COMPUTER ASSISTED LEARNING AND LEARNING DISABILITY: AN EVALUATION

by

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ABSTRACT

Computer-Assisted Learning and Learning Disability: An Evaluation

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The aim of this thesis is to evaluate the use of computer-assisted learning with people who have severe and profound learning disabilities. Theories of learning are central to our understanding of learning disability and contributions from the cognitive and behavioural schools are reviewed and related to methods of education and training for people with learning disabilities. This framework provides a rationale for understanding the premises of computer-assisted learning. A review of the literature reveals a lack of evidence for the efficacy of computer-assisted learning. Evaluation studies to date appear to be characterised by a lack of a methodologically sound framework. An evaluation survey of software designated for use with people with severe learning disabilities is presented which finds that much educational software lacks a sound grounding in established and effective principles of learning and teaching, although its use is still supported by instructors. Thus, the need for empirical research investigating the use and efficacy of computer-assisted learning in learning disability is identified.

Psychological models provide an appropriate method of such an inquiry, though methodological problems inherent in evaluative research with a special population appear to act as a barrier to the development of effective knowledge in the area. Within these limitations, three experiments are presented. The first compares conventional teaching with computer-assisted teaching. The computer was as effective as the teacher, though the conventional measures of achievement used were not sensitive to any differences between the two methods. The second developed a more finegrain analysis which revealed a difference between the quality of participants' interaction with computer and teacher instruction. Specifically, attentional behaviour was increased in the computer-taught condition, yet there was no concomitant increase in learning. The reliance of educational software on sensory reinforcement was postulated as underlying the ability of computer-assisted learning to maintain attention to the task. The third experiment directly addressed the ability of three different sensory reinforcers typical of those found in educational software to support learning a simple discrimination task. It was found that sensory reinforcers were not effective in supporting learning, though they did maintain attention and performance on the task. It is suggested that the multiple modalities used by software may interfere adversely with the coding of relevant information involved in the discrimination of stimulus dimensions and that this may account for the discrepancy between measures of performance and measures of learning on computer-assisted tasks.

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For Richard Southgate,
who did not participate in the research,
but who did participate in my learning.

CHAPTER 1

1. LEARNING AND LEARNING DISABILITY

1.1 Introduction

Recent years have seen a major impact of microtechnology on the education and training of disabled people. The great potential of this technology for the amelioration of disability has resulted in the widespread introduction of microcomputers, software and accompanying peripherals into special education. This is seen as a progressive and beneficial event by some educators who have been quick to seize the opportunity this appears to present. Others have criticised the introduction of an impersonal machine which they see as usurping the role of human interaction in education. This disparity of attitudes should not come as a surprise since the support for the use of microtechnology with disabled people seems to be founded more in enthusiasm than evidence. Thus, an opportunity is presented to inquire upon the efficacy of the use of microtechnology with people with severe learning disabilities, together with forging a greater understanding of the ways in which they develop through the use of this technology.

This thesis seeks to evaluate the use of computer-assisted learning with adults who have severe learning disabilities. This aim is met through the presentation of empirical work which evaluates applications of computer-assisted learning to education and training for people who have learning disabilities and through the discussion of relevant theoretical background, contributing links between evidence and theory where appropriate. Before the description of the empirical work of this thesis, it will first present a review of major theories of learning, relating them to learning disability, then proceed in the next chapter to a review of the literature concerning uses of computer-assisted learning in learning disability.

1. 2 Learning and learning disability

A central theme to the investigation of this method of education for people with severe learning disabilities will be the processes of learning taking place. So, it is necessary to first review the existing state of knowledge regarding learning in people with learning disabilities. While this review is not exhaustive, it serves to illustrate salient points of impetus and growth in the study of learning disability. It will be seen later that many of these issues bear relevance to the investigation of the the efficacy of computer assisted learning and further discussion will be warranted where appropriate.

1.3 Learning and learning disability: some definitions

The importance of learning in the understanding of learning disability has been apparent since the Idiots Act of 1886, in which training, as well as care, of "idiots and imbeciles" was made a requirement. Thus, "idiots" were at least regarded as able to be trained (Clarke and Clarke, 1985). The past one hundred years has seen progress to a point where the provision of education for all children with special needs has become a statutory requirement through the passing of the 1981 Education Act; though the maintenance of this care and education beyond school leaving age is still not mandatory.

Central to the progress made in the provision of service for disabled people has been the periodic revision of the classification of "handicap". This is witnessed by the terminological changes - from "idiots and imbeciles" through to "mental handicap" and on to the presently used phrase "learning disabilities". These phrases have been implemented as an attempt to describe states of difficulties with social and intellectual functioning. No one phrase is adequate to summarise all the wideranging conditions that the terms imply; however, it is necessary to use some descriptor in a general sense. Throughout this thesis, "learning disability" is used as an acceptable term in its connotations and one which will also be generally understood. This phrase refers to the observation of impairment in one or more of three areas: 1) maturation - people with learning disabilities take longer to pass through stages of human development; 2) learning - they also take longer to learn skills; and, 3) social adjustment - they will require more help, support and supervision than others of their age and few will attain full independence. (Clements, 1987). Many people with learning disabilities will also have additional physical, sensory, medical or psychological problems. In sum, they are people vulnerable to a wide range of difficulties.

The concept of a learning disability carries with it some reference to learning and it is necessary also to define what is meant by the term "learning". Colloquially speaking, learning may be described as the set of processes by which knowledge, comprehension or mastery is attained through experience or study. It is complex in its scope, it is an essential part of everyday life and living and, ultimately, it is the way in which our world comes to be presented to us - we learn about our environment and about our interactions with all that is contained within it. From a psychological standpoint, "learning" is usually taken to refer to changes in observable behaviour or changes in the potential for behaviour to occur as a consequence of experience. That is, it is concerned with the acquisition of new behaviours and skills, or the acquisition of the potential for behaviours to change. In this sense, it is conceptually distinct from the learning that is taking place in classrooms, which may involve a high degree of unobservable information gain. In this thesis, "learning" takes its psychological connotations and refers to the acquisition of new behaviours and skills through interaction with contingencies in the environment.

Learning disability can be seen as an impairment of learning ability rather than a state of complete inability to learn. This has prompted much investigation into the learning processes of individuals with learning disabilities in the hope of furthering knowledge and understanding of just what the impairment may be. These scientific studies of learning disability have been largely confined to the past fifty years (Poling, Fuqua and Miltenberger, 1983). The research literature consists of literally thousands of studies where people with learning disabilities have served as participants, although most reviewers (e.g., Clarke and Clarke, 1974) acknowledge that much of the early work has been of little lasting value. Clarke and Clarke (1980) report that for many researchers "the subnormal were little more than a captive population available for trivial experimental work". Three general categories of research can be identified in the literature. One group has attempted to specify the characteristic features of learning deficit, a second group is largely concerned with the etiology of learning disability, while treatment and amelioration of the condition is addressed in the third research area (Poling et al., 1983).

Psychologists have expressed greatest interest in the first and last of these three groups. Approaches to research have come mainly from two traditional divisions of academic psychology: the cognitive school and the behavioural school; with little, if any, rapprochement (Ager, 1983). This is historical in nature, and stems from a natural divergence of interest. The cognitivists were attempting to answer questions such as: How, in terms of processes, do people with learning disabilities think and is that different to non-disabled people? On the other hand, the behaviourists asked how people with learning disabilities behave and researched the control and maintenance of the disabled individuals' behaviour, stressing the importance of the adaptive value of a given behaviour. Irrespective of one's own background, by far the largest contribution to the study of severe and profound learning disability and the relation of this research to practice has come from the behavioural school of psychology.

1.4 Behavioural psychology and learning disability

Behavioural psychology is accepted here as that branch of psychology which encompasses the principles governing behaviour which grew out of the work of Thorndike (1911), Watson (1924) and Skinner (1953). According to these theorists the frequency of a response is sensitive to the consequences of that response. Behaviours are acquired, altered or maintained by the reinforcement received from the environment. Indeed, Skinner used the term "operant conditioning" to emphasise that a behaviour operating upon the environment may be conditioned by the outcome of that behaviour.

The contribution of behavioural psychology to the practice of care and treatment in learning disability has been prolific. Many writers have reviewed the applications of operant conditioning with people with learning disabilities (e.g., Clarke and Clarke, 1974; Kiernan, 1974; Kazdin, 1978; Whitman and Scibak, 1979; Baumeister, 1967; Spradlin and Girardeau, 1967, Watson, 1967). It is abundantly clear that the behavioural repertoire of people with learning disabilities may be significantly improved or changed through the systematic application of behavioural principles - generally termed "behaviour modification" (Kiernan, 1974). The use of behaviour modification has spread rapidly to many and diverse areas of the lives of people with learning disabilities. Some examples of areas where it is used are toilet training, speech, feeding, dressing, social skills, self-injury and aggression. It can be seen that the incidence of desirable behaviours may be increased and that of undesirable behaviours decreased. Essentially, the use of operant conditioning can be a powerful tool in the education of disabled people. Watson and Lawson (1966; quoted in Clarke and Clarke, 1974) state that "Of significance is the fact that...(these conditioning techniques)...have succeeded with the severely and profoundly retarded, where other training methods have failed".

The major criticism of the voluminous literature on the application of systematic training procedures is that, despite the large amount of data and information available, relatively little progress has been made in identifying those variables which are responsible for the success of behaviour modification (Watson, 1967; Kiernan, 1974, 1985; Poling et al., 1983). It may be argued that the principles of behavioural psychology are broadly operative; and that, in general, the focus of behaviour modification has necessarily been on clinical and educational situations where the isolation of variables from the potential hundreds which may control behaviour is a hard task. It is necessary then to turn to basic research findings regarding operant conditioning with people who have learning disabilities.

This type of basic research has most often been concerned with schedule effects on responding and stimulus control of performance. Poling et al., (1983) admirably summarise the clinical and theoretical implications of basic research findings from a number of studies. For the most part, the behaviour of people with learning disabilities is lawful and much like that exhibited by non-disabled humans (and other more extensively studied species).

Some differences have been reported. Performance has been established under fixed ratio, variable ratio, fixed interval and variable interval schedules. Some authors have reported that, in contrast to nonhumans, humans - whether learning disabled or not - maintain high and relatively uniform response rates under fixed interval schedules (e.g., Ellis et al., 1960; Headrick, 1963; Orlando, 1961; Orlando and Bijou, 1960). Of relevance here is the value of instructions given to the subject as a powerful source of control over their behaviour (Lowe, 1979). A number of studies have investigated the importance of instructions in determining the rate and patterning of responses (e.g., Baron, Kaufman and Stauber, 1969;

Buskist, Bennett and Miller, 1981; Harzem, Lowe and Bagshaw, 1978; Kaufman, Baron and Kopp, 1966; Matthews, Shimoff, Catania and Sagvolden, 1977; Shimoff, Catania and Matthews, 1981). In general, instructed responding is less sensitive to changes in reinforcement contingencies and tends to occur at a high steady rate (e.g., Ellis, Barnet and Pryer, 1960; Headrick, 1963; Orlando, 1961; Orlando and Bijou, 1960).

Another productive area of research has been that which concerns the development of stimulus control. Attainment of stimulus control (i.e., the discrimination of relevant stimuli) directs many daily adaptive behaviours, but discrimination learning deficits have been reported as "characteristic" of people with learning disabilities (Wood, 1988). Therefore, methods for establishing appropriate discriminations hold great practical importance for this population. Discrimination learning deficits are thought to be related to the failure to attend selectively to the stimulus dimension relevant to the discrimination and to associate that dimension with a reward (Zeaman and House, 1963; Fisher and Zeaman, 1973). This is similar to "stimulus overselectivity" in which behaviour becomes controlled by a restricted set of features from a complex stimulus which contains many relevant features (Lovaas, Koegel and Schreibman, 1979; Wilhelm and Lovaas, 1976; Bailey, 1981). However, such deficits have also been documented with non-disabled children (Bailey, 1981) and nonhumans (Reynolds, 1961). More recent research asks whether discrimination learning deficits are more a characteristic of the procedures used for discrimination training than of any particular diagnostic category. For example, the use of discrimination procedures based on "errorless learning" (Terrace, 1963a, 1963b, 1966), such as stimulus fading, have been found to improve performance (e.g., Strand and Morris, 1986; McDermott, Harsant and Williams, 1986).

Of significance in the operant literature are the areas of neglect where, by extrapolation from nonhuman research, effects of variables are probable but not yet researched in the laboratory with humans or effectively ignored when they occur in applied settings. A glaring omission is the lack of controlled studies concerning the efficacy of various reinforcers. The delivery of reinforcement is central to the implementation of operant conditioning techniques. In nonhuman research, edibles are most commonly used in conjunction with some level of prior food deprivation. But in applied settings the situation is different: The range of reinforcers is extended greatly beyond edibles, the number of potential reinforcers is vast, and prior levels of deprivation are not imposed (Wearden, 1988). It would be of considerable benefit to find out how reinforcers "prescribed" daily influence the rate, pattern and stability of performance. Given this, it is surprising that studies which empirically evaluate reinforcing events for people with learning disabilities have been scarce. Little is known, for example, about the dimensions of quality and quantity of differing reinforcers and their relative satiation levels. Some examples of research addressing these issues have looked at social praise (Hollis, 1965), money and tokens (Spradlin, Girardeau and Hom, 1966), music (Remington, Foxen and Hogg, 1977), vibration (Ottenbacher and Altman, 1984). Some comparisons of different reinforcers have also been attempted including the use of vibration or praise (Johnson, Firth and Davey, 1978), cigarettes or sweets (Ellis, Barnett and Pryer, 1960) and pennies or lock washers (Siegel, Williams and Forman, 1967). Awareness of the power of differing reinforcers is increasing. In particular, the role of sensory reinforcement in maintaining self-stimulatory behaviours in autistic and severely disabled children is receiving greater attention (e.g., Murphy, 1982). Knowledge of the relative values of reinforcing events is an essential step forward to the goal of achieving participation in more worthwhile activities for learning disabled people.

These findings of the behavioural school are reviewed here for two reasons. First, they are an illustration of the quest for behavioural research to contribute to the understanding of basic behavioural processes and/or deficits which may underlie learning disability. From these studies, it can be seen that a great deal of effort has been put into attempting to isolate variables and processes, with varying degrees of success. However, the development of applied techniques for intervention which exploit to the full this knowledge has been limited (Remington, 1991). This neglect leads to the second reason for examining these findings here, and that is to place a link between theoretical and empirical developments in behavioural research concerning learning disability and the development of interventions which use microtechnology. It will be seen in Chapter Two that many of these behavioural principles are found in computer assisted learning (CAL). The variables reviewed here of schedule effects, effects of instructions, stimulus control and sensory reinforcement have a place in the implementation of CAL, though they are largely neglected in any evaluative research concerning its effectiveness. The research presented later will eventually concern itself with effects of sensory reinforcers in the use of CAL for people with learning disabilities. These findings provide the empirical background to this later endeavour.

It has been said that practical approaches neglect such empirical evidence. One of the ways forward in remediating this situation relies on greater research efforts and, more importantly, the integration of findings from the laboratory and the "outside world" (Clarke and Clarke, 1974; Kiernan, 1985). It is a common complaint that laboratory research bears little relevance to clinical practice and that applied research is not sufficiently robust to support theoretical development. A major hurdle has been a lack of appropriate methodology to carry out reliable experimentation in practical settings with special populations, which may consist of small numbers. However, the development of quasi-experimental single case, small-n and "applied" research designs is proving effective in overcoming these problems by providing alternative methodologies for studying behaviour change in individuals and small groups (see, for example, Barlow and Hersen, 1984).

1.5 Cognitive psychology and learning disability

The contribution of cognitive psychology to the understanding of learning disability is more difficult to summarise as it is more diffuse and concerned with concepts not so easily observed. Also, until recently, treatments and amelioration of impaired learning processes has not been the brief of cognitive work in handicap; rather attempts have been focused on explanations of difficulties and/or failures to learn in terms of the "weakness" of a specific cognitive process (O'Connor and Hermelin, 1974). Current work can be seen to have emerged from the predominant theories of specific learning deficits proposed by Ellis (1963), Luria (1961) and Zeaman and House (1963, 1979).

Ellis' (1963) "stimulus trace" theory was based upon experiments investigating short-term memory in people with learning disabilities. He proposed that a characteristic low level of cortical arousal in disabled people resulted in a "weak stimulus trace" in short-term memory and a subsequent failure to establish events in long-term memory.

Luria's (1961) "verbal dysfunction" theory implied that the verbal difficulties of disabled people was related to their limited level of functioning. This was based on a series of experiments which demonstrated a deficit in language gaining control over behaviour. Luria contended that thought and language are intimately related and that speech plays a vital role in the regulation and integration of normal behaviour; thus, the observed disassociation of speech and motor signals of disabled people would result in retarded cognition. This approach would seem to have difficulties in helping to explain the retarded cognition of non-verbal or pre-verbal learning disabled adults. By implication, it suggests that those with learning disabilities are failing in the natural course of acquiring skills such as internalised control through self-monitoring and self-talk. As comprehension of speech occurs before production, there may be some reason to apply this also to non-verbal individuals.

Zeaman and House (1963, 1979) proposed their "attention theory" after a series of experiments on discrimination learning with people with learning disabilities. They found that the rate of improvement from the level of chance responding to the correct level of performance did not differ for learning disabled and non-disabled people - what differed was the number of trials occurring prior to learning the discrimination. Thus, they concluded that the actual learning of an association was not affected, but that there is a deficit in the process of attending to the relevant dimension appropriate to the discrimination. The defect of learning is secondary to the defect of attention (Wood, 1988). Attentional deficit has already been mentioned as a contributory factor to discrimination learning disabilities in the outline of behavioural contributions to our understanding of learning disability. It is notable that Zeaman and House published their "attention theory" as a cognitive orientation to learning deficit, yet most of the recent empirical evidence is drawn from "behavioural" research. While, in effect, the resulting discrimination deficits are the same from both points of view, there are differences in the concept of "attention" described by both schools. Two components of attention can be distinguished: the behavioural component which is an attentional set that requires some degree of orientation, effort and motivation and the cognitive component which is selective information processing (Wood, 1988). It is this information processing deficit which Zeaman and House proposed as a source of retarded performance.

While the three approaches of Ellis, Luria and Zeaman and House differ in theoretical emphasis, in common with each other they focus on early stages in the learning process and suggest problems for individuals in structuring their own experience. Each approach conceives of some form of specific defect which affects psychological function. Other research (O'Connor and Hermelin, 1978) has used as a starting point the idea that some form of specific deficit is present and has attempted to identify a common process underlying such disparate theories as these.

Based on observations from earlier experiments, O'Connor and Hermelin (1974, 1978) proposed that one of the basic elements of learning was the organising process which underlies specific operations such as perception, recall and recognition. This they termed as "coding" or the classification of input and its appropriate tagging for reference in perception, learning and memory. In considering specific deficits which might affect coding, they examined the relationship between general and specific impairments. Hence, they undertook a research programme consisting of a series of experiments investigating information processing in groups of "normal", sensorily and learning disabled children. The children were presented with a number of items for later recall or recognition. These items were sometimes visual, sometimes auditory and presented spatially and/or temporally. In other words, participants were given items which could be recalled in accordance with the participants' own organising process of incoming information or "coding bias". It was found that, when given a visual input, normal children used the temporal sequential order of the items to recall them; whereas deaf, autistic and children with learning disabilities recognised or recalled the spatially ordered sequence. Of particular concern to the understanding of cognitive processes in people with learning disabilities was the conclusion that the more severely disabled were the individuals, the more likely they were to code events in visuo-spatial terms (O'Connor and Hermelin, 1978).

Such work goes some way to a unified interpretation of the variations shown by learning disabled people in information processing at the early stages of learning. These dissimilarities to "normal" people cannot in any way be called deficits, but are potentially important differences. This conceptual framework usefully provides some degree of orientation toward the construction of practical approaches for the amelioration of learning disabilities (e.g., by identifying mode of presentation of input material as a critical factor).

The contribution of cognitive approaches to the practise of care and treatment in learning disability is seen in applications such as memory training, concept formation and symbolic play (Clements, 1987). Emphasis is also placed on enriching the social contexts of interactions by encouraging joint attention during shared activities with sensitive, responsive adults prepared to assign communicative significance to behaviours. Improving the quality of the social, communicative environment may also be augmented through signing. Self-instructional procedures, (i.e., using cognitive mediation of behaviour through self-talk) are also derived from the emphasis placed on the influence of internal mental processes on behaviour by the cognitive school.

Not all influential cognitive theories of learning deficit have focused on isolated processes. A generalised account of failure to learn is that which stems from theories of cognitive development, primarily those of Piaget (1953) and Inhelder (1968). Essentially, this view states that the learning disabled person's cognitive development can be described using the same theories of stage development that describe "normal" development. However, the cognitive development of the learning disabled person progresses more slowly through the same sequence and by lower limits to full development (Clarke and Clarke, 1974). Research data reveals so many differences between learning disabled and non-disabled people that some idea of "deviance" from the norm may have to be suggested rather than being able to accept completely this developmentalist view. However, "developmental delay" is a useful and valuable concept. For example, it has influenced thinking on social policies and attitudes and, more specifically, directly affected the assessment and description of extent of handicap (e.g., describing a learning disabled person as functioning at the developmental level of four years of age) and the structuring of educational goals relevant to previous attainment and future expectation (Ingalls, 1978).

It is also a view which fits well with the fundamental concept of learning disability being a state of social incompetence (Clarke and Clarke, 1974). By this it is meant that people with learning disabilities lack behaviours at a particular age which are deemed appropriate by society (Belmont, 1978). The role of developmental views in encouraging the attainment of socially and age appropriate behaviours (rather than solely developmentally appropriate behaviours) is self-evident and is a cornerstone of the current goals of normalization which are sweeping the day-to-day care and training of disabled adults.

1.6 An integration of behavioural and cognitive approaches

The traditional division between behavioural and cognitive psychology is longstanding and supported determinedly by protoganists from both sides; hence, a resolution will not be achieved here. The theoretical and empirical approaches to learning outlined above provide the background for an understanding of the learning processes involved when CAL is used with people who have learning disabilities and this will be more fully described and explained in the next chapter. It is important to say here that both schools of thought have made contributions to this area, therefore, it was relevant to give the background to each.

