the target word and 2 distractors. Say, "Find the word."

    If T is still wrong continue to follow the procedures for 15 - 17 i.e. take away distractor - present target word only - present word and 2 distractors.

    But remember that the maximum number of attempts for any trial is 9. After 9 attempts you automatically go on to trial 4.
18. Trial 4 - Identical procedure to trials 2 and 3 except that target word is present with 3 distractors. Say, "Find ____."
    (If T is correct then go to next item else follow next step.)
19. If T is wrong then remove the distractor he wrongly identified and place down the target word plus 2 distractors. Say, "Find _____."
    (If T is correct then present target word and 3 distractors.)
20. If T is wrong then remove cards and present word plus 1 distractor.
    (If T is correct then present target word with 2 distractors and then target word with 3 distractors.)
21. If T is wrong then remove cards and place down target word only. Say, "Point to the word."
22. Place down target word and 3 distractors.
    (If T is correct go to next item else follow next step.)

23. If T is wrong then remove cards - place down target word and 2 distractors. Say, "Point to _____."

24. Continue to break down task as above but remember to stop and go to next item after 9 attempts have been provided.

Following is an example session:

<u>Trial 1</u>

STOP (Can't fail this one)

<u>Trial 2</u>

STOP	(T makes error)	STOP	(can't fail)	STOP	(T is correct so
DANGER				CROSS	go to trial 3)

<u>Trial 3</u>

STOP	(T makes error)	STOP	(T fails)	STOP	(Can't fail)
DANGER		CROSS			
CROSS					
STOP	(T fails)	DANGER	(T is	STOP	(T is correct so
CROSS		STOP	correct)	DANGER	we go to trial
DANGER				CROSS	4)

<u>Trial 4</u>

STOP	(T fails)	STOP	(T right)	STOP	(T right so go
CROSS		DANGER		DANGER	to next item)
DANGER		CROSS		CROSS	
RAILWAY				RAILWAY	

NOTE: Maximum number of attempts for any trial is 9. Even if the trainee has not mastered the trial we proceed to the next trial or item after 9 attempts.

WORD RECOGNITION RECORD FORM: MODULE 1 (TOOLS)

Name of Trainee:	Date:
Session Number:	Mode:
Name of Teacher:	Location:

ITEM	Number of Attempts TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TIME
1. Bus Stop (p)					
2. 60 (p)					
3. Hammer					
4. Spanner					
5. Fork					
6. Knife					
7. Drill					
8. Pliers					
9. Saw					
10. Screwdriver					
TOTAL ATTEMPTS =					

Teachers Comments:

WORD RECOGNITION RECORD FORM: MODULE 2 (GROCERY/INFORMATION)

Name of Trainee:	Date:
Session Number:	Mode:
Name of Teacher:	Location:

ITEM	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TIME
1. Bus Stop (p)					
2. Go (p)					
3. Sugar					
4. Push					
5. Bread					
6. Pull					
7. Coffee					
8. Meat					
9. Cross					
10. Railways					
TOTAL ATTEMPTS =					

Teachers Comments:

APPENDIX G

RAW SCORE DATA

Computer Assisted Instruction Group
Raw Score Data: Module One

Item	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Mode	ED	ED	PA	PA	ED	PA	ED	ED	ED	PA	ED	PA	ED
list Order	1	2	1	1	1	2	2	2	1	1	1	2	2
Sex	F	F	M	M	F	F	M	M	M	F	F	M	F
Chronological Age	17	15	15	18	25	56	19	28	20	22	23	22	27
IQ	42	--	48	50	30	--	52	44	53	--	38	33	34
Visual Discrimination Score	31	25	31	39	35	35	41	33	41	43	25	25	35
Word Recognition (Pre-Test)	0	0	0	4	0	0	0	0	2	2	0	-	2
Word Identification (Pre-Test)	2	0	0	5	0	2	1	2	4	8	2	-	5
Picture-Word Match (Pre-Test)	0	2	1	6	0	1	4	2	5	5	1	-	1
Word Recognition (Post-Test)	0	2	3	8	0	1	3	2	7	8	3	-	5
Word Identification (Post-Test)	1	0	3	8	0	0	3	0	8	8	4	-	8
Picture-Word Match (Post-Test)	1	1	3	8	1	1	7	1	8	8	5	-	8
Transfer Test	0	0	4	8	1	0	2	4	7	8	4	-	6
Retention: Word Recognition	0	0	3	7	0	2	2	1	7	8	2	-	4
Retention: Word Identification	1	0	4	8	0	0	4	2	6	8	6	-	4
Total Training Time	72	147	55	67	118	161	94	90	88	59	98	-	94
Total Number of Attempts	232	361	162	173	271	438	170	200	160	164	179	-	184