It is also apparent that some similarities can be seen between the two approaches, and that some degree of integration would be helpful in order to appreciate some of the theoretical approaches to CAL. For example, O'Connor and Hermelin's work provides an account of information processing of incoming stimuli, yet it also enables some prediction of the likely outcome behaviour of an individual. Slow learning rates are observed under different stimulus conditions and cognitive relationships between stimulus and response are inferred from this. Theoretically, the model concerns itself with unobservable cognitive events, such as coding. But, to some extent, it validates these events by a quasi-functional analysis of the relationship between stimuli and behaviour (Ager, 1983). This can be interpreted as being neither strictly behavioural nor strictly cognitive in its construction, but shows some degree of rapprochement between the two approaches - though some may call this obscurity.

It will be seen later that this inference of process occurs in other theoretical interpretations of observable behaviours during the use of CAL.The implementation of CAL and our understanding of its place in the education and training of people with learning disabilities is still relatively limited and, for this reason, ideas should not be rejected out of hand. This situation calls for an openness of ideas and a plurality of approaches. Progress in the direction of providing remediation for learning disability is more likely through an open-minded evaluative approach which encourages the expression of ideas and their validation through research (Clements, 1987). The focus of the research presented in this thesis is largely behavioural, but where appropriate, it draws upon other approaches in the hope of enlarging the forum for ideas, research and discussion.

1.7 Conclusion

A collection of issues relevant to the process of learning observed in people with learning disabilities has now been established. Learning has been identified as a central concept in the understanding of learning disability. The question of how people with learning disabilities learn has been researched in two major directions, those of the behavioural and cognitive schools of psychology. While researching specifically different aspects of learning, each school has contributed further to theories of learning disability and both have implied practical approaches to beneficial treatments. For example, behaviour modification techniques from the behavioural school (e.g., differential reinforcement, prompting and fading, etc.) and communication remediation from the cognitive school (e.g., responsive verbal attention during shared activities to increase quality of linguistic environment and assign significance to communications). Thus, psychological methods of inquiry have proved their merit in providing exemplars of learning deficit and some means of amelioration.

These issues will now be used as the background to investigating a recent and potentially powerful mediator in the learning processes of adults with severe learning disabilities - computer assisted learning.

CHAPTER 2

2. COMPUTER-BASED LEARNING AND LEARNING DISABILITY

Learning assisted by technology is not a new idea. In education, there has always been the case for supplementing at least some of the curriculum with a degree of "technological assistance" - from audio-visual aids to the teaching machines of the 1960's (Cleary, Mayes and Packham, 1976). However, the falling cost of the microprocessor has resulted in something of a "microtechnology revolution". Educational and care establishments have gained access to the microcomputer which, with its tremendous power and relative reliability is a much more flexible tool than the technology previously available to them.

Computer assisted learning (CAL) may be regarded as taking place "where teaching or learning in any part of the curriculum are aided by some application of the computer" (Barker and Yeates, 1985). The progress of CAL has divided into two large areas. A major concern has been the development of hardware as a means for providing opportunities for disabled individuals to interact with their surroundings. Also, there has been a corresponding development of instructional software designed to teach, practice or improve skills. These programmes have usually targetted those skills which are of a traditionally scholastic nature or those that are recognised as pre-requisite for reading, writing or number work. There is necessarily some overlap between these two areas of CAL development (Hofmeister, 1982; Budoff and Hutten, 1982).

The computer can assume the role of instructor and present information to be learned. It can also check and monitor the students' progress and offer remedial help (when used in this way it is often referred to as computer-assisted instruction or CAI). Alternatively, the computer can act as the passive receiver of whatever information the learner chooses to give it, for example, by acting as a word processor, drawing pad or musical instrument. It can also play a more interactive role in, for example, games. CAL programmes may be short and cartoon-like or they may be text based. Generally, in special education most CAL programmes try to present striking visual and auditory stimuli in order to gain the attention of the learner.

The reasons which have been proposed for using microtechnology with people with learning disabilities are varied. There is some basis for the expectation that advantageous conditions for learning are provided with CAL. In particular, the learning environment achieved through the use of CAL:

- provides clearly defined expectations
- gives the learner undivided attention
- calls for active responses on the part of the learner
- allows the learner to work at their own pace without being hurried
- minimises social stress
- gives immediate feedback and reinforcement
- is tireless
- can be exciting and motivating through the use of animation, sound, rewards etc.
- can simulate real-life experiences

Many of the attributes listed above are suggested as important in the teaching of people with learning disabilities regardless of the identity of the instructor - whether human or machine (McDermot and Watkins, 1983). However, the use of CAL has been particularly commended as an appropriate medium for the education and training of people with learning disabilities, because it is argued that they have certain characteristics which may be particularly well served through the use of CAL (Clark, 1986; Conners, Caruso and Detterman, 1986; Hogg, 1984).

First, these learners require a great deal of repetition of material. The computer can deliver information tirelessly and in an identical fashion many times over. Also, this can occur without the instructor becoming impatient or frustrated. This lowering of tension or social stress may have particular importance if the learner is prone to emotional or aggressive outbursts.

Second, it has been noted that people with learning disabilities have a low expectancy for success (Bialer, 1961) and have frequently experienced failure within the education system (Clark, 1986). The demoralization that can result from this is frequently commented upon by educational and care staff. CAL's potential flexibility means that work presented may be suited to the individual's abilities and adjusted rapidly to provide remedial help if the learner is having difficulties.

Third, many people with learning disabilities are unable to read, so it is necessary for material to be presented in some other fashion. This can be achieved easily by using the computer's capability to produce graphics and sound or to control tape recorders, slides, etc.

Fourth, another often noted characteristic of people with learning disabilities is their distractibility in the learning situation. It is argued that two aspects of CAL may reduce this. The use of CAL as a tutor can offer one-to-one instruction and thus maximise the time spent engaged with the teacher. Also, many authors cite CAL as "motivating" for learners to use (e.g., Hogg, 1984; Ager, 1985). It is suggested that this motivational dimension is achieved through the experience of self-directed behaviour and by the use of the software's graphics and sounds which direct attention to the task.

A final point is that, because of their developmental delay, adults with learning disabilities are often presented with child-oriented materials. The use of a computer, however, provides an opportunity to present tasks via a medium which is seen to be part of the everyday adult world.

While CAL has the potential to fulfil the above criteria, the extent to which this occurs is dependent on the software employed and the hardware used to provide opportunities for the disabled learner to interact with the learning environment. There has been a proliferation in the number and types of switches or input devices allowing communication between the computer and an individual (Bourland et al., 1983; Flanagan, 1982; Goldenberg, 1979; Rostron and Lovett, 1981; Southgate, Fuller and Poon, 1983; Young, 1983). The impact that these devices have had is well described by Rostron and Sewell (1984) when they speak of microelectronics being the "enabling technology" for disabled people. This particularly applies to those with physical handicaps, but is also very relevant to people with learning disabilities who often find it difficult to interact with their surroundings. It is now possible in most cases to link the microcomputer and the learner, enabling access to this potential educational tool. However, hardware developments have outstripped those of software and the outlook is disappointing when the question of "What is being accessed?" is asked. The immediate object being accessed is the software, but any program must be a reflection of the educational strategy used in the learning process. There is a need, therefore, to look both at the software and the learning paradigm it is based upon. Considerably more progress has been made with the technical development of CAL than with the instructional material. At present, the equipment is much more sophisticated than any currently proposed theory of teaching required for its realization.

2.1 Teaching skills to people with severe learning disabilities

It has been suggested that CAL has done little more than repackage well-established educational techniques in elusive terminology and expensive hardware (Cleary, Mayes and Packham, 1976; DuBoulay and Howe, 1981; O'Shea and Self, 1983). This is questionable. While the hardware is now sufficiently able to allow truly responsive and flexible education, there is still the problem of programming it. Usually, educators are not software engineers and vice versa . Much educational software has been written by enthusiastic amateurs, whose laudable motives are not matched by their expertise. Conversely, those programs which are technically well written demonstrate a lack of understanding of educational principles. Consequently, most software ignores important psychological principles of learning (Pattulo, 1984). This mismatch could well be responsible for the commonly held view that available special educational software is inadequate (Ager, 1985; Budoff and Hutten, 1982; Hofmeister, 1982; Morris and McBrien, 1984; Southgate et al., 1983). However, psychological theories of learning and development may lend a framework to the premise that people who are disabled by severe learning disabilities can effectively use CAL. The two major schools of thought which have furnished the understanding of learning and learning disability outlined in Chapter 1 can be seen to relate to the use of CAL and these contributions will be discussed below.

2.1.1 Behavioural models

The development of effective methods to aid communication between the disabled person and the environment can fulfil one of the fundamental tenets of behaviour theory. That is, in being able to act upon the environment, the outcome of that action may be observed until eventually an association between a response and its consequence is learned. A broad interpretation of this principle is seen to apply in most, if not all, instances of CAL. The learner makes a response via the keyboard or switch and the computer provides or controls the consequence.

A more specific use of behavioural principles in instructional technology was first adopted during the late 1950's by Skinner and his associates. A type of instruction termed "programmed learning" was derived from the behavioural framework for operant training. This psychology of programmed learning is relevant to CAL in a very direct manner. Holland (1960) outlines the principles forming the basis of programmed learning as:

- Immediate reinforcement of response
- Student emission of response
- Gradual progression to establish complex repertoires
- Fading of stimulus support
- Discrimination training, abstraction and concept formation through controlled variation of examples
- Revision or modification of the program to fit the student

Further to this, Crowder (1960, 1963) introduced branching into programmed learning. Branching consists of directing the learner to supplementary material after an error has been made, thus giving the learner feedback on their errors and emphasising the role of remedial assistance within a program. This also enhanced learning programs by providing the facility to move "around" the program from one section to another, thus increasing the programs flexibility. The attributes of CAL which have been described earlier as useful for people with learning disabilities can be seen to closely parallel a combination of Holland

and Crowder's parameters for programmed learning.

Most currently available educational software is based loosely on the behavioural principles outlined above. Almost all software makes attempts at rewarding appropriate responses and extinguishing inappropriate responses, for instance. Indeed, CAL has been criticised for reviving "crude behaviourism in a seductive new guise" (Chandler, 1984). Very little overt discussion of this issue has taken place, however.

Part of behavioural theory has explained learning as the process by which behaviours are acquired and controlled through the operation of contingencies of reinforcement and punishment in the environment. Unfortunately, the manner in which such principles are presently implemented in educational software is much the same as was necessarily the case with the severely limited hardware of the 1960s. The first attempts to implement behavioural principles in the classroom came at a time when the microelectronic technology lagged far behind the behavioural technology. Thus, the "crude" behaviourism should perhaps be viewed as a function of crude hardware. Currently, there is a situation in which there exists a very powerful and flexible piece of electronic technology but, to a large extent, the application of well-researched behavioural principles to this technology is yet to be made.

For example, at the very least, each programme must be based on some kind of task analysis of the desired objective. In a task analysis, the task to be learned or taught is broken down into discrete components, each of which may be learned separately, then chained together to constitute "the task". The application of such an analysis to the CAL teaching situation appears to have received little attention. A cursory look at educational software leads one to question the provision of material in appropriate blocks and the use of reinforcers associated with these blocks, for example. The literature on learning would point to the need to pay better attention to many comparable issues. The effect of being given instructions, schedule effects on responding, the discriminability of stimuli and the efficacy of reinforcement are all issues which are relevant to the use of CAL yet are rarely adequately considered in software design. Even taken at its crudest, behaviourism has yet to be fully exploited in CAL.

2.1.2 Cognitive models

The ability of the computer to enable interaction between the user and the environment is central to cognitive explanations of the likely benefits of CAL. As seen in Chapter 1, the cognitive development theories of Piaget (1953) and Inhelder (1968) have been used to propose a model of learning deficit. These theories propose that cognitive growth is derived from action (Piaget, 1971). First, the child acts upon itself and objects, then is able to make mental representations of action and finally sequence mental representations and think in abstract terms. Many people with severe and profound learning disabilities have had impoverished experience of acting upon their environment. Thus, they may undergo developmental arrest through the lack of necessary interaction. It is suggested that the use of CAL, in providing opportunities to act directly upon the environment, may go some way to increasing the likelihood of the learning disabled person being able to derive knowledge through their actions. However, there is little direct evidence concerning the interaction between impairment of motor activity and cognitive development (Rostron and Sewell, 1984). Nor is there adequate knowledge to surmise if it is lack of motor activity itself or any neurological damage which precludes motor activity that also underlies the handicap. There is also a problem with this theory when trying to account for severely motor disabled persons who are cognitively very able.

Rostron and Sewell (1984) suggest that the views of Neisser (1976) can provide a more feasible outlook than classic Piagetian theory. Neisser argues that most objects and events in an environment are meaningful and that it is the acquisition of these meanings which determines cognitive development. The association between objects and events depends on the capacity of the individual for "information pick-up". Experience and interaction with the environment is necessary, but if this experience is not infused with meaning about the significance of the actions, then, ultimately, it does not lead in and of itself to the development of knowledge. Again, CAL can provide a degree of interaction with the environment to increase the potential for information pick-up and, importantly, can give significance to the interaction by providing feedback, thereby invoking the capacity for meaning to be assigned to the action.

Cognitive models are most clearly seen in applications such as LOGO (Papert, 1980). LOGO is a programming language designed to be very simple yet powerful. It is commonly used in conjunction with devices such as the TURTLE (Jessop Microelectronics Ltd.), which is a drawing instrument on wheels. The learner controls the actions of the TURTLE by communicating with the computer. The claims for this type of learning strategy is that it motivates self-directed behaviour and teaches the learner to learn through the action of the instructions on the environment, without necessarily involving motor responses on the part of the learner (Hope, 1982).

This type of approach relies heavily on computer controlled environments to make knowledge available to users. As such, it does not explicitly improve educational software of the type commonly used in education. Rotheray, Sewell and Morton (1986) put the case for interaction as a feature of instructional software design. Drawing on theories of linguistic development, they argue that a "conversational" approach to communicating with the computer may benefit children with severe learning (language) difficulties. That is to modify input and output to allow the use of the computer to occur as naturally as conversational turn-taking. This turn-taking is enhanced by the use of instructions given in intelligible synthesised speech. They also emphasise the need for feedback on errors. The user is informed of the nature of the error and the question is repeated. Spoken instructions, the use of pauses, screen displays and musical rewards are used to retain attention.

This procedure does rely somewhat on hardware to provide synthesised speech. However, it does incorporate the basic elements of acting on the environment, observing the consequences of those responses and being given feedback and/or rewards as a result of those actions.

2.2 The efficacy of CAL

2.2.1 Efficacy of CAL in mainstream education

As a supplement to traditional teaching, results concerning CAL have been favourable (Burns and Bozeman, 1981; Jamison, Suppes and Wells, 1974; Vinsonhaler and Bass, 1972). When used as a substitute for traditional teaching, findings have been mixed. Kulik, Bangert and Williams (1983) report greater effect sizes for substitution CAL than supplementary CAL. Edwards, Norton, Taylor, Weiss and Dusselsorp (1975) report equivocal findings for the two conditions. However, all reviewers report a reduction in lesson time when using CAL. In a general sense, then, CAL may be educationally worthwhile for children who are not learning-disabled. Let us now look at empirical work which attempts to answer this same question for people with learning disabilities.

2.2.2 Efficacy of CAL for adults with learning disabilities

Currently, there is a dearth of empirical evidence from experiments designed to address the efficacy of CAL for adults with learning disabilities. In reviewing CAL for people with learning disabilities, Conners, Cruse and Detterman (1986) and Lovett (1985) report that only a small amount of evaluative research has been carried out and very little of that has been with adults who have learning disabilities. Most work concerns the use of computers with learning-disabled children in remedial education or with people who have physical disabilities. A search of the literature located twenty-three evaluations - six of which specifically concern adults with learning disabilities. Many more have been conducted with children, and where appropriate, these findings will be included.

Perhaps the most common form of investigation is that involving observational studies where no attempt has been made to produce systematic results (e.g., Cassady, 1985; Rostron and Lovett, 1981; Watts, 1985). For example, Lally and Macleod (1983) describe a computer controlled technique of teaching telephone dialling skills to intellectually disabled adults, but no objective indication is given of its success. Such descriptions are helpful in that information is disseminated and applications of CAL detailed, but it is difficult to comment on the efficacy of CAL by relying on observation alone.

Another method has been to assess posttest gains against pretest measures. Significant gains in responding are reported by Scott (1984) and McDermot, Harsant and Williams (1986) using pretest- posttest comparisons to determine the effectiveness of two CAL programs. Scott (1984) describes results from fifteen adults with severe learning disabilities who were given CAL "designed to teach basic cognitive skills through reinforcement of a simple motor response". McDermot, Harsant and Williams (1986) used

CAL to teach visual discrimination to an adult with severe learning disabilities. Out of three other similar studies with children, all of them report improved attainments in spelling (Hasselbring, 1982), time-telling (Friedman and Hofmeister, 1984) and coin recognition (Farnell, 1984). These studies are favourable toward the use of CAL. However, the lack of control groups creates difficulties in definitely ascribing effects to the CAL intervention. The methodological difficulty of performing comparisons between groups is commonly encountered in learning disability research and will be discussed further later.

Some studies that have employed comparisons have found no differences between groups taught with CAL and groups receiving conventional methods of teaching. Individual tuition or CAL were used to teach sight word vocabularies to adults by Ryba and Webster (1983) and Baumgart and Van Walleghem (1987). In both studies, the CAL group did not perform significantly better than the teacher-taught group.

In contrast, three other studies with group comparisons of children present mixed results. Trifiletti, Frith and Armstrong (1984) found that CAL instruction improved the mathematics skills of the experimental group over the control group. But, in the other two studies, essentially equivalent gains by experimental and control groups were achieved in spelling and mathematics (McDermot and Watkins, 1983) and performance on a two-choice discrimination (Plienis and Romanczyk, 1985).

In another group comparison study, Lally (1981) used CAL instruction as a supplement to regular teaching rather than on its own. The control group received conventional instruction only. Significant differences were found in achievement of a sight word vocabulary, with the experimental group demonstrating increased word recognition. Taken together, the findings from these studies where CAL has been compared with conventional teaching suggest that, at least, CAL is just as good as individual tuition and can also be used effectively as an adjunct to classroom instruction.

In CAL research, the issue of comparison does not apply only to comparisons between participants, but also to comparisons between tasks (CAL and non-CAL tasks) and between different instructors (e.g., teacher versus CAL). There are multiple differences between each method of instruction. For example, the amount of teacher intervention, the style of instruction, the amount of time taken to teach via teacher and teach via a computer may all be different. Clearly, this is going to create problems in performing controlled comparison studies. However, comparison studies seem necessary logically and have been attempted with varying degrees of success. The results from such studies are of importance in the CAL evaluation literature. Such studies do not surmount the difficulties of making these comparisons, but point to one of the obstacles inherent in this type of research.

One example of a particular difficulty is the way in which tasks are transformed when they are transcribed between different methods of teaching. This is highlighted by Baumgart and Van Walleghem's (1983) study. During their instruction sessions, the learner either had to press a response key during CAL or to point to a card during teacher-taught individual tuition. In the CAL condition, the response keys were numbered to correspond with the words on screen. Thus, the subject had to be able to transfer spatial cues from the screen to the response key. It is unclear if there was spatial correspondence between the response keys and the screen array. During the individual tuition, it was only necessary to point directly to the card with the target word printed on it, thus probably making the task easier in this condition. This potential difference in response task characteristics is a problem in comparison studies.

Four studies compared different versions of CAL programs in an effort to determine the most appropriate format for instruction. Neither Ryba and Webster (1983) nor Torgeson (1984) found any difference when comparing two different instructional formats. Ryba and Webster (1983) employed two methods of CAL teaching of sight word vocabularies to adults: paired associate learning and errorless discrimination. No difference was found between the two methods. Torgeson (1984) compared two versions of drill-and-practise mathematics programs. One program used an arcade game format, while the other was a standard program that did not employ elaborate graphics. Each program was found to be equally effective in increasing the number of problems solved within a given period of time. Although the arcade format program was reported to be more enjoyable to use, both programs were labelled as "boring" by the children after being used for two weeks.

Two studies found improvements in achievement through using different CAL techniques to teach the same skill. Lally (1981) employed a computer controlled graphics tablet to assist with handwriting instruction. The graphics tablet would display incomplete outlines of letters or numbers and learners were required to trace around each figure correctly with a light pen. A cursor box was used to help cue correct tracking of the child's pen movements around the tablet. Three cursor box sizes were compared with respect to handwriting improvement - large, small and large reducing to small. The greatest improvements in handwriting samples were found to occur among those learners who used a reducing size cursor box. Thus, a better computer assisted technique for teaching handwriting was determined.

Similarly, Strand and Morris (1986) compared three different techniques to teach visual discriminations. One technique involved the graded use of physical prompting, but the other two used the computer to make different presentations of the visual discrimination tasks - graded stimulus fading and trial-and-error learning. Results showed that the graded stimulus fading was superior to the trial-and-error learning in terms of the number of learners reaching criterion, the number of trials to criterion and the number of errors. An additional advantage of the graded stimulus program was that it provided response feedback and automatically adjusted the level of difficulty as appropriate, so the program could be used without the need for constant supervision.

Some researchers have also looked at changes in collateral behaviours during CAL sessions. Ryba and Webster (1983) noted that self-directed behaviour occurred more often, aggressive behaviour diminished and changes in affect occurred while learners were partaking in CAL. However, Baumgart and Van Walleghem (1984) found that on-task behaviour increased during individual tuition while all participants demonstrated some off-task behaviour in the CAL condition. In contrast to this, Plienis and Romancyzk (1985) found that disruptive behaviour increased during individual tuition sessions. In fact, the two groups of people studied were very different. Baumgart and Van Walleghem were teaching adults with moderate learning disability, while Plienis and Romancyzk were teaching children with severe learning and behavioural difficulties. However, observations such as these suggest that the potential changes in behaviour while using CAL with people with learning disabilities reach far beyond enhancing traditional educational skills. Implications from evidence of this nature are likely to yield important contributions to the use of CAL in learning disability.

Only five of the above studies (Farnell, 1984; Plienis and Romanczyk, 1985; McDermot, Harsant and Williams, 19865; Ryba and Webster 1983; Scott, 1984) were aimed at teaching people with severe, rather than mild-to-moderate, learning disabilities. Any findings from one group cannot be generalised across the range of ability to another because of the high degree of variability in the range. But, as mentioned earlier, much more research has taken place with less disabled students and it would be imprudent not to take account of all findings while evaluation studies are still relatively few. It must be borne in mind that, because of the heterogeneity of the subject group, there is a difficulty in looking for consistent results that might lead to more general conclusions regarding the effectiveness of CAL. This problem applies to all of the studies described here and is one that is widely acknowledged in any investigations in the field of learning disability. There is a need to make specific assessments of participant characteristics and to delineate much more precisely with whom any particular approach is to be used (Aitken, 1988).

2.2.3 Efficacy of CAL for people with profound learning disabilities

2.2.3.1 Microtechnology as a "perceptual tool" for multiply disabled people

Some evaluative research concerning the efficacy of microtechnology has been carried out not so much to determine the effectiveness of computer-assisted education, but to use it and other forms of microelectronics as a "perceptual tool" (Brinker, 1984), i.e., to enhance the observation and perception of learning, from the observer's point of view, in situations where it is usually difficult to perceive. For example, to use microtechnology to enhance the observation of learning by a person who has profound, multiple learning disabilities. Examples of how CAL has been used in this way are illustrated below.

Brinker (1984) describes this function of microtechnology as being derived from the capacity of the microcomputer to store information about performance on an ever-expanding and easily retrievable database. Evidence gathered across time can enable hypotheses regarding each student's learning disabilities to be formulated. From this evidence, interventions can be suggested, and these hypotheses can then be frequently re-evaluated and new interventions can be designed. Thus, the learning processes of profoundly multiply disabled people can be better perceived and focussed upon.

Research is particularly needed to help create an appropriate learning environment to maximise the potential for change for this group of people. Studies such as some of those described below show how the computer may be used as a perceptual tool and are at the extreme end of the CAL continuum in that they do not conform to typical modes of CAL. However, they show important aspects of CAL in education (such as the potential to store large amounts of accurate information concerning each person, which can then be used to continually modify the learning strategy). While this is ostensibly true of all CAL programs this facility is not always used. It is invaluable when faced with detecting the subtle changes in behaviour which may signify learning by people with profound multiple disabilities. The information being gleaned from studies such as these about the learning processes of people with severe learning disabilities must not be ignored if worthwhile contributions are to be made to their education and care.

Several studies have demonstrated some learning while using microtechnology for profoundly multiply disabled people. Bourland, Jablonski, Allen and White (1983) describe switches designed for encouraging the attainment of target behaviours such as reaching, grasping, manipulating. Various devices were used such as lightweight pull strings and joysticks. The eventual goals of any manipulation of these switches were to improve sensorimotor operations, encourage exploratory behaviours and possibly develop some rudimentary forms of play. Operation of any of these switches resulted in the delivery of such reinforcers as bursts of music and activation of a toy spacegun or an air blower. After an initial baseline period of no-consequence responding, response consequent reinforcers were introduced for five adults with profound multiple handicaps. One case of contingent responding, one of no responding and three cases of varied responding are reported after the CAL intervention.

Brinker and Lewis (1982) describe the results from four profoundly disabled children between the ages of three months and four years. The child was seated in an adjustable infant seat. Switches were attached to ribbons which were tied to their wrists so that movement of the arm closed a microswitch and sent a signal to the computer. A carpeted panel at the infants feet enabled any kicking to also send a signal to the computer. The computer was programmed to turn on a tape recording (e.g., with music, the mother's voice) or a variety of other mechanical devices when movement occurred. Clear differentiation of reinforced from non-reinforced responding is reported.

Lovett (1985, 1988) reports similar results from two studies with nonambulatory, profoundly mentally retarded (NPMR) children. An ultrasonic switch was used which activated nursery rhyme music when the sound beam was broken by movement through it. The response rate during contingent reinforcement periods showed an overall increase over that of baseline periods. The second study involved breaking an ultrasonic beam to activate a small, battery operated car in which the children could ride. This movement was the putative reinforcer. The results showed that the children's response rate increased substantially during periods of contingent reinforcement as opposed to periods of non-contingent or no reinforcement. In addition, nursery rhyme music was used to indicate either the presence or absence of contingent reinforcement, thus acting as a discriminative stimulus. Lovett reports that clear supportive evidence was found to suggest that these children could learn to discriminate the different conditions.

Lancioni and Oliva (1988) and Wacker, Wiggins, Fowler and Berg (1988) developed and used computer-aided programmes with the aim of promoting independent activities for multiply handicapped learners. Using microswitches, students were able to select either spoken or pictorial representations of household or leisure activities. Once chosen, the students were able to participate in the activity. Results from these studies suggest that the students were able to discriminate preferred activities and to make requests for them by using microtechnology.

Similarly, Dattilo (1986), Datillo and Mirenda (1987) and Wacker, Berg, Wiggins, Muldoon and Cavanaugh (1985) used microtechnology in order to demonstrate individual preferences for discrete reinforcing events among people with severe and profound learning difficulties. The activation of microswitches by headturning, arm-raising or direct switch manipulation resulted in visual, auditory or tactile events. The number of activations for each event were systematically recorded and plotted by the computer and these results were used to construct hierarchies of reinforcer preferences.

The above studies employed microtechnology to enable access to non-computerised activities or reinforcers and to collect data concerning the responses made by the learners. However, commercially available CAL programs are usually of a type where both the responses <u>and</u> the consequences are limited to those that can be produced using the designated hardware of the computer system. External events, such as tactile stimulation or the delivery of edibles, are not generally available. A study which assessed the ability of CAL consequences alone to establish independent microcomputer use was performed by Dura, Mulick, Hammer and Myers (1990). The aim of this study was to establish independent responding, thereby increasing the potential opportunities for participation in other activities. Four students with profound, multiple disabilities were placed into a room which contained a joystick and a computer screen. The room was darkened to increase the saliency of the screen. Initially, students received prompting to activate the joystick. This activation would result in the screen illuminating in randomly determined colours and the computer would generate a tone. After the prompting phase, a spontaneous response phase followed, in which students received no prompting. Finally, an extinction phase ended the study. Results from this study showed that two out of the four learners who took part responded to the computer software and the training paradigm.

Much importance has been placed on active participation and independent responding in order for learning to take place, especially for those with limited physical capabilities. The increasing use of "enabling" microelectronic devices with people who are multiply disabled raises the importance of computer assisted interventions for increasing opportunities for active learning. The studies described above use microtechnology to demonstrate gains for a group of people for whom it has been notoriously difficult to provide opportunities for improvement - from the mastery of the most simple of tasks to having the opportunity to operate a self-driven car.

2.3 Empirical findings: conclusion

The studies outlined above demonstrate a wide range of CAL applications in learning disability. Taking the research literature as a whole, it is impossible to draw any general conclusions regarding the efficacy of CAL. There just has not been enough systematic research. What studies have been done present a diverse picture of the use of CAL with people with learning disabilities and it is difficult to integrate findings from studies which vary so widely from one another. Participant characteristics, the research aims and methodology and the specific application of CAL are different in almost each and every study. While this demonstrates that CAL may be widely applied, this flexibility itself means that no conclusive statements may be made regarding general principles of CAL implementation or effectiveness.

There is still little evidence for the effectiveness of the supposed attributes of CAL. The factors described earlier as being of theoretical importance, e.g., individualisation, motivation, active learning, feedback and reinforcement, have not received research attention. Most studies used CAL programs which did not have any great capability for individualisation. One study (Torgeson, 1984) directly addressed using "motivational" components in the software. All studies used the concepts of feedback and reinforcement, but seldom questioned their role in the learning process. Few attempts have been made, except at a most general level, to relate these attributes to the body of knowledge already possessed about learning and related difficulties. Ideally, CAL program parameters would be examined in the same way as other investigations into the factors involved in the role of guiding the learning behaviour of people with learning disabilities.

With regard to more practical concerns, it is disappointing that many of these studies make no reference to the day-to-day difficulties that must have been encountered while setting up CAL interventions and carrying out research in applied settings with people who have learning disabilities. In any evaluation of a teaching method, the application in its "true" setting of a school, hospital, Social Education Centre should also be considered. For example, how does a person with severe learning disabilities learn to use a computer? Some shaping of responses must be involved, particularly with people who have multiple handicaps. How much help should they receive during CAL sessions? CAL tasks may include having to perform a response on a keyboard that could be quite complex for learners with severe learning disabilities. What if they just sit there doing nothing? What if they walk away? What should the instructor do? On an organisational level, little guidance is given on how to structure CAL teaching. How long should a session be? How many sessions a week should be given and for how many weeks?

This type of question immediately springs to mind when reading the research literature. Valuable information and, perhaps, a greater sense of confidence could be shared between the instructors, psychologists, occupational therapists, nurses, teachers and others who are trying to implement day-to-day use of CAL in their establishments.

2.4 Computer-based learning and learning disability: Conclusion

So far, a varied picture of the use of CAL with people who have learning disabilities has been given. At first sight, the view is optimistic. The use of CAL is increasing and has extended beyond the classroom into the lives of adults with learning disabilities in day care centres, adult training centres and hospitals. There are articles, reports, newsletters, bulletins, workshops and courses coming from sources such as education, psychology and occupational therapy with the aim of providing practical advice for using the computer in adult special education. There must, however, be a note of caution. The rush into the new technology has found essential concerns still wanting. Most noticeable are the scarcity of crucial information regarding learning processes and the resultant transcribing of questionable educational strategies onto CAL programs for adults with severe learning disabilities. Concerning CAL, Sage and Smith (1984) noted that, "a substantial edifice has been erected in a commendably short time, but its foundations are shallow and in desperate need of underpinning".

The value of microtechnology and its applications with people who have learning disabilities thus remains open to question. Much of its use has been with children at school who, together with their teachers, view the computer as an enjoyable, easily accessible classroom activity which enhances the curriculum. Used as such, it has an inherent value. But, there is a lack of understanding of what is being achieved in terms of the behaviours and advances being gained by its use. While, from the beginning, there have been calls for basing the development of microtechnology in special education on a sound research basis, this has not occurred in any major way. This lack of knowledge must be viewed against a background of the rapid expansion of commercially available educational software, switches and other peripherals that enable communication between the user and the machine. The provision of a considerable amount of funding to facilitate the acquisition of this equipment should be noted here, too. There has developed a discordant situation where there is an implicit assumption that educational technology is effective in its aims - otherwise this wealth of equipment and funding would not exist - coupled with little explicit evidence that this is indeed the case. The great enthusiasm for CAL must be balanced with and accompanied by evidence for its supposed attributes.

Attempts to gather this evidence and to tie any conclusions to a theoretical underpinning are seen rooted in existing concepts of learning in learning disability. Yet, the answer to the question of "Does CAL work?" is, unfortunately, "We don't know." There is an urgent need to determine whether CAL programs improve or change the learner's performance on targeted tasks. Progress is dependent on the answers to the numerous questions which need to be answered. The following chapters describe research work which was aimed at fulfilling this need for greater examination of the use and efficacy of CAL for adults with severe learning disabilities.

CHAPTER 3

3. THE USE OF COMPUTER ASSISTED LEARNING: AN EVALUATION BY SURVEY OF SOFTWARE FOR ADULTS WITH LEARNING DISABILITIES

3.1 INTRODUCTION

In Chapter One, the theoretical background to learning and learning disability was reviewed. This was followed in Chapter Two by a review of the empirical evidence regarding the efficacy of CAL in learning disability. The purpose of this next chapter is to bring the emphasis on to current uses of commercial CAL packages and to some evaluation of them in the more applicable sense, rather than through empirical investigations of efficacy. The reasons for this are as follows. First, it is important to gain some idea of how CAL is being encouraged in day-to-day practise and to know what type of commercial packages are available and how these packages stand up to overall evaluations of quality. Second, it will provide a background concerning usual practices of CAL to the forthcoming empirical evaluations in the following chapters. Third, it seeks to outline different methods of evaluation that are not experimental, but which are commonly used when assessing educational materials. That is, evaluation that occurs through inspecting materials and making some judgement of them against some agreed list of criteria which are considered to constitute good educational practice.

This chapter attempts to bring together some of the more practical aspects of CAL implementation with educational and psychological concepts of "good practice". It begins with a description of software evaluation and the development of appropriate evaluation criteria and evaluation forms based on ideals of educational practise. It goes on to highlight the lack of evaluation criteria developed specifically for software in special education for adults. It then reports an evaluation study which comprised: 1. Developing a software evaluation form for special educational software, and, 2. Using this form in a survey of the use of CAL with adults who have severe learning disabilities.

3.1.1 Information technology in education: An introduction

The use of computers in education within the UK has been continually developing over the past ten years or so. Progress has been sporadic with much of it relying on localised pockets of expertise and enthusiasm. There have been attempts to coordinate developments, the largest of which was the setting up of the Microelectronic Education program (MEP) in the early 1980s. This was a centrally-funded program to introduce and develop the use of microelectronics in education in the U.K., part of which was to be devoted to special education.

In 1982, further initiatives resulted in the setting up of four regional support and information centres for pupils with special needs in schools. These SEMERCs (Special Education Microelectronic Resource Centres) were funded centrally through MEP and were based in Newcastle upon Tyne, Manchester, Bristol and the London Borough of Redbridge. Their main functions were 1) to raise awareness of the potential of IT for special needs; 2) to provide a regional information service and 3) to liaise with Local Education Authorities (LEAs) concerning in-service training. The SEMERCs were originally to be funded for a period of two years but received two further extensions of funding until 1989 when LEAs took on the responsibility. At the same time the MEP became the MESU (Microelectronics Education Support Unit) and then the NCET (National Council for Educational Technology), which it remains to this day, funded by the

Department of Education and Science.

Currently, the responsibility for supporting special needs developments rests with a national team for 'IT and special needs' within NCET and with the three regional SEMERCs. More informally, two other centres have also gained and retained recognition as centres of excellence within the field (Information Technology/Special Educational Needs Focus, Newcastle Polytechnic and Special Educational Needs Support Unit Resource, Doncaster).

The latest government review regarding the development of the use of IT with pupils with special needs was undertaken by Her Majesty's Inspectorate and published in 1990 ("Information technology and special educational needs in schools" - H.M.S.O.). This is based upon observations and opinions gained from 200 schools throughout England during a six-year monitoring period (the exact dates are not specified). The primary key finding of this review asserts that:

"IT is making a unique and valuable contribution to the learning of pupils with special educational needs, enriching their learning experiences and enhancing their access to a broad curriculum."(p.vi)

And, for pupils with profound and multiple learning disabilities,

"IT can play a crucial role in encouraging responses which are precursors to communication and independent action." (p.2)

As we have seen in earlier chapters, such wholly positive claims cannot be said to be supported by the existing empirical evidence. It seems that one of the difficulties with statements such as those above is the tendency for "Information technology" to be viewed as an entity in itself. Somehow there is an idea that IT exists in and of itself and that it is an applicable unit of technology that can be joined together with special education to bring about "technologised special education". In practice, the concept of information technology in education represents a diverse set of ideas and many different applications of hardware and software capabilities.

There are now a myriad of examples of hardware developments opening up opportunities for learners with special needs, especially for people who are physically disabled. But still the central problem remains - what exactly is it that is being accessed by the hardware? The most obvious answer to this question is that it is the educational software that is being accessed here. However, not all software attempts to be educational in itself and may merely be controlling a hardware device and giving access to, say, for example, a speech synthesiser for a person who has little ability to produce their own speech.

What, therefore, can be said of software that purports to be educational? The research evidence outlined in Chapter Two suggests that much of this educational software has resulted in limited or equivocal gains in various skills. It is time to question what constitutes effective educational software and to take a thorough look at the software that is being used in special education.

3.1.2 The evaluation of software

From the first introduction of CAL into education, there have been repeated calls to base educational software on sound principles of teaching and learning and to evaluate software within that same framework. Here we will discuss software evaluation that has largely been developed for mainstream education and then proceed to look at issues which are especially relevant to special education.

Attempts to evaluate educational software can be seen to fall into two camps. First, there is the empirical investigation of whether or not educational software, that takes the promotion of learning as its fundamental premise, is indeed able to influence the process of learning. At present, these studies might address such questions as: Does the learner acquire the skill with CAL, but fail to acquire it without CAL? Does the learner's performance when using CAL differ from their performance while using other mediums of instruction? We have seen how research questions such as these have been addressed in empirical investigations (see Chapter 2).

However, adherence to "evaluation" in this experimental sense is not always desirable. Far more frequently, what is required is an evaluation method by which potential users of software can make some sort of assessment of the suitability of a piece of software prior to purchasing it. That is, for "evaluation" to be a device by which to ascertain the likely usefulness of a particular piece of software in an applied setting rather than for it to be an experimental study of the efficacy of CAL.

The solution to this need has been tackled in a variety of ways. For example, many journals in the field of educational computing publish software reviews, similar to book reviews. The purpose of these is to give an opinion on any particular piece of software. A review may answer questions such as: What is the aim of this program? What group of learners is it suitable for? What does it propose to teach and how does it achieve this? Is it 'user-friendly'? Does it run without any hitches or problems? Is there record-keeping facility (such as printing out scores obtained or graphs of progress, etc.)? So, by reading a brief descriptive summary and analysis of the program, a potential user may gain an idea of the likely usefulness and quality of the software.

Another method of evaluation is to employ any one of a number of criterion-referenced checklists and questionnaires. The purpose of these checklists is to aid the evaluator in their evaluation by providing a systematic framework within which to observe the strengths, weaknesses and characteristics of the program. These forms have been almost exclusively published in the USA over the past 10 years and are to be found in a variety of sources. For example, in textbooks that focus on educational computing. Also, professional organizations and departments have produced their own software evaluation forms and guides (e.g., New York State Department Center for Learning Technologies). The development and publication of these type of forms has not occurred to this extent here in the United Kingdom and evaluation forms from the USA may not be as useful in the British context. In the USA, CAL has been and continues to be used much more extensively and educators may be faced with hundreds of different programs, especially those of the drill-and-practise type, targeting a similar area of skill. In the UK, although there has been rapid expansion, there are still much fewer programs and drill-and-practise is used far less frequently in comparison (Preece and Jones, 1985).

A third type of evaluation method in the literature comprises more 'academic' review articles containing expert opinions, likely to be based on theory, regarding what constitutes 'good' software. The range of concepts espoused within these is varied - embracing learning theory (e.g., Criswell and Swezey, 1984), cognitive-developmental theory (e.g., Jay, 1983; Scaife, 1989) and teaching theory (e.g., Shuell and Shueckler, 1989). These articles may aid evaluation by imparting information and guidelines on what any particular piece of software 'ought to' contain.

Although many of these articles and evaluation forms have set out to unravel the confusion of evaluation, instead they may have unwittingly contributed to the perplexedness of the evaluator. One of the difficulties now facing a potential user/purchaser has been knowing which type of evaluation method to rely upon. Each method demands that a plethora of questions and issues be addressed. Roblyer (1981) states that "Developing standards and evaluation procedures has been a difficult problem in that there has been a wide range of opinions over what the 'ideal courseware product' should be." Often, each separate publication lists page after page of very similar evaluation criteria. The question arises of just how informative are each of these evaluations? One way to answer this would be to review each evaluation form or review and to look for similarities and differences between them.

A recent attempt at this came in the form of comprehensive comparison of evaluation forms and reviews conducted by Schueckler and Shuell (1989). Their method was to collect together a number of evaluation forms and reviews of instructional software for the Apple computer (which is widely used in education in the USA) and to identify the evaluation criteria employed in each case. Where a review was the evaluation instrument, the evaluation criteria was inferred from the narrative. A comparison of inclusive evaluation criteria was performed by cross-tabulation and criteria common to each method were summarised. This summary of Schueckler and Shuell's evaluation criteria is illustrated in Table 1 below.

Fundamental Program Characteristics

Basic Information

- Programme name - Title of programme and/or package containing several individual programmes
- Subject area - All subject-matter areas for which the application is relevant
- Publisher - Company which distributes and issues the software
- Cost - Price attached to the software programme

Technical Aspects

- Hardware - Specification of computer make, model, memory capacity and number of disk drives necessary to run the programme
- Additional hardware - Additional hardware needed to run the software such as colour monitor, voice input, mouse, joystick

Type of Programme

- E.g., authoring system, drill and practise, educational game, problem solving, simulation, tutorial, word processor, utility or a combination of these

Operational Concerns

- Includes bug-free, "user-friendly", ease in correcting errors, help menus, screen display, sound/graphics enhancements

Directions for use

- On the screen and/or in the documentation

Execution Time

- Estimated total number of minutes required to load, use the programme and save completed work

Instructional Concerns

Social Interaction

- Competition/cooperation - Attitudes/values elicited
- Instructional groups - Size of group for which programme is designed

User Orientation

- Teacher - Opportunity for teacher to alter level of difficulty, content, speed of presentation; teacher supervision/intervention is needed
- Student - Opportunities to change level of difficulty, etc.; freedom from the need for external supervision/intervention

Prerequisite Skills Stated

- Prior knowledge required to use the programme and reach the stated objectives

Table 1. Criteria Used by the Forms and the Reviews to Evaluate Software (Schueckler and Shuell 1989)

Educational Objectives Stated

- Well-defined objectives stated

Educational Objectives Achieved

- Evidence that students attain stated objectives

Educational Content

- Content is accurate and has educational value

Teaching/Instructional Style

- Type of student involvement; guided learning, explanatory approach, etc.

Material Presentation (Small Steps)

- Material presented in small units, interspersed with questions to determine the students understanding

Appropriate Use of Computer

- Assets of computer are utilised

Principles of Teaching and Learning

Motivation

- Program is stimulating and challenging; offers variety and interaction

Feedback

- Effective and appropriate response to input from student

Record/score Keeping

- Immediate information on accuracy of response and/or summary total provided

Cognitive Level Determined

- Content based on one or several cognitive levels, such as knowledge, application, evaluation, etc.

Evaluative Teaching Methods Used

- Assessment of students' work via a management system, a comparison of users' scores, a diagnostic test, a formal test at the end of of the lesson, etc.

Table 1. (cont'd) Criteria Used by the Forms and the Reviews to Evaluate Software (Schueckler and Shuell 1989)

This gathering together of common evaluation criteria in Table 1 does indeed appear to summarise well the evaluation literature to date. It can be seen the evaluation criteria fall into four domains. However, it must be remembered that the above represents a summary of 19 different forms and reviews and that there are individual differences between the forms in the extent to which they cover each of these domains. Schueckler and Shuell (1989) point out that many of the evaluation forms are inadequate in that they fail to include what would seem to be essential criteria for evaluation. Most astonishingly, the two domains which were found to be least well covered by the forms are those that are concerned with "Instructional concerns" and "Principles of teaching and learning".