*Missing Data = --

Computer Assisted Instruction Group
Raw Score Data: Module One

Item	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S 26
Mode	PA	ED	PA	PA	PA	PA	ED	ED	PA	PA	ED	ED	PA
List Order	2	1	2	2	2	1	1	1	1	2	1	2	1
Sex	F	F	M	F	F	M	M	M	F	M	F	M	M
Chronological Age	17	22	19	35	19	32	22	29	23	22	21	18	23
IQ	44	30	--	--	54	--	37	35	40	55	42	50	--
Visual Discrimination Score	32	31	24	30	38	35	23	33	34	37	30	--	--
Word Recognition (Pre-Test)	1	0	0	0	0	0	0	0	0	0	0	-	0
Word Identification (Pre-Test)	2	2	0	2	4	2	6	1	1	1	0	-	0
Picture-Word Match (Pre-Test)	0	0	5	1	4	0	5	1	2	0	0	-	0
Word Recognition (Post-Test)	1	3	0	2	7	2	6	1	7	3	4	-	0
Word Identification (Post-Test)	2	4	1	4	8	3	7	6	7	6	5	-	0
Picture-Word Match (Post-Test)	0	0	2	0	8	5	8	3	7	6	8	-	2
Transfer Test	2	1	1	0	7	3	8	2	8	3	5	-	-
Retention: Word Recognition	0	0	1	2	7	-	7	0	7	3	3	-	2
Retention: Word Identification	1	0	0	2	6	-	8	1	7	2	4	-	3
Total Training Time	87	154	100	62	49	57	84	138	54	75	95	-	94
Total Number of Attempts	252	283	311	207	162	160	166	335	160	281	196	-	198

Computer Assisted Instruction Group
Raw Score Data: Module Two

Item	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Word Recognition (Pre-Test)	-	0	0	-	0	1	0	2	0	2	0	0	1
Word Identification (Pre-Test)	-	1	0	-	1	4	1	3	7	8	6	1	3
Picture-Word Match (Pre-Test)	-	1	1	-	0	1	3	5	8	6	3	1	2
Word Recognition (Post-Test)	-	0	3	-	2	0	3	8	8	8	7	2	6
Word Identification (Post-Test)	-	0	3	-	1	4	6	7	8	8	8	4	8
Picture-Word Match (Post-Test)	-	4	3	-	3	1	5	8	8	8	8	4	8
Transfer Test	-	2	4	-	3	4	4	5	6	6	6	6	5
Retention: Word Recognition	-	0	5	-	0	3	2	5	8	8	8	4	6
Retention: Word Identification	-	1	4	-	1	4	3	8	8	8	8	4	6
Total Training Time	-	147	55	-	142	106	114	109	113	54	119	81	114
Total Number of Attempts	-	339	162	-	290	280	164	165	166	160	166	197	165

Computer Assisted Instruction Group
Raw Score Data: Module Two

Item	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26
Word Recognition (Pre-Test)	0	0	0	0	0	-	-	0	-	0	1	0	-
Word Identification (Pre-Test)	4	0	0	2	8	-	-	0	-	0	4	5	-
Picture-Word Match (Pre-Test)	1	0	1	3	5	-	-	0	-	0	3	1	-
Word Recognition (Post-Test)	0	1	2	0	8	-	-	1	-	0	7	5	-
Word Identification (Post-Test)	2	2	3	0	8	-	-	5	-	1	8	6	-
Picture-Word Match (Post-Test)	4	4	0	1	8	-	-	3	-	6	8	4	-
Transfer Test	3	3	0	1	6	-	-	1	-	1	4	4	-
Retention Test: Word Recognition	4	2	1	1	6	-	-	0	-	0	6	2	-
Retention Test: Word Identification	2	4	0	0	8	-	-	3	-	1	8	4	-
Total Training Time	161	165	113	95	51	-	-	160	-	80	110	131	-
Total Number of Attempts	340	249	395	250	160	-	-	332	-	306	164	224	-

Individual Instruction Group
Raw Score Data:Module One

Item	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Mode	PA	PA	PA	ED	ED	PA	ED	ED	PA	PA	PA	PA	PA
List Order	2	2	1	2	2	1	2	2	1	1	2	1	2
Sex	F	F	M	F	F	F	M	F	F	M	F	F	M
Chronological Age	22	25	31	19	19	26	28	19	28	26	22	17	16
IQ	--	41	--	--	55	45	30	45	--	40	30	--	50
Visual Discrimination Score	29	45	36	30	30	30	28	37	43	25	38	37	38
Word Recognition (Pre-Test)	1	0	0	0	3	0	0	0	1	0	0	8	0
Word Identification (Pre-Test)	0	0	5	3	6	0	2	0	2	0	0	6	0
Picture-Word Match (Pre-Test)	0	1	1	1	4	0	2	1	2	0	-	6	1
Word Recognition (Post-Test)	1	2	4	5	8	4	0	0	6	3	0	8	2
Word Identification (Post-Test)	1	4	3	5	7	4	0	0	5	2	2	8	0
Picture-Word Match (Post-Test)	2	1	-	4	8	8	3	1	5	2	-	-	1
Transfer Test	2	2	5	4	4	4	2	1	8	1	0	8	1
Retention: Word Recognition	1	0	3	0	6	3	0	0	8	1	0	-	0
Retention: Word Identification	0	2	5	1	4	5	1	0	7	2	1	-	2
Total Training Time	134	60	87	95	65	54	72	61	51	203	75	48	38
Total Number of Attempts	606	192	273	284	176	160	214	198	160	449	319	166	193

Individual Instruction Group
Raw Score Data: Module One

Item	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26
Mode	ED	ED	ED	ED	ED	ED	ED	PA	ED	PA	ED	PA	PA
List Order	1	2	1	2	1	1	1	2	1	1	2	2	2
Sex	M	M	F	F	M	M	F	M	M	F	F	M	M
Chronological Age	28	20	31	15	26	33	23	20	33	20	20	43	24
IQ	--	38	--	46	43	48	--	36	30	32	--	51	38
Visual Discrimination Score	25	43	26	38	39	23	28	26	32	29	25	30	34
Word Recognition (Pre-Test)	0	1	0	-	2	0	0	0	0	0	0	0	0
Word Identification (Pre-Test)	3	1	0	-	6	0	1	2	0	1	2	4	0
Picture-Word Match (Pre-Test)	2	1	0	-	5	0	0	1	2	0	5	0	2
Word Recognition (Post-Test)	6	3	4	-	8	6	3	1	1	0	0	1	1
Word Identification (Post-Test)	5	2	5	-	8	3	0	0	1	0	0	0	1
Picture-Word Match (Post-Test)	1	3	2	-	8	-	3	0	2	0	-	0	2
Transfer Test	3	4	1	-	8	3	0	2	3	0	0	0	1
Retention: Word Recognition	0	1	0	-	5	2	0	1	2	0	0	0	0
Retention: Word Identification	4	3	2	-	7	4	2	1	1	0	2	0	2
Total Training Time	-	100	-	-	-	100	-	-	-	67	42	95	125
Total Number of Attempts	226	209	183	-	170	184	310	160	466	231	189	376	232

Individual Instruction Group
Raw Score Data: Module Two

Item	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Word Recognition (Pre-Test)	0	3	0	0	2	0	0	0	2	0	0	6	0
Word Identification (Pre-Test)	2	3	3	1	4	0	3	1	7	2	0	8	0
Picture-Word Match (Pre-Test)	1	1	5	1	6	2	1	0	4	0	0	6	1
Word Recognition (Post-Test)	1	4	6	1	5	7	2	0	8	0	1	8	0
Word Identification (Post-Test)	3	5	6	2	5	7	3	0	8	1	1	8	1
Picture-Word Match (Post-Test)	1	6	9	2	8	8	3	1	8	5	-	-	3
Transfer Test	0	5	5	4	5	6	1	1	5	1	1	5	0
Retention: Word Recognition	1	4	4	2	6	1	4	0	7	1	0	-	0
Retention: Word Identification	0	7	8	4	7	3	2	2	8	3	2	-	4
Total Training Time	88	41	57	25	73	50	96	84	45	127	113	41	24
Total Number of Attempts	409	172	197	315	184	162	262	264	162	395	456	160	276

Individual Instruction Group
Raw Score Data: Module Two

Item	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26
Word Recognition (Pre-Test)	0	0	0	3	4	0	0	0	0	0	0	2	0
Word Identification (Pre-Test)	2	0	0	1	8	2	1	1	0	0	0	1	4
Picture-Word Match (Pre-Test)	1	0	0	6	8	1	0	1	0	1	2	1	1
Word Recognition (Post-Test)	1	5	0	8	8	4	2	4	2	0	1	2	1
Word Identification (Post-Test)	3	6	1	8	8	6	3	5	0	3	8	0	2
Picture-Word Match (Post-Test)	1	5	0	8	8	-	-	8	2	0	-	0	2
Transfer Test	2	5	2	6	6	2	2	2	3	1	3	2	3
Retention: Word Recognition	0	2	0	7	8	2	2	5	0	1	1	0	1
Retention: Word Identification	0	6	1	8	8	4	1	6	4	0	3	1	2
Total Training Time	-	124	-	24	-	-	-	67	-	49	60	109	182
Total Number of Attempts	216	201	219	186	166	188	253	164	315	214	201	462	289

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