It is difficult to know why this might be the case. Certainly, one of the influences must be the fact that many existing educational programs were not conceived of and designed by educators, but by computer programmers. Also, they have been marketed in a fashion concordant with the "high-tech" business world which is designed to have maximum impact on sales. It is easy to see how first evaluative glances at the software turn into a process of seduction by the glossy marketing and sophisticated software of high technical quality, especially for those in the often "low-tech" world of education. Consequently, evaluation packages have also been led to focus on the immediate characteristics of the software (i.e., packaging, documentation and what you see on the screen) rather than becoming concerned with a true reflection of the educational content in the software. This is not to say that the educational content is ignored entirely by the evaluation forms, but an assessment of the learning principles incorporated by the software is often lacking. Two notable exceptions which do attempt a thorough assessment of the learning principles guiding the software are evaluations proposed by Criswell and Swezey (1984) and Shuell and Schueckler (1989).

Criswell and Swezey (1984) constructed a software evaluation checklist containing items derived from the principles of behavioural learning theory. The goal of the checklist was to determine if the software incorporated behavioural learning principles. Items on the checklist covered a range of such principles and checked whether or not the software included the following:

- A basic learning paradigm of presenting material to which the student could make an active response and receive a contingent consequence;
- Reinforcement and punishment in the form of messages, tones or pauses;
- Shaping - by changing difficulty across the lesson or the criteria for reinforcement;
- Chaining - by increasing the number of steps performed before reinforcement was delivered;
- Prompting and fading - by giving extra help if needed then fading this out gradually;
- Stimulus control, stimulus generalisation and response generalisation - referring to the processes by which the student learns to discriminate when to perform a particular response, then to generalise this response to other circumstances and to making similar responses when appropriate.

Criswell and Swezey (1984) intend that the checklist could be used to point to instructional sequences which might be improved and suggest generally how to improve them. However, if a piece of software is purchased when the programming is already complete, this objective of improving the instructional sequences of the software is unlikely to be realised unless the checklist is used during early stages of programming or unless the program can be edited after purchase.

In contrast to this exclusively behavioural outlook, Shuell and Schueckler (1989) chose to investigate the extent to which software incorporates principles of learning and teaching which derive from "a perspective that combines cognitive conceptions of human learning and research on teaching". A nineteen-item evaluation form based on these principles was developed. Seven areas of interest were covered: objectives, prerequisite knowledge, presentation of material, practice, motivation and graphics, and, record keeping. These areas were represented by items such as: "The instructional portion of the program is consistent with stated objectives" and "A check is made to determine if the student understands the material being learned." Each item was judged by noting its presence or absence and was also scored on a six-point scale from "Low" to "High". Presumably this refers to how well the evaluator felt the item was incorporated in the software, though this is not made explicit. This form was then used to evaluate sixteen programs chosen at random from a software library. It was ensured that the programs selected a representative sample.

In general, Shuell and Schueckler's (1989) results indicate that existing instructional software utilises various principles of effective teaching and learning to varying degrees. Most of the programs were rated high with regard to 1) presenting the to-be-learned material in appropriate steps or blocks; 2) the instructional part of the program being consistent with the stated objectives; 3) providing appropriate examples and 4) providing opportunities for independent practise.

On the other hand, programs received low ratings with regard to: 1) informing the students of the instructional goals/objectives of the program within an easily understood framework; 2) determining if students have the necessary prerequisite knowledge for learning the new material presented by the software; 3) reviewing that prerequisite knowledge, and, 4) reteaching any information that the learner is lacking.

Generally speaking, the facilities and abilities of a computer to rapidly and easily check previous knowledge, to monitor performance on the new material, to provide practice on difficult areas and to re-assess the learner's performance were not capitalised upon.

Another area which received low ratings was with regard to maintaining motivation and attention, especially the utilisation of visual imagery and graphics. This is an interesting finding given that this is a feature often mentioned as being unique and different to teacher-only instruction and one for which computers have much potential. However, present programs may be severely limited by the lack of graphic capabilities in most school hardware.

Shuell and Schueckler (1989) conclude that more attention needs to be paid to incorporating known principles of learning and teaching into software. They make the point that, at present, much software is lacking in this respect, though attempts have been made and continue to be made to improve software. They also surmise that some of the software which was rated poorly in their evaluation could be implemented still in schools if teachers were prepared to make up for its limitations. For example, by informing students of the software's objectives and purpose, a teacher could overcome the lack of this function in the software. If further developments of software are to be most useful, it seems that a distinction must be drawn between software that is expected to be educationally effective is in own right (i.e., to be an independent vehicle for instruction) and software that is to be adjunctive to teacher-based instruction. In either case, the software should operate within the well-researched framework of effective learning principles.

3.1.3 Software evaluation in special education

Turning now to the development and use of evaluation instruments in special education, we can see a similar set of issues as those outlined above.

First, here too the evaluation literature is small though interest in the area is widely expressed. Two articles, Hannaford and Taber (1982) and Bennett (1985), pertain directly to the evaluation of software for handicapped users. However, other articles concerned with the development of software for handicapped users also discuss criteria relevant to software evaluation (For example, Weisgerber and Rubin, 1985). Both Hannaford and Taber (1982) and Bennett (1985) propose similar evaluation criteria to those of Shuell and Schueckler (1989) outlined in Table 1. However, there are important differences which arise out of the need to consider the special characteristics of people with learning disabilities. In Chapter 2, the needs and characteristics of handicapped learners were seen to pertain to the suitability of CAL as an instructional medium in special education. If consideration of these is now applied to evaluative approaches to software for handicapped learners, it becomes clear that some additional evaluative criteria are required.

One of these is that, in special education, the wide ranging individual differences of learner needs and characteristics require that consideration of individual need is paramount. For example, we may consider differences in learners' developmental levels and physical abilities. So, it is particularly important for evaluative approaches to consider issues pertaining to the software's flexibility and capacity for individualisation. Such additional evaluative criteria could include the following.

Concerns about the software's technical adequacy may include consideration of an individual's sensory/psychomotor needs. It is necessary to ask questions about whether the learner has perceptual problems or physical limitations and whether these may influence the extent to which software will be able to be used. For example, what physical responses does the learner have to make in order to use the software? Can additional switches be used in conjunction with the software to enable the learner to use it? Can the task be altered to allow for sensory handicaps (e.g., increase in volume, increase in character size)? Will striking the wrong key accidentally, perhaps by the poorly co-ordinated keyboard user, cause the program to halt abruptly?

Instructional concerns may include questions such as: What developmental range is the program suitable for? What objectives are targetted by the program? What specific prerequisite skills are necessary (reading, writing, number skills, speech, motor coordination, etc.)? Is the software able to be used by learners who are unable to recognise letters or numbers? Is the learner branched to a level to suit their abilities? Can the pace of the program be altered or controlled? Can the length of sessions be altered to fit in with individual attention spans? Is a choice of instructional style available (drill and practise, modelling, etc.)?

The ability of the software to motivate the learner and to provide reinforcement and feedback is deemed important by all schools of learning. So, related questions of interest might be: How does the software attract and hold attention? Is there a choice of graphics available? Is feedback given after an inappropriate response? Is a reward or feedback given for appropriate responding? Is there a choice of rewards?

A paramount concern is that the content of the software is accurate, complete and organizationally sound. An infamous example of software that did not meet these criteria was that of the SEMERC's Blue File "Beans on Toast" program designed to help teach the cooking sequence for beans on toast. In the content of the program, the toast could be left in the toaster indefinitely and never burn! It is important not to overlook what may seem such minor details, especially when aiming to consolidate practical skills of this nature.

Also, questions of a more pragmatic nature are warranted which look at the compatibility of the software with the educational setting. For example, it is helpful to have an idea of whether the program can be used in a noisy, busy room by an individual. Or, can the program be utilised by groups? Does the running of the program require much supervision? Can a learner be left alone, and for how long, before the program needs to be reset?

The inclusion of evaluative criteria based on the questions postulated above, in addition to those outlined for the evaluation of mainstream software, yields the potential for developing an evaluation instrument aimed specifically at software for people with special educational needs. The remainder of this chapter presents the development of such a software evaluation form and gives the results of its implementation in a regional survey of establishments using CAL with adults who have severe learning disabilities.

3.2 DEVELOPMENT OF AN EVALUATION FORM

3.2.1 Method

A 63-item evaluation form, based on the principles of 1) software evaluation and 2) learning and teaching ideals in special education, was developed. This was done by taking relevant evaluation questions from the evaluation literature and combining these with additional new criteria arising from consideration of issues relevant to the implementation of CAL in adult special education. The initial draft of this instrument was distributed among clinical psychologists with expertise in learning difficulty and other researchers in the area of special education and CAL. Based on feedback from these individuals, a final evaluation form, which was intended to evaluate any individual software program, was revised and finalised.

This form was subsequently revised to a 40-item survey instrument (see Appendix 1). This covered the areas of Hardware, Objectives, Use of the Program, Suitability for Students, Presentation and Motivation, Principles of Learning and Teaching and Amendment to Suit Individual Need. Examples of evaluation items from these areas include:
"Have you made any modifications to the standard equipment in order to use the program?",
"Is the explanation of the purpose of the program clearly stated?"
"How long must a student concentrate on the program to gain a result?",
"Does the program require reading skills?",
"Is there a choice of rewards?",
"Does the program use reward training?",
"Is the feedback for an inappropriate/incorrect response rewarding?",
"What is your assessment of the manufacturer's claims?", etc.

This evaluation survey was circulated to all day-care establishments for adults with special educational needs in the geographical area covered by the South Western Regional Health Authority. The intention of this survey was to identify common practices in the use of CAL with adults with severe learning disabilities. It would also serve as a means by which to evaluate a sample of programs that are used by this particular group of learners.

3.2.2 Procedure

Thirty-seven day-care establishments for adults with special educational needs were identified and questionnaires sent out to the managers of these units with a covering letter. The survey took place between March to May 1988. Survey respondents were asked to return the questionnaires by Freepost within one month. A reminder to return them was sent out after 6 weeks.

3.3 RESULTS

The questionnaire responses were compiled and inspected. Frequency counts of response alternatives or qualitative analyses of open-ended questions were made where appropriate. A summary of the responses to the main evaluation criteria is shown in Table 2 below.

3.3.1 Description of the survey sample

Response rate: Of the 37 questionnaires, 19 were completed and returned. Therefore, 51 per cent of the sample responded.

Use of computers: Of these nineteen, eleven establishments (57%) used computers for educational purposes with adults with severe learning disabilities.

Four establishments (21%) had purchased computers, but did not use them with their day-care attenders. One of these currently used a computer for administrative purposes only, but were considering it's use with attenders. Three centres were in the process of obtaining suitable software before operating their computer with attenders.

Evaluation Criteria	Name of Software Program											
	Coins	Front Page Extra	Safety	Special Care	Podd	Pre-reading	AMX Pagemaker	BIMH Compact Series 1-4	Bristol SEMERC	Other SEMERC's	Moving In	% Yes
Objectives Clearly Stated/Self Evident	•	•	•	•	•	•	•	•	•	•	•	100%
Skills Improved a)motor/physical b)attention c)scholastic d)language e)social/self help	b c d e	a b c e	a b c d e	a b e	a b c d	a b c d e	b d e	a b c d e	b c e	a b d e	b c d	a) 63% b)100% c)73% d)73% e)82%
a)Drill and Practise b)Reward training c)Modelling d)Game playing e)Exploration	a b	a c d e	a d	a b d	b e	a b d e	a	a b d e	b e	a b e	b c d	a)73% b)73% c)18% d)54% e)54%
Instructions clear	•	•	•	•	•			•	•		•	73%
Instructor intervention needed		•	•	•	•	•	•	•	•	•	•	91%
Can be used in noisy busy room	•		•		•	•		•	•	•		64%
Easy to make wrong response by accident	•	•	•	•		•	•		•	•		73%
Survives inappropriate responses	•		•	•	•	•	•	•				64%
Required skills: a)Reading b)Writing c)Language comprehension d)Speech production e)Motor	a c	a c d	a	e	a b	a c d	a b d	a d	a c	a c d	a d e	a)91% b)18% c)45% d)54% e)18%
Attention span in minutes a)<1 b)1-2 c)2+ d)very variable	b	d	c	d	c	d	d	d	d	d	c	a) 0% b) 9% c)27% d)64%
Age appropriate	•	•	•	•	•	•	•	•			•	82%
Attractive layout	•	•	•		•	•		•	•	•	•	82%
Entertaining and stimulating	•	•	•	•	•	•	•	•	•	•	•	100%
Sustains initial interest	•	•	•	•	•	•	•	•	•	•	•	100%
Correct / incorrect feedback clearly differentiated		•	•	•	•	•		•	•		•	73%

" • " - Criteria pertains

<u>Table 2 . Results of Software Survey</u>

Evaluation Criteria	Coins	Front Page Extra	Safety	Special Care	Podd	Pre-reading	AMX Pagemaker	BIMH Compact Series 1-4	Bristol SEMERC	Other SEMERC's	Moving In	%Yes
	Name of Software Program											
Corrects wrong response	•	•	•			•	•	•	•	•		73%
Choice of graphics		•						•	•	•	•	45%
Choice of rewards		•		•		•			•	•		45%
Suggestions for changing to suit individual need		•										27%
Pace can be altered or controlled		•		•		•	•	•	•		•	64%
Session length can be altered	•							•			•	73%
Keeps record of performance		•	•	•		•	•	•	•	•	•	82%
Judged to be educationally sound	•	•	•	•	•	•	•	•	•	•	•	100%
Creates organisational difficulties		•	•						•	•		36%
Does something conventional methods do not	•	•	•	•	•	•	•	•	•	•	•	100%
Range of learning disability a)mild b)moderate c)severe	all	a to b	a	c	b	all	a	all	all	all	a to b	a)36% b)27% c) 9% All:45%
Can be used with sensory / motor disability	•	•		•				•		•	•	54%
Comments	More realistic graphics	Staff training needed	Good eyesight required.	Volume too loud	Supply answers for teacher	More staff training	Needs to be more simple	GIves control to students	"Childish."	Improve sound.	More special effects	

" • " - Criteria pertains

Table 2 (cont'd). Results of Software Survey

One centre replied that their computer was purchased and that they intended to use it with attenders, but that it was not working.

The remaining three centres did not have a computer, though one centre was waiting to take delivery of one.

Hardware: All centres who replied (100%) used Acorn BBC computers. One also had access to an Amstrad PC.

Time spent on computer-based activities: The mean time spent on computer-based activities within the centres was 15.95 hours per week (range 2-40 hours). Individual session lengths varied between 2 and 120 minutes, with the average session length being 46.27 minutes per session and the modal session length being approximately 30 minutes.

The most frequently used programs: There were twenty-four different programs reported to be used regularly, but those used most frequently were:

1) The British Institute of Learning Disabilities "Compact" series.

2) The MEP "Blue File" programs. (In particular, "Front Page Extra", "Colour and Shape Matching", "Beans on Toast" and "Moving In".)

3) The "Pre-reading" and "Add" series by Nordis Industries.

4) The Scottish Microelectronics Development program software. (In particular, "Coins", "Safety", "Eating for Health", and "Timetelling".)

Modifications to standard equipment: 9 centres (82%) replied that they had not made any modifications to the standard equipment in order to use it with learning disabled attenders. One centre had special switches made for use by attenders, had introduced speakers above the monitor and were using a very large screen. Another centre had enlarged their Concept Keyboard overlays from A4 to A3 size.

3.3.2 Evaluation of the software

A summary of the responses to the evaluation criteria is found in Table 2. Inspection of the questionnaire responses revealed that there was little variability between respondents ratings of programs in terms of their uses, suitability for learners and standard of presentation. Most of the programs were aiming to improve basic education skills and were of the drill-and-practise and/or reward training type. Most of the programs were more suitable for learners with mild or moderate learning disabilities and respondents had few criticisms of the program design and rated the presentation of the material as age-appropriate for adults.

There was greater variability in the extent to which programs were perceived to incorporate the various principles of effective learning and teaching. Most programs were seen to have clear objectives and, also, to achieve these objectives to a large extent. In terms of individualisation, most programs were limited in their capacity to be amended and adapted to suit individual need. They were seen to provide differentiated feedback, some opportunity for remediation and to reinforce responding. Survey respondents felt that all the programs were educationally sound and that the programs achieved something that conventional methods did not.

3.4 DISCUSSION

This discussion will follow in two parts. First, the focus will be on the results from the present survey and, second, a more general discussion will follow regarding software for people with special needs.

3.4.1 Basic Information

All the respondent establishments provided education for adults with a wide range of learning disabilities - from adults with mild to severe learning disability and also for adults with profound and multiple handicaps.

Use - Most establishments reported obtaining and using their computers for educational purposes with attenders as opposed to using them for organizational or administrative purposes. It was apparent from comments that there were some difficulties in commissioning the system into use once it was obtained. One such comment was as follows:

"My difficulty is that, although we have a BBC Master 128, double disk drive, Concept Keyboard, umpteen switches, Turtle, printer, etc., we can't get it working...although several of us have micros at home, none of us can be called an expert and we have been left to muddle-on and try to get the system commissioned".

A factor cited in cases such as this was the lack of staff training in the use of information technology. This issue has also been highlighted in the H.M.S.O. report on the use of information technology in schools (H.M.S.O., 1990) and, also, in a report by the National Council For Educational Technology ("Information technology and Special Needs in the post-16 Sector", NCET, October 1991). The latter reports a survey of colleges that were using information technology with adults who have special needs. Regarding training, the survey by NCET found that only 37% of staff had received training in using information technology with learners with special needs and that this training usually consisted of attending a course giving a general introduction to information technology or attending some "awareness-raising" sessions.

In the present survey, staff commented on their lack of training and confidence in being left to set up the microcomputer equipment and to deal with any problems that may arise during its use. Clearly, if the technology is to be used confidently, staff need to have adequate training which leaves them feeling sure of their knowledge and able to maximise the potential of the equipment.

Time - The length of time that establishments spent on computer-based activities was varied. Some establishments reported that their computer was "in constant use" while others used it for only two to three hours a week. The length of any one session of computer based activity was reported to vary between 2 and 120 minutes and most establishments had sessions of about 30 minutes. Given that this questionnaire was aimed at finding out about CAL for adults with severe learning disabilities, this session time appears to be overlong if one takes into account factors such as the difficulties in concentrating and attending for long periods usually attributed to this group. It is not known whether the longer sessions reported were during the use of social education software where it is common for a large group to explore the programs together with the instructor in a discussion group format.

However, some establishments did report shorter sessions of "a few minutes", five and ten minutes per individual. These shorter sessions are usually deemed better educational practise for this group of learners, though this assumption is based upon customary practise and observation rather than any evidence regarding the optimum length of 'learning trials' for this group.

Programs used - The three most commonly used programs were amongst a number which have been marketed or recommended for use with people with severe learning disabilities and/or profound and multiple learning disabilities.

One of these packages ("Pre-reading" and "Add" - Nordic Software) was originally designed for adults who were "very slow learners". One (BILDs "Compact") was designed for "people with severe and profound learning difficulty" and the remaining programs (SEMERC "Blue file") were originally designed for children with learning disabilities.

The target of the survey questionnaire was software for adults with severe learning disabilities, but a wide range of ability was represented by the resultant sample. It was apparent that some of some of the programs in use were probably more suitable for learners who were more able than the categorization of "suitable for adults with severe learning disabilities" might warrant. This suggests that it may not be relevant to categorize software within rigidly defined limits. Instructors have clearly found that any particular piece of software may have some uses for the entire ability range and that a flexible, adaptive approach may yield uses of the software that are not necessarily within it's identified objectives. For example, a colour matching program may be beyond the ability of someone with profound and multiple disabilities, but it may still provide bold and clear colours suitable for providing sensory stimulation for someone of this ability level.

Availability - All of the three most commonly used packages are a collection of a number of different individual programs gathered together on a number of disks and sold as a package. Two, the 'Compact Series' and the 'Blue File' programs, are distributed through the British Institute for Mental Handicap and the Northwest SEMERC respectively. The latter collection of programs (the "Blue File" software) was originally available through the MEP and has now been expanded and is added to continually. It is freely copiable and available at the cost of production (i.e., usually the cost of the disks to copy the programs onto). The third most frequently used 'program' is also a collection of programs developed for a County Council Social Services department. This software is distributed through their industrial unit.

Respondents did not comment on the ease of obtaining the software.

3.4.2 Educational Concerns

Objectives - Most of the programs were seen to have clear objectives, though a significant proportion of programs did not have clear objectives stated and nor were they self-evident. Instructors are left to interpret and decide the objectives for themselves and there may be difficulties in putting these programs into an overall framework of experience or learning for the student if an instructor is unclear as to what the program is aiming to achieve. This lack of clarity of program objectives may also account for the fact that, in this survey, programs for more able learners are heavily present in the survey sample.

The targetted areas of skill that the programs aimed to improve included attentional/ motivational skills, self-help and social skills, traditional scholastic and language skills and motor/physical skills. In fact, an enormous range of objectives was represented in this relatively small survey sample. Even in the sub-sample of those programs most frequently used, the stated objectives ranged from targeting overall improved concentration (more specifically, eye contact, visual tracking, visual exploration and visual/motor skills) to teaching pre-reading and addition skills. Social education was also represented here, e.g., learning about eating a healthy diet.

The objectives of the programs were often described in bald terms by the instructors with no indication of how these objectives might fit in with an overall "curriculum" or framework of learning experience. There seemed an implicit assumption that the use of computer and the related programs constituted an objective in and of itself regardless of any overall curriculum.

It may be that, in some instances, adult day-care centres do not have a core philosophy or curriculum for their program of activities. The introduction of the computer may partly fulfil a need for the provision of an activity for attenders to take part in, rather than, as is perhaps more common in schools, being used as a tool for learning parts of the curriculum. If one takes into consideration the need to provide adult day-care attenders with appropriate activities, then to use the computer in this way may be a beneficial and valued activity. One comment from an instructor when asked about the objectives of the software seems to reflect this: "Some [objectives are to play] arcade games; even these are educational to people with learning disabilities"

Instructions - Instructions for using the program were usually clear to the instructor and/or the learner, but only in about three-quarters of cases. The need for clarity in instructions for use is self-evident and it is disappointing to note this lack in a nearly a quarter of cases.

Instructor intervention was needed in almost all cases and, this may be related to a lack of "user-friendliness" due to poor instructions, but also, possibly, from the following.

In the majority of cases, it was easy for a student to make the wrong response by accident and it was found that few programs would survive inappropriate key presses. If additional instructor intervention is due in part to a technical hitch arising from the programmer's oversight in not making the program "crash-proof" and suitable for use by those with poor physical coordination, then this situation needs further attention. The ongoing development of alternative switch and keyboard inputs is testament to this factor being taken into account, but it must be recognised as being of importance, especially for this group of learners. However, it should also be accepted that few adult learners with severe learning disabilities would be expected to use a program from start to finish without some additional intervention and that this would depend on the individual's capabilities.

Suitability for learners with special needs - Almost half the programs reviewed required reading skills. A quarter required number skills and comprehension of speech or language skills respectively. Other pre-requisite skills needed were: writing, good eyesight, motor skills, production of speech. Many of these pre-requisite skills seem at an extraordinarily high level of ability given the fact that the user is assumed to have severe learning disabilities.

Most of the programs could be used by learners with sensory or motor handicaps such as hearing loss or physical disabilities. However, there were some exceptions. Many programs were not suitable for those with visual handicaps and others did especially require fine motor skills, such as the ability to use the keys on the keyboard. Few of the respondents apparently used specialist switches and devices to enable access to the programs for less physically able students, although most of the most frequently used programs may be routinely used with a Concept Keyboard or Micromike (a microphone switch that operates sound-activated software). One respondent had enlarged the Concept

Keyboard overlays. One establishment used a range of switches to enable adults with profound and multiple handicaps to operate the software.

In general, few modifications of a physical nature were made to increase the program's suitability for learners with special needs. This could mean that the microcomputer system was considered adequate "straight out of the packet" for this group or it could also indicate that instructors were unaware how to or unable to tailor the set-up to the needs of this group.

It is interesting to note that the establishment that used the computer most frequently for sensory stimulation for profoundly handicapped learners found it necessary to make the most modifications to the learning (or "stimulating") environment. Here, the pictures were enlarged by using an old television rather than the system's monitor and this was placed at eye level. Similarly, a pair of speakers was employed to "bring" the program's sound to be in the same place as the images to better direct the learners' attention rather than relying on the computer's built-in speaker.

Such suggestions for enhancing the learning environment are apparently becoming more commonplace [see, for example, Kilton Hospital School's leaflets prepared by Tait, J.A., Graham, G.V. and Watts, G.T. (undated)], but this enhancement requires a degree of flexibility in the hardware systems. Overall, the trend in hardware design is one toward more and more compact desktop systems. In the area of special needs, however, it may be important to retain or even increase the degree of flexibility so that its ability to provide sensory stimulation may be maximised.

Age-appropriateness - Encouragingly, when answering about age-appropriateness for adult learners, most respondents felt that the programs were indeed age-appropriate, with only a small proportion being regarded as "too childish". The fact that using a computer is seen to be valued as an adult activity was highlighted in Chapter 2 as an particular asset of CAL for adult learners with learning disabilities.

3.4.3 Presentation and motivation

Overall, the programs were felt to be well-presented. They were deemed to be both entertaining and stimulating and to sustain the learners' interest after initial interest. This is important as any motivation arising from the novelty of using the computer would be assumed to dwindle after a time.

Specific criticisms of presentation were few. Sometimes it was considered that the screen layout was too complex. Screen presentations that are too complex may distract from intended learning. Programmers will often, with all good intention, attempt to focus attention on what is to be learned by incorporating dramatically striking colours, graphics and animation. However, the role of this type of presentation in CAL for people with learning disabilities is, as yet, almost unresearched. Intuitively, it seems a good idea to encourage attending to the screen in this way, but whether the screen displays themselves may distract the learner and potentially hamper subsequent learning is a question yet to be answered.

The sound production was also criticised as being too "electronic" rather than of a better tonal quality and it was commented that the sounds of the program could be irritating during repeated or prolonged exposure. This is one of the limitations of using the BBC computer, but it must also be acknowledged here that not enough is known about the role of sound in the learning process during CAL. This observation of the potential for it to be irritating and off-putting, rather than facilitating, may warrant further attention.

Another factor relating to the noisiness of the program was whether it could be used in a busy room. Most respondents felt that the program could be used in such a room, presumably when other activities are taking place. This need is likely to arise given that many activities are pursued simultaneously in a group room because of the ratio of instructors to attenders. But, it is not known how the noise of the computer activities may affect others in the room or whether the presence of others may affect the learners' use of the computer.

3.4.4 Principles of learning and teaching

The questionnaire included a number of items regarding the instructional style of the programs. These items were based on principles of learning and their particular applicability to CAL for people with learning disabilities. These were discussed in Chapter 2 and are not reviewed here.

Mode of delivery - In terms of the general mode of delivery, the majority of programs reviewed by respondents used a drill-and-practise format. A smaller, but substantial, number were of the "exploration and discovery" type of program. Lastly, some of the programs were games.

Reinforcement and feedback - Most educational software employs some form of "reward training" (i.e., reinforcing correct responses) and the programs reviewed here were no exception. Most commonly, auditory and visual reinforcers were used. An animated colourful display would appear, often accompanied with musical sounds. Sometimes these were combined with social praise in the form of written messages on screen saying, for example, "Well done!" or "Good!". An example of more concrete reinforcement or feedback on performance came in the form of learners being able to print out a picture they had created and take it home or put it on the wall.

Indeed, one comment from an instructor regarded the feedback given to the learner in this way when using wordprocessing or drawing programs. They commented that being able to produce a printout provided learners with "a sense of achievement" and was a valued feature of those types of programs.

Overall, the programs were considered to employ rewards for performance well. One difficulty noted by some users of educational software has been that the software's response to an incorrect answer can be inadvertently rewarding. For example, an incorrect response may produce an animated display accompanied by sounds that, in some cases, can be more interesting and stimulating then the display for getting a correct answer. Hence, the learner is rewarded for getting the answer wrong.

In this survey, some programs were rated for the rewards for correct and incorrect responses being clearly different. However, a substantial proportion of replies indicated that feedback for an incorrect response could be rewarding in some instances. This is an issue which needs to be addressed by educators and programmers alike.

The programs provided nominal feedback (i.e., informing the learner of a correct or incorrect response) and were also considered to help correct wrong responses. The method by which this was achieved is unclear. Did the programs actively correct performance by reteaching material? If so, how did they do this? Did they provide any extra help, perhaps in the form of prompts for the correct answer? Did they simply indicate the correct response after an incorrect response was made? Generally, in most educational software, the latter method of correction, rather than any graded prompting and fading, is more commonly found.

Most programs had the facility to keep a record of the learner's performance and this is usually in the form of a basic summary of numbers of correct and incorrect responses. There is not any consistent checking of how well the student understands the material and reteaching or shaping responses as necessary. The potential facility for computers to actively monitor performance and to remediate as required is not capitalised upon.

Some goals of the programs are unable to be monitored by the computer. For example, in considering programs for people with profound and multiple handicaps which are aimed at encouraging basic skills or behaviours, it is clear that the program itself would be unable to keep record of, say, improvements in visual tracking. This would be required to be observed by an external supervisor.

Amendment to suit individual need - One of the attributes of CAL for people with learning disabilities was regarding the heterogeneity of this group, the individuality of the learner and the potential considerable flexibility of the computer in meeting these individual needs of learners. However, only just under a half of the programs reviewed had any adjustable features to suit individual need or preference. Where it existed, the extent of this individualisation was small. A choice was allowed from a range of graphics to present the task and rewards for the learner and the pace at which the program ran could be altered or controlled. The length of teaching session could be set by the teacher or learner rather than being predetermined by the program.

3.4.5 General comments

Overall, the programs were considered by the respondents to be "educationally sound". Interestingly, all respondents also considered that the educational software was able to achieve something that conventional methods could not. Suggestions for what these differences might be included:

"Enabling self-directed learning; responding immediately and consistently; allowing students to control events; being more visually stimulating and giving feedback in a positive fashion, even when the learner has been unsuccessful".

3.5 CONCLUSION

The purpose of educational software is that the learner develop new skills and acquire knowledge. As we have seen in Chapter Two, the empirical underpinning regarding how software fulfils these aims is still lacking. This survey has attempted to look at how educational software is being utilised with adults with severe learning disabilities, what the software constitutes and whether the purchasers feel that it does achieve its aims.

First, the need for adequate staff training and support is highlighted. At a most fundamental and necessary level, this training needs to encompass the practicalities of using a microcomputer system. The provision of back-up support is necessary for when staff find themselves encountering difficulties, be they in the initial setting up of a system or, later, in the development of new ways in which the computer can be used to its full potential.

There is a need to develop a framework into which CAL can fit. It is apparent that a wide range of software with an even wider range of individual objectives was being used. It is not clear how much these programs were compatible with the curriculum of the day-care centres or the needs of the individual learners. There is a large amount of educational software available and it would be helpful to know how particular pieces of software are selected to be purchased or used. Is it selected on the basis of criteria such as availability, cost and compatibility with a particular computer make and model or is consideration given to what it purports to teach and how well it does this?

There may be scope here for programs to be selected on the basis of how well their objectives fit into the curriculum. However, as the concept of curricula is not usually applied to day-care for adults, it may be more useful to tie in the use of particular software with a person's individual "strengths/needs" plan. Such co-ordinated plans for helping to guide an individual's development are commonly in use, for example, the "Individual Programme Plan" or "Shared Action Plans".

Turning now to specific instructional concerns, it is clear that software for people with learning disabilities incorporates some principles of teaching and learning, but this appears to be only at a rudimentary level. There is little taking into account of prerequisite skills needed to use a program. Whether some of the software is suitable for people who are cognitively impaired is in doubt if, in order to use the program, high level cognitive skills and complex visuomotor repertoires are required. In any case, prerequisite skills are rarely checked as an integral part of the program. If the program is intended for independent use, then this checking of skills needs to become routine.

If they are not intended for independent use, or, if in practice, they are unable to be used independently, then this raises questions about the instructor's role in the utilisation of educational software. First, one of the oft-mentioned positive attributes of CAL in special needs is that it may provide opportunities for the development and maintenance of independent exploration and practise. Indeed, this is a fundamental tenet of models of learning. It is not known, though, how this opportunity for independent practise (and any subsequent acquisition of new skills and knowledge) may be compromised by the necessary intervention of a helper or instructor. Shuell and Schueckler (1989) state that "Undoubtedly, good teachers can make up for the limitations of instructional software", but there needs to be some greater examination of the relationship between the role of the software and the role of the teacher.

Most of the software surveyed here made use of behavioural techniques such as reinforcement, feedback and shaping responses (increasing level of difficulty). However, these appear to be applied in a blanket fashion with little consideration of individual preference or need. Again, one of the hopes for using CAL was to maximise the potential of a computer's capacity to monitor, to "diagnose" difficulties and to adapt accordingly, i.e., to be flexible. The degree to which programs could be individualised was found to be minimal. It seems that behavioural technology is being applied in a cursory and poorly understood fashion, and while it is being applied in this way, it is resulting in the capability of the microelectronic technology to also be poorly used. There needs to be some examination of the way in which behavioural principles are applied in educational software. This could then enable programmers to be more considerate in the application of such principles in the software.

So, from a theoretical standpoint, there is considerable dissatisfaction with educational software for adults with learning disabilities. However, the purchasers of the software seem quite content with what they have bought. Whether their satisfaction will remain over time is not known. Whether their initial enthusiasm may disappear if developments in software do not keep pace with what they need or want is also unknown.

One of the issues here appears to be the question of what it is to "keep pace" with the needs of adults with learning disabilities. In some cases, it appears that instructors want the technology to "slow down", i.e., to avoid rushing into complex routines, sophisticated graphics and questionable objectives for this group of learners and to limit itself to providing small steps of experience for these learners.

The difficulty in discussing many of these issues is the lack of basic research in the area. There are many unknowns. Is it the case that CAL is repackaging "ordinary" teaching techniques in a seductive new guise? Is it achieving anything different to conventional methods? What attributes does it possess that may make it different or better or the same? How may these attributes best be applied?

The remaining chapters of this thesis present empirical evaluations of CAL which aim to address some of these issues. First, an appropriate methodology needs to be identified and applied. The next chapter discusses some of the methodological difficulties of applied empirical evaluations and presents a pilot study of evaluating commercial CAL in an applied setting for adults with learning disabilities.

CHAPTER 4

4. ESTABLISHING A METHODOLOGY

4.1 INTRODUCTION

In general, the scientific community emphasises quantitative, experimental approaches. However, Levine (1974) states that "those who have worked with clinical and field problems have long chafed with the lack of fit of scientific method, as it is usually practised, to problems faced daily." Researchers who wish to assess the educational value of CAL must cope with an overwhelmingly messy set of variables. Performing anything like a clean experiment seems an elusive goal (Goldenberg, 1984). It is easy to find methodological flaws in the experiments outlined previously in Chapter 2, but before rushing to reject findings from studies such as these, there should be some discussion and consideration of the special conditions and problems that research with people with learning disabilities can generate.

4.1.1 Methodological issues concerning research with people with learning disabilities

Gardner (1978) and Schindele (1985) outline some of the issues relevant to research with people with learning disabilities. The first consideration is the difficulty in establishing a participant group. People with learning disabilities represent a heterogenous population with great variability in cognitive and adaptive behaviour. Any group of learning disabled people would include individuals possessing a variety of neurological, sensory and physical characteristics. This non-equivalence of participants often renders matching procedures impractical. Individual participants each show a specific complexity because of their particular disability. Therefore, the use of methodologies which rely on using groups of normally distributed participants may not be appropriate in learning disability research. There are also likely to be relatively few people who can take part in a research project, therefore research tends to be limited by the necessity of using the only available participants. Thus, the possibility presents of the necessary selection of an atypical sample.

Secondly, the environment in which the research takes place is characterised by a variety of institutionalised and non-institutionalised settings involving a number of treatment personnel. These persons may have widely differing and strong opinions about appropriate treatment. Their acceptance of any outside agency coming in with equally robust ideas about treatment is never guaranteed. But, their potential to influence the running and outcome of any study should not be ignored. It is essential to gain an understanding of the existing philosophy of the care staff and to take time to introduce research ideas in order to minimise possible extraneous effects.

The day-to-day setting of the research may also present problems. In an active applied research environment, obstacles of a practical nature present repeatedly and may hinder the maintenance of a constant experimental environment. For example, an experimental room or setting may be suddenly changed or made unavailable to the researcher due to other demands coming from the unit. Similarly, staff who had made a commitment to be present during experimental sessions may find themselves unexpectedly unable to fulfil this. Such difficulties can seriously disrupt even the most basic attempts to create stable experimental conditions. Thus far, the methodological considerations are typical of field research settings and require researchers to adopt a quasi-experimental approach (Cook and Campbell, 1979).

Third, further issues pertain to the special nature of educational research. When undertaking research on an educational process, the object of the research is difficult to access because it is complex and multidimensional, of a dynamic nature and belongs specifically to the individual. So, problems may be encountered in establishing appropriate measures and developing means by which to collect data. For example, there is an overall lack of adequate assessment measures for people with learning disabilities. There may be a need to adapt any tests and procedures to the specific disability of each participant. In addition, there is the problem of identifying performance indices that equate to "learning". Standard performance indices, such as the number of correct responses, may not be sensitive to achievement gains in people with learning disabilities - susceptibility to ceiling and floor effects is not uncommon.

Fourth, there are also ethical and moral considerations. These "require particular attention in research concerning people who have exceptional developmental and learning conditions. For such people any decision about their treatment may have a significant - positive or negative - effect; because of their small number and their dependence on specialist provision they risk being misused by research" (Schindele, 1985). This is worth taking special note of when considering why there is a lack of basic research with learning disabled people. In general, care staff are very concerned that their charges are not merely used as participants, but that the benefits of being involved in a research project or objective are obvious for both parties.

These conditions outlined above may give rise to specific problems in the design, execution, data analysis and interpretation of research with people who have learning disabilities. Schindele (1985) cites the following factors as bringing about special methodological problems in any research with this group:

- the establishment of adequate participant groups, especially in group referenced experimental designs;
- the representativeness of the research population;
- the generality of findings and their practical significance;
- the danger of failing internal validity through intervening variables or regression effects and interaction of variables;
- the danger of failing reliability through inadequate measurement instruments or procedures;
- and, the danger of inadequate use of inferential statistics, especially in significance testing with group designs.

There is a need, therefore, to improve the methodology or to take new approaches. Suggestions for this include using more flexible research designs such as multi-element, multiple baselines or time-series designs. The use of small-n designs and mixed designs of qualitative and quantitative methods and evaluation research seems particularly well suited to institutions, organizations and educational programmes. There is also a need to allow for the development of adequate measurement procedures and the application of more appropriate statistical procedures for data analysis.

4.1.2 CAL and evaluation

The evaluation of CAL in the education and training of people with learning disabilities is an area of research which will likely demonstrate many of the special conditions and problems outlined above. Therefore, any empirical evaluation of the use of CAL needs to take heed of these points.

In order to gain a practical awareness of the difficulties of conducting research with a special population in an applied setting a pilot evaluation study was deemed necessary and is reported below. The purpose of the study was to familiarise the researcher with both practical obstacles and methodological difficulties which would arise in the course of conducting this type of evaluative research. Further aims were to formulate ideas concerning specific methodological issues in CAL evaluation and to use this study to make an evaluation of a piece of software designed specifically for people with learning disabilities.

An important point to bear in mind throughout is the wish of the researcher to assimilate the "real world" issues as viewed by the eventual consumers and users of the new technology. If evaluative research of CAL is to be useful, this seems a necessary corollary. Therefore, all the CAL applications reported in the following evaluations are drawn from those which are commercially available to parties interested in employing CAL with adults who have severe learning disabilities and, as much as possible, they have not been especially constructed for the research. Rather, they were selected from materials specifically marketed for this group.

4.2 PILOT STUDY. An evaluation of an application of CAL to increase the vocalisation of two adults with severe learning disabilities and challenging behaviour

The lack of evidence regarding the efficacy of CAL with severely learning disabled adults has been noted. To begin with, then, there is a need for investigations aimed at providing some empirical evidence for the effectiveness of CAL with these adults. Necessarily, this research must be assimilated into the settings in which people with learning disabilities go about their daily lives. Thus, appropriate procedures for such research need to be established.

In the investigation of the efficacy of CAL programs within a care setting, there appear to be three levels to the evaluation. First, evaluation takes place at the level of assessing the CAL program and what it purports to teach. This is, part of evaluation is to validate the goals and aims of the software. Second, there is also the need to assess the impact of the CAL sessions on the progress and behaviour of the client. That is, to evaluate the effects and outcome of implementing CAL. Third, one needs to assess the ease with which the unit can appropriately use CAL to teach or encourage new skills. That is, to evaluate the practicality of implementing CAL. If CAL is to be implemented successfully, it must fit in with the other routine activities of the care establishment setting. For example, the care staff must be able to administer and run the CAL sessions as part of a normal day.

4.2.1 Aims

The aim of this study was to evaluate the use of a CAL program that was designed to encourage the production of vocal sounds by presenting visual and auditory reinforcement contingent upon vocalisation. Also, it served as an identification of methodological procedures and problems in establishing CAL in a care establishment for adults with severe learning disabilities.

4.2.2 METHOD

4.2.2.1 Participants

Two participants, R.L. and D.T., who were both male and aged 18 years 10 months and 16 years 4 months respectively, participated in the study. Both attended an National Health Service day care unit for adults with severe learning disabilities and challenging behaviour. Standardised IQ scores were in the range of severe mental handicap (IQ <50) for both participants. Neither participant had any known sensory or physical handicap.

The reason for these particular participant's inclusion in this study was that their keyworkers had expressed an interest in trying to encourage them to vocalise more frequently. Both D.T. and R.L. were observed by their keyworkers to vocalise infrequently, although it had been noted on occasions that each participant was capable of using some language.

4.2.2.2 Setting

The pilot study was carried out in the National Health Service day care unit which the participants attended. Four other people with severe learning disabilities also attend this unit. The unit is a self-contained centre and is organised as follows. Each attender is allocated a small room in which they carry out their daily educational activities structured according to the individual's programme plan (IPP). These activities take place in half-hour periods during which one-to-one care and instruction is given. These sessions cover a range of educational needs. For example, from eating and dressing behaviours to matching-to-sample and language skills training. In order to carry out this teaching, the care staff in had all received a course of training in basic behaviour modification techniques [EDY - Education of the Developmentally Young; Foxen and McBrien (1981) and McBrien and Foxen (1981)]. This training was provided by the local clinical psychology department.

In addition to these structured teaching sessions, all attenders and care staff meet in a communal room three times a day. This room contains materials for leisure purposes such as toys, jigsaws, musical instruments and large, soft, PVC-covered shapes for physical play. There is also a room dedicated to sand-and-water play containing the appropriate materials, a kitchen and the nurse's office.

For the purposes of the study, the CAL sessions took place in the sand-and-water-play room. A small area (approximately 2m x 2m) was marked out. This contained a table and chairs and the computer was set up on the table. During the experimental sessions, the windows of the room were "blacked out" with black construction paper and the overhead lighting was switched off. This was done in order to increase the salience of the monitor screen's illumination. It also served to reduce the likelihood of other items in the room distracting the participant.

4.2.2.3 Equipment

The CAL program was to be delivered using a microcomputer system which comprised the following: A BBC-B microcomputer and Cumana single disk drive, a PYE StudioColour television with a 12" screen and the "Micromike" by Magpie Systems, Widnes, Cheshire.

The Micromike is a vocal switch based on the C.B. radio microphone. Two versions of the switch, handheld or desktop, are available. This study utilised the desktop model with the option of a clip-on microphone. A thumb-press switch and a variable threshold control to adjust to the level of the user's voice output are located on the Micromike.

4.2.2.4 Software

A commercially available program for the Micromike, called "Shells", was used. This particular program operates on a simple cause-effect/response-reward strategy. When the program is loaded, the outline of seashell-like shape appears on the screen in front of the participant. This shape is segmented. Each vocalisation from the participant that is of sufficient volume to be picked up by the Micromike results in the screen display changing; that is, a segment of the shell shape is filled in by colour. A selection of colours are used, so the resultant effect is multicoloured. When the shell is complete a simple tune is played and the background to the shell flashes during this time.

For the purposes of the research, the program was modified by the inclusion of a timer to record the length of time the program was running and the cumulative amount of time spent vocalising. Both these figures were displayed onscreen. This did not affect the normal operation of the program in any way.

4.2.2.5 Procedure

Prior to commencing the study, an initial decision was made with regard to attempting to reduce the degree of disruption to the normal day-to-day operation of the unit. The educational programs in progress were well established, as was the daily routine of the staff and attenders. So, there was considerable care taken to fit in with each day's usual course of events in order to keep any disturbance to a minimum.

In keeping with the behavioural orientation of this particular unit, a part of the daily educational programs was the delivery of edible reinforcers upon completion of targetted tasks or demonstration or targetted behaviours to the learners. In the majority of cases, these reinforcers were edibles delivered under an FR1 schedule of reinforcement. Most of the participants' days were taken up with training programs, so it follows that they were completely accustomed to receiving frequent presentations of food rewards. Normally, in order to ascertain the effects of the CAL programme, it might be expected that these reinforcers should be discontinued for the duration of the CAL instruction. However, after discussions with each participant's keyworker, it was agreed that the sudden cessation of these frequent deliveries of food could have a potentially disruptive effect on the participant's usual behaviour. Therefore, it was decided that both participants would continue to receive their usual foodstuffs (e.g., a sweet, crisp, piece of biscuit or cheese) throughout the experimental period. In order to control for any effects that the delivery of these reinforcers may have on the participants' vocalisations, the presentation of these was made non-contingent and they were delivered at random intervals throughout the experimental sessions.

Also, throughout all phases of the study, staff were asked to keep a diary and note any absences, illness or other circumstances and any unusual occurrences of behaviour.

4.2.2.6 Design and implementation.

A replicated single-case A-B-A design was implemented and the study was carried out as follows.

Phase 1: Baseline.

From a long history of staff observation, the behaviour being assessed was known to occur extremely infrequently and at a variable rate. Consequently, baseline measurement comprised the minimum of three data points suggested by Hersen and Barlow (1976) as an adequate baseline measurement in such instances. This baseline measurement consisted of both participants' vocalisations being observed and recorded for 1 continuous hour per day for 3 consecutive days. Mealtimes, toileting and those times when the participant displayed disruptive behaviour were excluded from this observation period. Both educational activities and leisure time spent in communal room were included. The observer accompanied the participants throughout the unit during a randomly selected hour of their day. Any vocalisations produced by the participant during the hour were timed by the observer using a stopwatch. Thus, a cumulative recording of seconds of vocalisation for that hour was made. Data from this phase is represented by points 1 to 3 in Figure 1.

Phase 2. Pre-intervention modelling.

The first part of the intervention was the modelling of the production of vocalisations in front of the computer. The participants were introduced to the sand-and-water-play room accompanied by their keyworker. The researcher, who acted as observer and recorder, was also present. Participants were given a few minutes to familiarise themselves with the new layout of the room. When the participant was settled, he was seated in front of the computer with the Micromike in position, but with the computer switched off. The participant was prompted to vocalise by their keyworker. This took the form of a verbal request of "_____, say "...aahh" or "...ooohh". This vocal behaviour was then demonstrated for the participant by the keyworker. The prompt for the participant to imitate and vocalise was then repeated. The prompting and modelling sequence was repeated several times during the session. This modelling without the program running was done in order to determine whether any subsequent increase in vocalisation was a result of using the computer program or an effect of being asked to vocalise by a member of staff.

Modelling sessions took place twice on one day of the study. Each session lasted five minutes. This length of session was determined by conferring with the keyworkers about the participant's likely attention span on a new task. During the session, any vocalisations made by the participant were timed by the researcher using a stopwatch. Data from this phase is represented by points 4 to 5 in Figure 1.

Phase 3. CAL Intervention

On the subsequent day following this modelling period, each participant began the CAL sessions; that is, sessions using the Micromike with the "Shells" program running. In total nine CAL sessions took place. These were conducted over three sessions each day for three consecutive days. Each session was of five minutes duration.

Participants were given initial prompting to vocalise, but were then left to work independently (to discover the effect of vocalising into the Micromike for themselves). Any vocalisations produced were timed by the computer. Sessions were terminated if disruptive behaviour occurred at any time.

During this phase, the baseline measure was continued. Participants' vocalisations were recorded for 1 continuous hour per day during the period of intervention. This was done in the same way as the initial baseline in Phase 1, with the added condition of excluding time spent in CAL sessions. This was to assess whether any increase in vocalisation that may have resulted from using the Micromike might generalise to other situations and is referred to as the "Generalization baseline". Overall, data from this phase is represented by points 6 to 14 in Figure 1, with generalization data at points 7, 10 and 13.

Phase 4. Post-intervention baseline.

The final part of the study was to record a baseline for 1 hour a day as before for 2 weeks. This was to be completed by care staff. Unfortunately, during these 2 weeks R.L. was absent for 4 days and D.T. for 8 days. They could not attend because of a high occurrence of staff absence. Understandably, on those days when the participants were present, the few attending staff experienced difficulties in maintaining the normal operation of the unit while also recording data. Thus, the baseline observations are incomplete. Only 7 hours and 2 hours of baseline were observed for R.L. and D.T. respectively. Data from this phase is represented by points 15 to 21 in Figure 1.

4.3 RESULTS

The results for both participants are presented in Figure 1 below. The amount of time spent vocalising during each period of observation is expressed as a percentage of the total time spent in an observation session. The raw means and mean percentages for both participants are presented in Table 3.

	Observation Sessions				
	Pre-treatment	Modelling	Intervention	Generalization baseline	Post-treatment
R.L.	0.146	0	0.518	0.155	0.203
(Raw Mean)	(5.2 sec)		(1.5 sec)	(5.6 sec)	(7.3 sec)
D.T.	0.583	0	5.929	0.481	1.995
(Raw Mean)	(21 sec)		(18.1 sec)	(17.3 sec)	(67 sec)

Table 3. Mean percent of observation sessions spent vocalising

Visual inspection, rather than statistical analysis, was used to identify and evaluate the effect of the CAL intervention. While appropriate small-n statistics are now available to analyse such data as obtained here (see, for example, Morley and Adams, 1989), they were not applied in this instance. It was felt that inferences about the effect of the intervention could be readily drawn from visual inspection alone and that additional statistical analysis would not be a useful supplement to questions about any particular facets of the data. For a discussion of these issues, see Kazdin (1984).

D.T.'s results

Visual inspection of the data reveals that, overall, D.T. showed an increased amount of vocalisation during the CAL sessions compared to his initial baseline and modelling

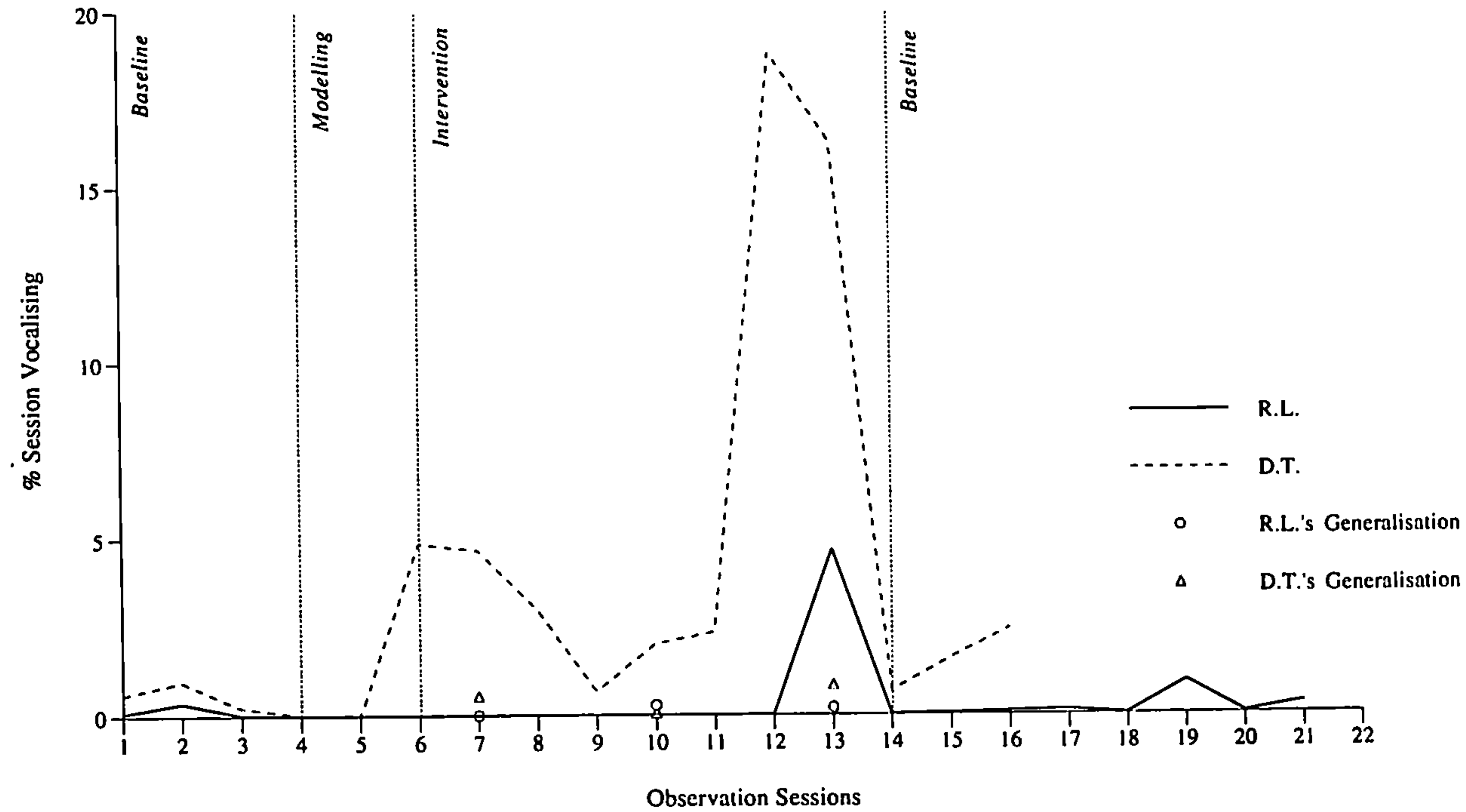


Figure 1. Proportion of Observation Sessions Spent Vocalising

performance. There was a high degree of variability across the CAL sessions. The generalization measure does not appear to differ from D.T.'s initial baseline performance.

R.L.'s results

R.L. showed one instance of increased vocalisation during the CAL sessions and no other vocalisations at any other time. Again, R.L.'s generalization measure does not appear to differ from his initial baseline performance.

4.4 DISCUSSION

4.4.1 Present results

The results indicate that, for D.T. at least, the CAL program did have an effect on the amount of vocalisations produced. If D.T.'s data from the previous baseline and modelling sessions are compared with that from the CAL sessions, it may be seen that the use of the Micromike program to encourage vocalisation was to some extent successful. However, as the generalisation baseline data shows, this increase did not generalise to other times during the day.

Potential causes for this observed increase in vocalisation during the CAL sessions may only be speculated upon at this point. There is the possibility of any increased vocalisation being a result not of the program itself, but from being placed in a novel setting (of the "CAL room"), but this seems unlikely as the increase was only observed in those sessions when the program was running. So, the increase may be related to the program itself, though this success cannot be unequivocally attributed to any individual parameters of the program.

There is the additional possibility that being faced with a task demand (being "asked" to vocalise) might lead to an increase in vocalisation. However, this seems an unlikely cause for the observed increase as neither participant vocalised during the prompted modelling sessions. In fact, informal observations suggest that neither participant vocalised when prompted to do so. This non-compliance with the staff prompt to vocalise could be viewed as maladaptive behaviour rather than disruptive "challenging behaviour" (i.e., behaviour likely to result in sessions being stopped immediately). On these occasions of maladaptive behaviour, staff would make comments such as "He's being cheeky...he's playing me up." They felt that the non-compliance was a deliberate act rather than a failure on the part of the participant to understand the requirement. On the removal of the staff task demands and the initiation of CAL demands, the increase in D.T.'s vocalisation was observed, further suggesting that it was the program, rather than any other demand variables which encouraged D.T.'s vocalisations.

It will be recalled that the aim of the program was to encourage vocalisation by presenting visual and auditory reinforcers contingent upon vocalisation. The findings here raise questions concerning the role and efficacy of such reinforcers. In this application, this type of reinforcer was apparently effective in increasing a behaviour. At this stage, with such a small observed effect in only one participant, it is only possible to raise the issue. Further discussion will follow later. However, the potential importance of D.T. responding at all to such reinforcement when he was entirely accustomed to receiving reinforcers of food rewards and social praise must be acknowledged.

4.4.2 CAL and challenging behaviour

The questions raised here concerning the effects of task demands and their influence on the target behaviour is of interest with respect to the evaluation of CAL with adults who have severe learning disabilities and accompanying behavioural problems. Typically, these participants may be uncooperative and there is some evidence to suggest that CAL demands are less likely than staff demands to result in disruptive behaviours. Plienis and Romanczyk (1985) cite four studies of severely disturbed children where adult-delivered instructional demands elicited escape responses of aberrant behaviour. Plienis and Romanczyk looked at adult- versus computer-delivered task demands on severely disturbed children and found that less disruptive behaviour occurred in the computer-delivered condition, while gains on the learning task were equivalent in the adult and computer conditions. They conclude that, in effectively producing acquisition of skills while reducing the occurrence of maladaptive behaviour which interferes with skill acquisition, computer-delivered instruction could become a valuable component in the educational plan for children with severe learning and behavioural problems. One important skill to be acquired is compliance with adult or peer instructions or requests. If the child acquires similar skills in a positive manner with the computer, she or he may have a larger repertoire of desirable skills to employ in the context of human interaction.

In relation to the present study, only one instance of directly disruptive behaviour was noted in a CAL session, though it was observed that participants were non-compliant with spoken staff requests on several occasions. For example, R.L. looked visibly pleased to withhold prompted vocalisations during the initial trials in the CAL condition and he would remain silent for the rest of the session. The moment the program was switched off, he would begin to "sing". At other times, in contrast to this negative response to the CAL sessions, he was observed to run from other instructional sessions into the "CAL room" and sit in front of the computer. Observations of this type lend support to the idea that, as an adjunct to instructing a targetted behaviour, more generalised effects upon a participant's behavioural repertoire might occur. Whether or not such volitional acts as those observed happening with R.L. are viewed as positive or negative depends entirely on the orientation of the observer. One could label his behaviour "disruptive" or see the occurrence of self-directed behaviour on the part of an adult as a desirable goal.

Observations such as those described above would seem to point especially to the special circumstances surrounding using CAL with people who have challenging behaviour. However, they raise more general considerations, too. The whole process of providing adjunctive instructions to prompt engagement with the computer may fundamentally alter the learner's propensity to interact naturally during CAL. Indeed, the cognitive models which underlie some of the explanations for the use of CAL may suggest that interfering with the natural process of interaction is also interfering with the process of learning. As yet this question is unanswerable. However, it may be the case that learners should be given less staff guidance than would be dictated by "common sense". Staff encouragement may even increase the likelihood of non-interaction. At the least, it points to the need for staff intervention to be measured in its approach.

4.5 IMPLICATIONS FOR METHODOLOGY AND SOME PRACTICAL RECOMMENDATIONS

This study helped to clarify some of the more general methodological issues encountered in first endeavours of this kind. Previously published studies were noted to use widely differing methodologies. When considering how to conduct any evaluation studies intended for this thesis, it became ever more evident that there is no one method which would ensure the encapsulation of the many concerns inherent in the implementation and evaluation of CAL. This pilot study was conducted with two aims: One, to evaluate an application of CAL; and second, to elicit general methodological issues and consider their solution. Some of the major points will now be discussed, together with suggestions for practical recommendations.

The first considerations are those of experimental methodology and the selection of appropriate designs, etc. From the Introduction to this chapter, it will be remembered that this issue grapples with difficult philosophical arguments concerning the nature of experimentation and its "fit" with the necessary move into applied settings and attempts to evaluate the influence of variables in complex, multidimensional processes. From the applied researcher's point of view, the solution is "to accept variability as an unavoidable evil" (Barlow and Hersen, 1984) and to maintain an open-minded approach.

Methodologies such as quasi-experimentation (Cook and Campbell, 1979), single-case designs (Barlow and Hersen, 1984) and small-n studies (Robinson and Foster, 1979) provide convincing recommendations for the solutions to obstacles in applied settings present in true experimentation. The strategies suggested by these authors allow for the study of effects of independent variables under circumstances which unavoidably comprise difficult-to-control-for conditions. While they may not be sufficient always to allow strong tests of causal hypotheses, in complex situations they may be useful to suggest new ideas and alternative interpretations which may then be subjected to further study.

Thus, the problems with research in special education (or learning disability) outlined by Schindele (1985) above may be addressed through the use of such alternative methodologies. This is especially the case for concerns such as the establishment of adequate participant groups, the generality of findings and their practical significance, the danger of failing validity through the interaction of variables and the danger of inadequate use of inferential statistics.

Details of CAL implementation in an evaluation also require a flexible approach. One of the points raised in Chapter 2 concerning previous research was the wide discrepancy in length and timing of a CAL program or intervention. This pilot study exemplified the difficulties in prescribing any particular length of assessment or intervention for studies involving participants of widely differing abilities and behavioural problems. It has been suggested by Conners, Caruso and Detterman (1986) that evaluation studies should not have to be lengthy field studies, though given the slow rate of learning manifested by people with learning disabilities, anything other than lengthy studies can seem inadequate. However, in order for research to proceed at a reasonable rate, methods must be established which "sample" learning. From these samples, effects of variables could be inferred and these variables could then be subjected to greater scrutiny in longer experiments.

It may be difficult to ascertain the length of a treatment phase. It is usual to wait for behaviours to stabilise within treatment phases before introducing the next phase, but this may result in impossibly lengthy studies. This pilot study showed that a concentration of sessions over a short period of time was able to show some possible effects of the intervention, with the outcome of yielding further research questions for later study. Clinical and practical considerations may take precedence over methodological rigour when trying to establish procedures. For example, the length of treatment phases in this study was in part determined by the degree of intrusiveness of the research that the unit felt able to manage. Staff expressed a preference for greater disruption over a shorter period than to experience longer lasting changes to their usual schedules. Even with this in mind, the intervention phase length was altered from the original plan as staff absences made it difficult to justify using staff resources for research when other demands were competing.

Of course, it would be possible to suggest here that staff need not be used to the extent that they were in this pilot study; however, in retrospect, it is clear that consultation of staff opinion and their active participation in the intervention was absolutely essential to the feasibility of the study. First, their expert knowledge of the participants yielded suggestions for the running of the study that would have taken a considerable time to ascertain otherwise. For example, decisions concerning session length, number of sessions, where to hold the sessions, whether to continue the edible reinforcers, etc., all came directly from consultation with staff.

Secondly, and this may pertain more especially to evaluations in a challenging behaviour unit, their well-established relationships with participants fundamentally enabled the study to be conducted. It is doubtful whether participants would have worked with an unknown instructor. Such characteristics of participants must be considered at the stage of planning the evaluation, but there must be a balance of respecting staff opinion while maintaining the conditions necessary for a study. For example, there was considerable anxiety and scepticism expressed by the staff concerning their prediction of extremely disruptive behaviour if participants were left relatively unchecked in front of "fragile" microtechnology. However, unprompted, independent trials were necessary to investigate the effects of the program. Fortunately, these fears were able to be dismissed as it became apparent that participants would maintain attention for minutes at a time and not become exceedingly disruptive when left to "work on their own" in the presence of a member of staff.

Generally speaking, the presence of keyworkers throughout the evaluation sessions was a necessary requirement. It was suggested earlier, however, that this presence may be considered to be an intervening variable in the assessment of CAL. What is called for is a structured approach to staff intervention that could, if necessary, be quantified and included in any analysis. These staff were trained in the use of a hierarchy of graded prompts - from verbal to physical. It would be possible to record the level of prompt used during trials and to make some assessment of the necessity of prompts in order to sustain subsequent behaviour. In this way, the relative effects of the influence of staff versus the influence of the CAL program could be monitored.

This brings us to the issue of measures used to ascertain effects. The measures taken will clearly depend on the aims and objectives of the CAL intervention; so, in this case, where increased vocalisation was the aim of the program, it was appropriate to record the duration of vocalisations. Other programs would require other measures. A lot of software makes use of making "correct" or "incorrect" responses, but for software that can be neither correct or incorrect, such measures would be nonsensical. Where the aim of the program is not clear, some observation of participants using the program (or the researcher using the program themselves) is necessary in order to describe the component behaviours of the task and to devise meaningful measures of progress or use. Duration of responding is often used in research with those who have severe learning disabilities. The program in this study was able to record this automatically during the CAL sessions, but other methods may need to be used if this is not possible, as was the case during the baselines. Adjunctive behaviours may need to be categorized and recorded. This study did not actively record such behaviours as "appropriate responding", "off-task behaviour", "eye contact with screen", but examples such as these may have been useful additional measures used in order to evaluate the effects of the program. In general, traditional achievement gains are the most usually recorded measure in CAL evaluations, but direct observation of behaviours is also likely to be a useful and sensitive measure of the effects of CAL. Suitable methods for assessing the reliability and validity of such observational measures are available. [See, for example, Sackett (1978) and Murphy (1985)].

It is important also to make some assessment of generalisation to other behaviours or situations, though there could be an argument that the usefulness of CAL may be sufficient as an activity in and of itself regardless of whether or not it has other effects on behaviour. Generalisation measures will be difficult if CAL is providing an activity which is available only through that medium (for example, the use of microswitches to provide contingent onscreen stimulation to people who are profoundly handicapped). There is an unresolved issue of comparability between CAL and other mediums (see Aitken, 1988). Therefore, the issue of generalisability between conditions is also unclear. At these preliminary necessarily inductive stages of an evaluation, there can only be recognition of the difficulty in making valid comparisons, but comparisons are still necessary and worthwhile in order to further knowledge of the area and to understand any potential differences between CAL and other forms of instruction or interaction.

Lastly, the usefulness of statistical analysis will be discussed. It was stated earlier that visual inspection was used where intervention effects could be seen and further analysis would not have provided useful additional information. There are arguments for and against the use of inferential statistics in single-case and small-n designs. The nature of the research population means that designs other than these will be infrequently used. Designs of this nature do not necessarily fit well with commonly used statistics which are based largely on tests of within-group variability in groups of subjects in between-group research. Such analyses may be deemed unsuitable in single-subject and small-n designs, yet more suitable statistical analyses (such as those suggested by Morley and Adams, 1989) may be criticised for not being suitable for testing intervention effects. Again, some compromise and acceptance of the conflict is necessary. Kazdin (1984) proposes that "at the initial stage of research, statistical analyses may serve a useful purpose in identifying variables that warrant further scrutiny and development". It may be important, too, to detect small effects that would not be amenable to visual inspection or to analyses which rely on relatively large differences in the data. For this reason, appropriate statistical comparisons of treatment effects will be used in the evaluations presented in this thesis.

4.6 CONCLUSION

The aim of this pilot study was to assess the feasibility of assimilating evaluative research into the day-to-day activities of a care establishment. This study illustrated some of the benefits and some of the problems that arise from such an undertaking.

Appropriate practical recommendations which address these methodological issues have been made above.

In considering the hypothesis that the CAL application would have increase the amount of time spent vocalising, the findings here suggest that this was the case for one of the two participants. Vocalisations during experimental sessions increased, though this increase did not generalise to other situations. The reasons for this effect of the CAL intervention remain unclear at this point in time, though the role of sensory reinforcement is implicated.

The aims of this study were modest and it is important not to overemphasise or overgeneralise the findings. This study confirmed that it is possible to implement CAL in a care setting with adults who have severe learning disabilities and to systematically collect data concerning its effect. It has pointed to some aspects of CAL, e.g., the provision of sensory reinforcement, that it may be useful to look at further. Additionally, it has illustrated the nature of evaluative research of this type. Applied evaluation must be viewed as part of a complex set which includes all the "real world" variables inherent in any applied setting; e.g., staff absence, participant needs and characteristics, routines of the setting, availability of resources. As such, evaluation of this nature may demand some methodological compromise. The following chapters describe experimental work aimed at investigating the efficacy of CAL which attempts to take into account such methodological issues.

CHAPTER 5

5.1 COMPARING CAL WITH OTHER FORMS OF TEACHING

5.1 EXPERIMENT 1. Evaluating active and passive methods of instruction: A comparison of computer-taught, teacher-taught and video-taught (passive) instruction for the teaching of shape discrimination (sorting), size discrimination (ordering) and picture completion (jigsaws).

5.1.1 INTRODUCTION

It was noted earlier that the literature on the use of CAL with people with learning disabilities is characterised largely by anecdotal studies and little systematic research. Even though it is considered to be important to determine the efficacy of CAL as an educational method, few studies have attempted to compare CAL with other methods of instruction.

Ryba and Webster (1983) and Baumgart and Van Walleghem (1987) found that groups taught with CAL performed no better than teacher-taught groups. Trifiletti, Frith and Armstrong (1984) found that CAL improved the performance of the experimental group over the control group. But, McDermot and Watkins (1983) and Plienis and Romancyzk (1986) found that equivalent gains were achieved between the experimental and control groups.

Two of the above studies (Baumgart and Van Walleghem, 1987; Ryba and Webster, 1983) focused on using CAL with adults with learning disabilities (as opposed to children) and both of these targeted word recognition skills. These findings suggest that CAL may be just as good as teacher-taught instruction when used to teach word recognition to adults with moderate-to-severe learning disabilities.

The present study aims to provide an empirical evaluation of CAL against traditional teaching of a variety of skills to adults with severe learning disabilities. It employs a control condition in which participants simply watch a video of another person with severe learning disabilities working at a computer. It was expected that this "passive" method would provide little positive gain and it would provide a control for attention and a baseline against which to determine whether there were any positive gains attributable to either method of instruction. The institution of this "passive" method of training also serves to initiate some examination into the role of active learning, which is stressed as one of the advantages that may pertain to CAL when compared to other forms of instruction (e.g., Rostron and Sewell, 1984).

The study employs a range of tasks (shape and size discrimination and picture completion) which tap a variety of educational and perceptual skills. This diversity allows a comparison of the different methods of instruction over a broader range of skills than previous studies. This was considered important in moving towards an overall evaluation of the different methods of instruction.

5.1.2 METHOD

There were practical difficulties encountered in the pilot study relating to the use of care staff to conduct the teaching sessions and which may have led to an increase in pressure on staff time and, possibly, staff absenteeism, too. This present study was proposed to take place in an Adult Training Centre which had far lower ratio of staff to attenders than the previous unit. Therefore, the decision was made for the researcher to conduct all the research sessions alone. An initial period of gaining familiarity with the Centre and with the attenders was required, as was training in administering psychometric assessments and conducting teaching sessions.

5.1.2.1 Participants

Twenty-four attenders at an Adult Training Centre (age range 20-41 years, mean of 28 years, SD = 7.16 years) were identified by their instructors as suitable for possible inclusion in a training study. Their IQs were assessed by the Wechsler Adult Intelligence Scale (Wechsler, 1955) and had a mean of 47.75 with an S.D. of 12.95 and a range from 68 to 20. This lower value was assigned to three attenders who failed to score in the measurable range for the WAIS.

All twenty-four attenders were baselined on eight baseline tasks (see "Baseline Tasks", section 5.1.2.4 below). From the data collected during this initial period, a final sample of one male and five female participants was selected. The mean IQ of this sample was 37.33 with an S.D. of 14.19 and a range from 54 to 20.

This final sample was selected on the basis of whether or not participants showed scope for improvement on most of the initial baseline tasks. (See Table 5, p.122.) If a participant was completely unable to perform the tasks or if they were performing at the maximum level on most of the tasks, they were considered to be unsuitable for a training programme.

5.1.2.2 Setting

The study took place within a local Adult Training Centre in Plymouth. The "Staff Room" was offered to the researcher for the purpose of conducting training sessions. This room measured approximately 5m x 5m and contained coffee tables and comfortable chairs. It was selected as the experimental room as it was self-contained and quiet during the normal activity periods of the Centre. It was the place in the Centre where any experimental sessions were least likely to be disrupted, but using the staff room meant that training sessions necessarily had to fit in around staff breaks. Similarly, the equipment had to be easily contained within a small space at the side of the room. Tables and chairs on which to set up the equipment were provided.

5.1.2.3 Equipment

The equipment and materials used in each of the three conditions are described below. Tasks to be taught were presented by three methods: Computer-taught, teacher-taught and video-taught.

The task components are outlined below. For details of the number of trials, criteria for correct and incorrect responses and the teaching procedures, please see the Teaching section (5.1.2.6.1) in the Procedure.

5.1.2.3.1 Computer taught condition

The tasks in the CAL condition were presented on a microcomputer system which comprised a BBC microcomputer, a Cumana single disk drive, a Microvitec CUB medium-resolution colour monitor and a STAR Concept Keyboard (A4 size).

The three CAL programs used, each presenting one of the tasks to be taught, were:

1. For picture completion, "Jigsaw" (Produced by Ega Beva Software (SESS) Ltd.)
This program presents a picture on the screen for about 10 seconds. The picture is then divided up into rectangular segments (there are three levels of difficulty available with 4,6 or 9 "pieces" respectively) and the picture reappears with the segments "scrambled" onscreen. The learner must then unscramble the pieces and, by doing this, reassemble the picture. This may be achieved as follows.

The overlay for the Concept Keyboard is divided into the same number of segments as the picture onscreen. Each segment on the overlay corresponds with a segment onscreen. The student may exchange the pieces on the screen by pressing consecutively the corresponding segments on the Concept Keyboard overlay that represent the exchange of pieces. For example, if the learner wishes to exchange the piece in the righthand corner for the piece in the lefthand corner, they would press the segment in the overlay's righthand corner followed by pressing the segment in the overlay's lefthand corner and the two pieces will exchange on the screen. They would continue in this fashion until the picture is complete. If and when the picture is correctly reassembled a tune is played.

2. For shape discrimination, "Specialsort" (Produced by Specialsoft).
This program teaches and provides practice on sorting and matching skills as follows. A T-maze appears on the screen with an object in either arm and, at the bottom of the maze,

another object corresponding to one of the objects in the arms of the maze appears. The student may send the object at the bottom into an arm of the maze in the following manner. Using the Concept Keyboard, the learner may move the object at the bottom of the maze into one of the arms. An overlay (provided with the programme) is placed on the keyboard. This shows the midline of the board and splits it into 2 halves. Pressing the left half of the Concept Keyboard sends the object into the left arm and pressing the right half sends the object into the right arm. A correct response is one of sending the object into the arm which contains its match.

There are three levels of difficulty in this programme. The easiest level is that of sorting plain single- coloured squares. The next more difficult level is sorting 2-coloured squares of different layouts (like flags) and the third and most difficult level is sorting pictures of "real-life" objects (e.g., a figure, house, dog, etc.). A correct response is rewarded by a tune playing while a graphic display flashes and moves onscreen.

3. For size discrimination, "Order" (Taken from the "Pre-reading" package produced by ESM Software)

This program teaches and provides practice on size discrimination and ordering shapes in sequence according to size. The learner may use a sequence of movements on the Concept Keyboard to select a shape and to place it in the correct order of size amongst a series of identical shapes that match it except for a difference in size. The three levels of difficulty to this task were represented by the task involving 3,4,or 5 shapes respectively. A correct response is rewarded by a short noise and flashing colours.

During the periods of teaching, the programmes were loaded and operated by the researcher. The participants were not expected to perform this initial part of the program's operation and would begin to participate in the teaching program at the appropriate point.

5.1.2.3.2 Teacher-taught condition

The tasks in the teacher-taught condition were designed to closely resemble the computer tasks. The two forms of task - teacher or computer - were intended to be analogous forms of one another. The following materials were used to present the tasks in the teacher-taught condition.

1. Picture completion (Jigsaws)

Three jigsaws were constructed by taking large and simple pictures from magazines and gluing them onto cardboard. These picture boards, of roughly A4 size, were then divided into 4,6 or 9 rectangular segments and cut up into pieces which were then covered in PVC. These three different sizes of jigsaw (4,6 or 9 piece) correspond to the three levels of difficulty presented by the computer-assisted jigsaw programme.

The participant was presented with the complete picture for about 10 seconds. This was then obscured from view by a large piece of paper held upright and the pieces were scrambled behind the paper. This scrambled picture was then revealed and the learner was asked to move the pieces to reassemble the picture.

2. Shape discrimination (Sorting)

The participant was presented with two dissimilar objects and a third matching object was placed 20cm away (as in an imaginary T-maze, with an object in each arm and the object to be matched at the bottom). The participant then had to move the object at the bottom to a position adjacent to its match. The three levels of difficulty were represented by sorting single-coloured counters, double-coloured "flags" and small figures of "real-life" objects.

3. Size discrimination (Ordering)

The participant was presented with toy barrels of increasing size. The barrels were arranged in a line in front of the participant in a random order and the participant had to place them in a line in the correct order from "smallest to biggest". The three levels of difficulty were represented by the task involving 3, 4 or 5 barrels respectively.

5.1.2.3.3 Video-taught condition

The video was of two attenders from the Training Centre performing each of the computer tasks for a 15 minute session. These attenders were chosen from the original pool of participants and were not included in the final sample. Clearly visible on the video was the screen display of the program, and the responses required of the participant. The experimenter could be seen and heard giving any necessary prompting (see Prompting Scheme (5.1.2.6.2) in the Procedure).

Each session of video-taught instruction consisted of the participant watching a 15 minute recording of a computer session.

5.1.2.4 Baseline Tasks

A baseline indicator of performance on each of the different tasks was taken before and after each cycle of the teaching sessions (see Design, 5.1.2.5). The procedure followed to take the baseline is outlined under "Teaching" (5.1.2.6.1) in the Procedure.

5.1.2.5 Design

Participants were randomly assigned to the three conditions according to the 3x3 treatment matrix of the confounded analysis of variance design outlined in Kirk (1968, p.336). This type of design allows all treatment combinations to be assessed on a relatively small number of participants. The running order of participants (S1 to S6) and conditions are shown in Table 4.

		Sessions 1-6		Sessions 7-12		Sessions 13-18	
	(BL1)	Task/Method	(BL2)	Task/Method	(BL3)	Task/Method	(BL4)
S1	I	Sort/Video	I	Jigsaw/Comp	I	Order/Teach	I
S2	I	Order/Video	I	Jigsaw/Teach	I	Sort/Comp	I
S3	I	Sort/Teach	I	Jigsaw/Video	I	Order/Comp	I
S4	I	Jigsaw/Comp	I	Order/Video	I	Sort/Teach	I
S5	I	Jigsaw/Video	I	Order/Teach	I	Sort/Comp	I
S6	I	Order/Comp	I	Sort/Video	I	Jigsaw/Teach	I

Teach = Teacher-taught **Video** = Video-taught **Comp** = Computer-taught
BL = Baseline assessment on all six tasks between series of sessions

Table 4. Treatment Matrix for Experiment 1.

Due to the number of combinations of conditions involved, the design can evaluate effects of task and type of instruction, but not the change over training sessions; change was evaluated by using improvement scores between baselines as the data for the analysis. The design controls for order of presentation of the conditions. The effect of time is not being tested, so the design requires that not every combination is represented during each training phase. However, all combinations are represented within the period of the study and the variance related to the treatments is partialled out in the analysis.

5.1.2.6 Procedure

5.1.2.6.1 Teaching

Each participant had six 15-minute teaching sessions on each task. These teaching sessions followed on a daily basis. Each participant was allowed to work at their own pace; therefore, the number of trials within each 15 minute session varied depending on type of task and the participant's ability.

Participants were started on the first level of difficulty for each task. Each presentation of a task was counted as one trial. If they responded correctly on two out of three trials at any level, they were presented with the next level of difficulty. Trials were discontinued after two consecutive incorrect responses. The adoption of this criteria for promotion to the next level or discontinuation was in keeping with criteria adopted by standardised assessment instruments, such as the WAIS. Subsequent training sessions commenced at the level of difficulty that had been achieved in the previous session.

For all tasks in the computer-taught condition, correct responding was praised using the inbuilt "reinforcers" of each programme as detailed above. Similarly, incorrect responses were met by the program's response. This was usually the sounding of a "negative" tone (sometimes accompanied by a flashing "X" onscreen) followed by the next presentation of a trial. If the participant failed every trial to criterion, they were told "You worked really hard today, _____." and their attention was diverted from the computer and no further reference to the session was made.

For all tasks in the teacher-taught condition, the following procedure was followed for correct and incorrect responses. Verbal praise (e.g., "That was good, _____!" "Well done, _____!") and social praise (e.g., smiles, a happy demeanour) was given for a correct response. If the learner failed any particular trial, the researcher said "Let's try again." in a neutral tone. If the participant failed every trial to criterion, they were told "You worked really hard today, _____", the materials were removed from sight and no further reference was made to the session.

Measures

The task performance indices measured were time (in seconds) to complete a trial, level of prompt required in order that the participant complete the trial (see Prompting Scheme below), and whether the response made for each trial was correct or incorrect.

5.1.2.6.2 Prompting scheme

Many teachers use a hierarchy of prompts (verbal, pointing, demonstration, physical guiding, etc.) as a method of shaping responding on a task, but in a way which is intended to allow the learner to retain the opportunity for independent work. That is to say, prompts are graded with regard to their level of intrusion and are given in a systematic fashion if and when the teacher observes that the learner is unable to proceed with the task.

In this study, prompts were used if necessary to help the participants engage with the task at hand. The hierarchy of the level of prompt was, from the lowest to highest level of prompt, verbal prompt (e.g., "Start now, _____", "Look at the screen, _____", "Press the board, _____") gestural prompt (e.g., pointing at the board or the screen), and physical prompt (e.g., guiding the participant's hand). A record of whether the participant required verbal, gestural or physical prompts was kept for each trial.

5.1.2.6.3 Baseline tasks

Baseline tasks were presented in the same fashion as in the teaching sessions with the following exceptions. During the teaching sessions, participants received initial instruction and subsequent prompting and reinforcement. During the baseline assessments, initial instruction and prompting on the first trial was given, but no subsequent prompting or reinforcement was provided. Each participant was started on at the lowest level of difficulty of each task and if the correct response was made on two out of three trials progressed to the next level. If they failed two or more trials on any level, the baseline on that task was discontinued. Subsequent baseline measurement always commenced from the lowest level of difficulty.

5.1.2.6.4 Feedback questionnaire

Immediately following the termination of the study, the participants were asked to take part in a feedback session on the computer-based work they had done in the training sessions. A six-item questionnaire was prepared (see Appendix 2i) which asked them for their views. Some indication of their ability to understand what could be perceived as complex questions on their attitudes toward the computer was obtained by administering a short (five-item) verbal comprehension screening test (see Appendix 2ii).

5.1.3 RESULTS

Since the absolute number of trials in each session was varied, the data reported here are the proportion of correct trials in a session (i.e., number of trials correct/total number of trials in session).

5.1.3.1 Participant selection and initial baseline data

The final sample of participants was selected from the original participant pool on the basis that their initial baseline performance indicated that there was scope for improvement on the majority of baseline tasks. A Friedman non-parametric 2-way analysis of variance was performed on these data to ascertain whether there were pre-existing differences between conditions at the initial baseline. This was not significant ($Xr^2 = 9.7552$, $df = 5$, $p > 0.05$). Table 5 presents the initial baseline data for these participants.

	Jigsaw/Comp	Sort/Comp	Order/Comp	Jigsaw/Teach	Sort/Teac	Order/Teach
S1	0	.66	0	.60	0	.50
S2	0	.66	0	.66	.66	0
S3	0	.33	0	.66	.33	0
S4	0	0	0	0	1.0	0
S5	.66	.33	.33	.50	1.0	0
S6	.60	1.0	.33	.66	0	0

Table 5. Proportion of correct responses on each task for each participant at Baseline 1.

A Pearson product-moment correlation was performed between the full-scale WAIS scores and the proportion of correct responses on the initial baseline tasks obtained by the original participant pool (N = 24). This correlation was significant ($r = .57$, $df = 22$, $p < .01$). The verbal and performance subscores of the WAIS also correlate significantly with baseline performance (Verbal subscore: $r = .40$, $df = 22$, $p < 0.05$; Performance subscore: $r = .52$, $df = 22$, $p < 0.01$). See Table 6.

	Verbal	Performance	WAIS	Baseline 1
Verbal	-	.63	.79	.39
Performance	-	-	.84	.52
WAIS	-	-	-	.57
Baseline1	-	-	-	-

Table 6. Pearson correlation coefficients for verbal and performance subtest scores, full-scale WAIS scores and proportion of correct trials at baseline assessment (BL1).

5.1.3.2 Efficacy of the different teaching methods

The data used in this analysis were improvement scores, i.e., improvement on the tasks over the 4 baselines as measured by changes in the proportion of correct responses on each task at each baseline. These improvement scores were obtained by calculating the difference in proportion of correct trials across a given period of time (e.g., from baseline 1 to baseline 2, from baseline 2 to baseline 3, etc.).

The effects of task and method of instruction on improvement scores were assessed using a 2-way, confounded analysis of variance with repeated measures (Kirk, 1968, p.336). The two factors, each with three levels, were: Method of instruction (3 levels: computer, teacher and observation) x type of task (3 levels: jigsaw, sorting and ordering).

There was no significant difference between the three types of task ($F_{(2,4)}$= 4.6859, p> 0.05). See Table 7. The difference between the three methods of instruction was not significant ($F_{(2,4)}$ = 4.0075, p> 0.05). See Table 8. Similarly, the interaction was not significant ($F_{(4,4)}$ = 2.7513, p> 0.05). The analysis of variance table is presented in Appendix 3.

Type of Task	Baseline 1-2	Baseline 2-3	Baseline 3-4	Overall Mean
Jigsaw	0.33	0.5	0	0.276
Sorting	0.055	0.12	0.336	0.17
Ordering	0.835	0.335	0.5	0.55

Table 7. Mean Improvement Scores by Type of Task

Type of Instruction	Baseline 1-2	Baseline 2-3	Baseline 3-4	Overall Mean
Computer	0.665	0.83	0.336	0.61
Teacher	0	0.67	0.33	0.33
Video observation	0.37	0.04	-	0.205

('-' indicates that this condition had no participants in the confounded design employed. However, this treatment combination was represented during an earlier phase of the study and it will be recalled that the effect of order has been controlled for in the design.)

Table 8. Mean Improvement Scores by Type of Instruction

5.1.3.3 Participant feedback

After the initial verbal comprehension screening test, five out of the six participants completed the feedback questionnaire by interview. All five were positive in their evaluation of the computer-based work. They reported that it had been enjoyable to learn new things and that, for example, using the computer "felt like working". Two felt that they would like to work much more on the computer and three suggested a balance between computer-based work and other activities (e.g., working in the laundry; working for the clothes factory). One said that they thought "a teacher was better than a computer". No one specific programme was singled out as most favourable, but participants said they liked the pictures and the sounds of the programmes. One complained that the rewards were repetitive ("all the same") on the "Sorting" programme.

Most participants wanted the Centre to have a computer to use and wanted their friends to have the opportunity to try using it. They thought they could also use it to play games on at breaktimes. One participant felt the Centre should not have a computer because some people might not like it and it would "make your eyes go funny".

5.1.4 DISCUSSION

The results indicate that there is no significant difference in the three methods of instruction. Previous studies comparing CAI with teacher instruction have also found no significant difference in the two methods (e.g., Ryba and Webster, 1983), so this study bears out previous findings. However, the small number of participants used in this experiment, and their large variability means that the statistical power of the analysis of variance to detect significant effects was low. It is quite possible that real differences between conditions were present, but were missed. Therefore, some of the trends that were evident in the data will be discussed.

Visual inspection of the data suggests that training by computer produced slightly greater gains than training by the teacher-taught method. Also, the relative effectiveness of either method of training depended on the task that was being taught; the greatest improvement occurred on the size discrimination ("Ordering") task as compared with the other two tasks. It may be that different tasks are better taught by different methods, but definite conclusions would have to await significant findings.

One difference between the tasks is that size discrimination involved a more complex response (putting objects in a sequence as opposed to putting them into one of two fixed positions). It is possible that some parameter of the training assisted this task more than the others. Observation of the participants during this task suggests that the computer-taught size discrimination was more stimulating and/or motivating than the teacher-taught version. It required numerous keyboard operations, each one of which would be reinforced and participants appeared to enjoy this action. The overall improvement score by task regardless of method of training may have been elevated by increased engagement during the CAL training. Clearly, one area of future research would be an investigation of the attributes of tasks that determine whether they are best taught by CAL or more traditional methods.

Regardless of the method of teaching, there were some overall differences in improvement on each of the three tasks. These differences in improvement could be a reflection of the difficulty of the tasks themselves (e.g., whether size discrimination is inherently different to shape discrimination) or of the task response characteristics (e.g., whether it is easier to make responses on a Concept Keyboard as opposed to manipulating objects on a tabletop). This difficulty in comparing task response characteristics was acknowledged earlier (e.g Baumgart and VanWalleghem, 1987). In the present study, attempts were made to match the tasks for the level of skill required to complete each task, but the task response characteristics were necessarily different. For example, during the running of the study it became clear that participants were able to complete the teacher-taught shape discrimination task more quickly and to attain a greater number of correct responses on this task that on the others.

In part, this may be attributable to the familiarity of the participants with a task such as this. One of the functions of the Adult Training Centre was to provide some opportunities for employment for the attenders. A local clothes factory provided the Centre with buttons and the attenders could be paid for sorting these buttons into similar groups. Experience such as this practise on a similar task may account for the participants greater speed and accuracy at shape discrimination during the study.

The prediction for the "passive" video-teaching method was that it would not be as effective as either computer-teaching or teacher-teaching. The results of the analysis of variance indicate that this was not the case. However, visual inspection of the means suggests that the amount of improvement on performance produced by video-teaching was lower than in the other conditions.

In the video-teaching condition, participants saw and heard exactly that which they would have seen and heard if they had been actively using the computer, so a possible explanation of the greater gains in the CAL condition is that observing the CAL task using this method helped participants perform the actual version of the task. Thus, some generalisation from this condition to the CAL condition may have been taking place. This elicits the issue of whether CAL may be an adjunctive form of instruction to other methods or whether other methods might enhance performance of CAL tasks. An interesting possibility here is that teaching the task using one method helps participants perform a component of the task that was hampering success in the alternative version of the task. It suggests an interchangeable role for different training techniques to help to overcome specific problems that prevent successful performance on a given task.

The lack of success of passive observation may also suggest that the mere demonstration of the task to the learner of the necessary responses for obtaining the visual and auditory "reinforcers" was not enough to support learning. Another interpretation is that active participation and "earning" the reinforcer is a requirement for learning and not just the presentation of the reinforcing stimuli. Theories of observational learning (e.g., Bandura, 1977; Miller and Dollard, 1941) state that it is possible to learn a behaviour by observing its occurrence even if the act is performed by another agent. These theories vary in their view of whether or not direct reinforcement of the observer is necessary for the acquisition to occur. The findings from this study that mere observation of sensory reinforcement was not effective in establishing the behaviour may be of some heuristic value in questioning the role of sensory reinforcement in CAL.

A problem encountered in this study was the adequacy of the performance indices used to measure "learning". One of the obstacles in cognitive models of learning discussed earlier was that of accounting for the cognitive abilities of someone who is severely motor handicapped and has been unable to derive knowledge through action, but nevertheless, has been able to develop intellectual skills (Rostron and Sewell, 1984).

This discrepancy between action and knowledge may be postulated in some CAL tasks. For example, the size discrimination ("Ordering") task required a complex series of responses on the Concept Keyboard and a participant might not be able to correctly perform this sequence, but they could verbalise the right solution without being able to perform the necessary sequence of actions to attain a correct response. It was noted that if there were occasions of a participant becoming frustrated and demoralised at their inability to perform the task response (and there were such occasions), they would give the right response verbally. However, this could not be counted as "correct" in terms of performing the computer task even though, clearly, the participant had learned the concept.

It can be seen that the direction of the discrepancy between knowledge and action may also be reversed. When a participant "earns" a reinforcer from a computer program, is it the proposed educational objective (which may be an abstract concept) which is being reinforced or is it the sequence of movements that produced the stimuli that goes with a "correct" response that is being reinforced? A test of generalisation is required, but this brings with it the difficulties of testing across different methods of instruction.

If CAL, which is largely performance based, is to be used there may be a need to screen for the ability to perform tasks. There was a positive correlation between the WAIS scores of the original participant pool and those participant's performance on the initial baseline which suggests some predictive ability of the WAIS regarding suitability for a training programme. The performance subscore was more highly correlated with the initial baseline data than the verbal subscore. The subsequent tasks were performance based and a higher performance subscore would indicate the potential ability to undertake such tasks. However, as just discussed, some of the participants did have difficulties performing the tasks, though they could verbalise the solution. The positive correlation was based on the scores of the entire original participant pool. The smaller group, having been selected by virtue of lower attainment scores at baseline, may represent different performance abilities. There may be some virtue in further exploration of screening assessments for identifying suitable CAL users.

The design of the present study enabled the desire to examine factors at multiple levels on a small number of participants within a manageable length of time given the special needs of the participants and the restrictions of the applied setting, but not without cost. The low statistical power afforded by the small numbers of participants, the considerable variability between participants and the nature of the analysis in attempting to make a large number of comparisons were all problematic in this study. The dearth of experimental research in the area of learning disability and CAL made an experimental study seem both necessary and attractive. However, the difficulties in adhering rigorously to "acceptable" methods of experimentation in order to meet these needs quickly became apparent. The outcome was that little could be definitely concluded from a study of this kind, though it served the purpose of raising further questions for investigation.

Research on a small heterogenous population in an applied setting carries with it many methodological difficulties, as outlined earlier. While there is an increasing awareness of the need for the use of alternative methodologies, there is a corresponding lack of acceptance of the power of such methods to make experimental comparisons. However, the relevance of high statistical power is perhaps questionable when it becomes necessary to conduct experimental research for the sake of it that may not lend itself easily to the conditions required for such testing.

Concerning the participants views of taking part in a training programme, on the whole, the feedback from the participants concerning their participation was good. They enjoyed using a computer and would do more computer-based activities if the facilities were available. They appreciated the industrious feel to the educational programs and also could see that playing games on it would be fun. They identified problems with CAL such as its repetitive nature and a lack of human interaction though they did want to use it with their friends. The overall feeling was that it offered a valued activity in a motivating fashion. Whether it would maintain its ability to motivate if introduced for a longer period of time is unknown.

5.1.4.1 Organisational and contextual factors

This research encountered the practical difficulties of any applied setting. While many of the difficulties in the previous study were avoided by using the researcher as teacher and choosing to work with a less challenging group of participants, there were new obstacles in the present study. For example, the staff room was utilised as the "experimental room". Occasionally, staff would wander in and out during teaching sessions and display their interest by intervening in the sessions. Some participants (and the researcher) were easily distracted by this and appeared apprehensive at being watched. There were further interruptions to the smooth continuation of experimental sessions by, for example, outings that participants were participating in, holidays and absence through sickness. Particularly noteworthy was the fact that when a baseline was attempted on a Friday, it had to be abandoned and reattempted in the following week because the participants demonstrated a complete lack of interest in working. Instructors from the Centre later explained that this was to be expected on a Friday as attenders anticipated the weekend in very "high spirits".

Also, the fact that the study took place during the two months of the year immediately preceding Christmas presented further interruptions. Throughout the Centre, there was a very joyful, if almost manic, anticipation of the festival with the usual routines taking second place to the preparations. This brought special problems of a practical nature. In the final days of the period of study, the experimental setting had to be suddenly changed and the equipment and training sessions were moved into a small storage room adjacent to the staff room. This was due to the space in the staff room, which had been designated to the purposes of the research some months previously, being needed for the purpose of storing and displaying Christmas cakes for the Centre's Christmas Fayre.

While the detailing of practical problems such as these may seem out of place in a psychological study, it points to more serious issues. First, it is in keeping with the usefulness of detailing practical difficulties to others who may be interested in implementing CAL or undertaking applicable endeavours of this kind. Second, it raises issues concerned with taking an application of technology and psychology into a novel environment.

With hindsight, the researcher became aware of many of the issues raised by writers such as Byrnes and Johnson (1981) who comment in depth on the process of implementing technology in mental health care systems and the resistance that is likely to be encountered in doing so. This resistance needs to be planned for and attended to. Adequate consultation that ensures the readiness of staff and a planned strategy for coping with difficulties is required, but this was lacking in this study. Staff were consulted beforehand and gave their support and approval to the planned research, but the underlying resentment or anxiety were manifested in such instances as staff entering the room when they knew experimental sessions were running or by the Christmas preparations taking priority over the research when its completion was imminent within days anyway.

Entering an Adult Training Centre to conduct a study may seem to a naive researcher a fairly innocuous event, but it does change (perhaps temporarily) the system within which it takes place. As this study unfolded, the communication of ideas and emotions regarding the implementation of the study and, more importantly, its implications became more open.

It became apparent that there had been a lack of consultation between the Manager of the Centre and the other staff who worked there regarding the running of the research in the Centre. Informal conversations with staff revealed that they felt left out and, in some instances, threatened by what was happening. Some staff felt fearful of the implementation of any new teaching technology and were concerned about "machines taking over". They felt that their role as human teachers and carers was, in some way, being undermined and with this came feelings of being devalued.

It had not occurred to the researcher that such emotions might arise out of the aim to conduct an empirical comparison of teaching methods. However, this experience enabled an awareness to be gained of the crucial necessity of ensuring adequate staff briefing over and above mere information-giving and of the need to assess any internal political issues of the unit that may interfere with the research. These objectives can take some considerable time to achieve and this should be allowed for in the research timetable.

In part, the knowledge gained from consideration of the above issues accounted for some of the obstacles encountered in the research (e.g., staff intervention in the experimental sessions). In general, this study reiterated the need for the careful consideration of the special conditions pertaining to applied evaluative research.

5.1.5 CONCLUSION

This study yielded no significant results and no firm conclusions regarding the relative efficacy of CAL against other methods of teaching, but it did fulfil the requirement of eliciting further questions to consider. For example, are different tasks best taught by different methods? Can non-computerbased tasks serve an adjunctive role to CAL tasks or *vice versa*? What is the role of reinforcement and how does it function in establishing "correct" performance on a computer-based task?

Overall, a problem with this particular area of investigation is that there is the lack of an integrated framework of theory upon which to lay any findings and begin to organise them. So far only fragments of theories have been utilised. When such theory is lacking, it is necessary to start from scratch and build up knowledge using a "common-sense" approach. Existing evaluative studies have taken this as their starting point as did the present study. So, it started off with a general aim of comparing different methods of teaching.

However, the difficulty with such "common-sense" psychology is that, while it can serve as a useful initiation of investigation, its conclusions can only be weak. It seems that a further disintegration (or dissection) of the object of study is necessary in order to more usefully identify components of CAL and learning that may stand up to greater theoretical examination. For example, any specific differences in any mechanisms of learning occurring during the different methods of instruction could be looked at.

The next study presented in this chapter takes a further step toward unravelling component processes of the action of learning through CAL or learning with a teacher.

5.2 EXPERIMENT 2. A comparison of computer-taught and teacher-taught instruction:An analysis of staff and learner behaviours.

5.2.1 INTRODUCTION

From the outset, one of the questions asked about CAL has been "Is it any better than or different to teacher-taught instruction?" Commonly, changes in achievement gains, such as number of correct responses, have been used in an attempt to answer this question and there are examples of studies of this nature reviewed in Chapter Two (e.g., Ryba and Webster, 1983; Trifiletti, Frith and Armstrong, 1984). However, changes in participant behaviours during the use of CAL have also been used to point to differences between teacher-taught and computer-taught instruction. For example, Baumgart and Van Walleghem (1984) found that on-task behaviour increased during teacher-taught individual tuition and off-task behaviour increased during CAL. However, Plienis and Romanczyck (1985) found the opposite; that is to say that disruptive behaviour increased during individual tuition as compared to its rate of occurrence during CAL. Ryba and Webster (1984) noted that self-directed behaviour occurred more often, aggressive behaviour diminished and changes in affect occurred while learners were using CAL.

It is clear that there is some potential for differences in behaviour during either computer-taught instruction or teacher-taught instruction, though it is as yet unclear whether any differences between the two mediums can be reliably demonstrated. Such differences may help to identify components of learning that differ during the two forms of instruction. For example, it is often stated (and assumed) that CAL has the potential to be "motivating" for the learner (Hogg, 1984; Ager, 1985). Therefore, one might expect to observe behavioural correlates of increased motivation during CAL that would not be apparent during teacher-taught instruction. Such a correlate might be an increase in ontask behaviour, signifying increased engagement with the task as a result of it being motivating for the learner.

Another example is the identified potential of CAL to increase the amount of active self-directed responses on the part of the learner (Rostron and Sewell, 1984). One way to assess whether this is occurring is to look at changes in the amount of prompting given by staff during the two forms of teaching. The role of prompting in directing the learner and helping them to gain independent responding was outlined in the previous experiment. One might expect that the amount of prompting or teacher intervention required for the learner to complete a task would differ between teacher-taught and computer-taught instruction, perhaps with less prompting needed during computer-taught instruction. From the studies and hypotheses reviewed thus far, such potential differences in behaviours during the two conditions might be expected, but they need to be empirically demonstrated.

The next experiment aims to investigate differences in behaviours occurring during teacher-taught and computer-taught instruction to adults with profound and multiple handicaps. Its first aim is to investigate the use of computer-taught or teacher-taught instruction with this population in terms of performance measures that are not solely achievement gains (e.g., ontask and offtask behaviour together with correct or appropriate responding). Secondly, it will address the role of staff interaction with the learner while utilising the two different teaching mediums.

5.2.2 METHOD

5.2.2.1 Participants

This study took place at a Local Authority Special Care unit for adults with profound and multiple handicaps. From a group of all attenders at the Day Care Centre, eight attenders (four male attenders and four female attenders), were selected to participate in the present study. They were selected on the basis of a "screening test" (see Appendix 4) which consisted of attempting to use a few different CAL programmes and switches with each person to see if they showed any interest or ability in working on computer-based activities. Those attenders that were disruptive, or who were distressed by the activities, or who showed no interest in the activities were not included in the study. The opinion of the Centre's staff was also sought regarding who they felt would be able to take part in a training study.

An attempt was made to ascertain the relative developmental level of functioning of the final sample of the eight attenders using Griffiths' Mental Developmental Scales (Griffiths, 1954), but this was largely unsuccessful. Participants demonstrated mastery of a range of test items, but these points were widely scattered across the five subscales of the test and no one participant completed enough of the test battery to allow a calculation of Mental Age. As a guide, an inspection was made of the highest scoring items for all participants. These corresponded to a range of functioning at the developmental level of 6 months to 24 months, with the average being a developmental level of 16.5 months. The mean chronological age of participants was 24 years 4 months, with a range of 19 years to 32 years.

These participants were profoundly handicapped and all but two of them also had physical disabilities. Examples of their disabilities include paraplegia, epilepsy and limb spasticity. All needed assistance with daily living skills. In general, communication was achieved using simple vocalisations, facial expressions and physical displays of intention (e.g., pointing to what they wanted or trying to take it; being physically prompted by staff to partake in activities, etc.). They were attending a Day Care Centre which provided day-to-day activities and which also had some educational remit in terms of providing training and/or rehabilitative opportunities. None of the participants had used a computer before.

5.2.2.2 Setting

A room in the Centre was allocated to the researcher for the purposes of conducting the study. This was self-contained and in a quiet area of the Centre, a short distance from the main activity rooms. The room measured approximately 4m x 5m and contained two tables, chairs and, in a corner, a video camera set up on a tripod. The computer system (see "Equipment") was set up on one table and the other was used for tabletop teaching. There was sufficient access for the two participants who used wheelchairs. There were blinds on the windows which were used to darken the room, thereby increasing the contrast of the computer screen. No other materials were kept in the room and it was not used for any purpose other than the research during the period of the study.

5.2.2.3 Equipment and materials

The computer-based tasks were presented using a microcomputer system which comprised a BBC-B microcomputer, a 200k single disk drive and a medium resolution monitor.

The teacher-taught tasks were presented by staff from the Centre. These staff had received training in behavioural methods of teaching by completing an "EDY" course. [Education for the Developmentally Young, Foxen and McBrien (1981); McBrien and Foxen, (1981)].

Full procedural details regarding the length and presentation of sessions are found in the Procedure below.

Computer tasks: software, switches and procedure

The software used is commercially available rather than designed for research purposes, and it was produced specifically for a special care population.

1. "Build" (Special Care Software produced by Alan Nixon)

This is a piece of "cause and effect" software. A blank screen is presented and if a switch is activated, part of a simple picture of an object appears. Subsequent activations of the switch result in further presentations of parts of the object. Each presentation of a new part is accompanied by a noise. Eventually, after a series of presses, the picture is "built" and the object appears complete. When the picture of the object is complete, music plays and the graphics alter so movement is perceived onscreen. For example, the object in the picture may be a rocket and it "takes off"; if it is a stationary object, such as a picture of a house, the surround will flash in different colours. Five pictures of objects were available: a rocket, a submarine, a helicopter, a man and a house. These were presented randomly as the programme ran.

In the present study, the switch used to activate the software was a sturdy box-shaped device constructed from wood. It had an angled sprung lid set at approximately 45 degrees to the horizontal 8 cm above table height that could be depressed slightly by pressing on it. A microswitch was placed in the box and any downward pressure on the lid would act as a lever to complete the switch circuit. A light but definite "press" with the hand on the top of the angled panel would activate the switch, thus running the programme.

The participant was seated at the table on which the computer system was placed and the monitor was arranged to be in the participant's line of view (usually at head height). The switch was placed on a non-slip mat on the table within the participant's reach. The participant was prompted to watch the teacher and the first press of the switch (and, consequently, the first placing of a part of the picture onscreen) was modelled for the participant. The participant was prompted by the teacher, using the verbal-gestural-physical prompting hierarchy described in the last study, to "Press the switch, _____". If the participant pressed the switch but did not look at the screen, the participant was prompted to "Look at the screen, _____" using the same prompt hierarchy. If all prompts failed, the task was modelled for the participant by the teacher, while the participant was prompted to look at the performance of the task.

2. "Scrib" (Produced by Computer Applications to Special Education, University of Keele) This programme utilises the ability of the computer to be a "drawing pad". It is operated by moving a joystick in any direction away from its vertical resting position. When the joystick is moved, coloured lines which correspond to the movement appear on the screen, i.e., it mimics the action of "scribbling" on the screen. As the lines appear, they are accompanied by a somewhat unmelodious sound of varying pitch.

Any commercially available joystick may be used to operate this programme. In this study, given the unpredictability of the participants' physical responses (and strength), it was decided not to use the usual "lightweight" joysticks that are widely available. Instead, a "heavy-duty" joystick was utilised that had been constructed to withstand considerable mechanical pressures. The instructions for building this are contained in a catalogue of switches ("Switches and Interfaces") available from the "Aids to Communication" Centre, Ormerod School, Oxford.

Again, the participant was seated at the table with the monitor at head height. The teacher modelled the task while encouraging the participant to watch. Then, the joystick was placed on a non-slip mat within the participants' reach and the participant was prompted using the prompt hierarchy to "Move the stick, _____." and "Look at the screen, _____." As above, further modelling was used if necessary.

Teacher tasks: materials and procedure

1. "Rocket" ("Pop-up Rocket", Kiddicraft Ltd.)

This task was the teacher-taught version of the computer task "Build". The Pop-up Rocket comprises five plastic pieces which are placed on top of one another to build a rocket. The pieces are designed to be easy to manipulate and to require little effort to lock together when placing them one on top of the other. When the rocket is complete, a button may be pressed at its base that will "launch" it.

Participants were required only to place one part on top of another. They did not have to decide in which order to place the pieces. Just as the "Build" programme demonstrated the correct order and the same order each time in which to "place" the parts of the picture, so too were the parts of the rocket handed to the participant in the correct order and the same order every time by the teacher.

The participant was seated at the table. The base of the rocket was placed on a non-slip mat in the participant's eyeline and within reach. The first part was placed on the base by the teacher and the participant was prompted to look. The next part to be placed was handed to the participant and they were prompted to "Build the rocket,_____." Prompting and modelling were used as required.Each successful response by the participant was reinforced by the teacher saying, for example, "Good! _____." When the building of the rocket was complete, more verbal and social reinforcement was given (e.g., "Well done, _____." "Look at what you've done".) and the button to "launch" the rocket was pressed.

2. "Crayon"

This task was the teacher-taught version of the computer task "Scrib". This was the task of moving crayons across blank sheets of paper to produce coloured lines. The participant was seated at the table and crayons and paper placed in front. The teacher modelled moving the crayons on the paper to produce "scribbles". The participant was presented with a blank sheet of paper and prompted to "Move the crayon, _____." and to look at the coloured lines that were produced. Prompting and modelling were used as necessary. If "scribble" was reinforced with "Good! _____" and, at the end of the period, further verbal and social reinforcement were given by the teacher, e.g., "Good! ____." " Well done." "That's a nice drawing!".

In order to make a comparison between computer-teaching and teacher-teaching, an assumption was allowed that each pair of computer and teacher versions of the task (i.e., "Build" + "Rocket" and "Scrib" + "Crayon") represented conceptually analogous tasks.

Clearly, any task that takes place either on or off a computer cannot be truly equal in both of these versions. However, in order to begin to understand any potential differences in the two methods, it seems necessary to make this assumption about the conceptual equivalence of the tasks that are taught. In this study, expert opinion and the availability of software that was of an appropriate level for this group of learners was used to guide the researcher in the construction of equivalent tasks.

5.2.2.4 Design

An alternating treatments, repeated measures design was used. (See Table 9.) The type of task, order of teaching and the identity of the teacher who would provide the teaching was counterbalanced across the group of participants and participants were randomly assigned to these different orders. Each participant received teaching on each of the four tasks. Baseline assessments were taken at the start of the study, after each teaching phase and at a 1 month follow-up.

Order of Baselines and Training Phases for each Participant										
	bl1	tr1	bl2	tr2	bl3	tr3	bl4	tr4	bl5	bl6
s1		Rocket		Build		Crayon		Scrib		
s2		Rocket		Scrib		Crayon		Build		
s3		Crayon		Scrib		Rocket		Build		
s4		Crayon		Build		Rocket		Scrib		
s5		Build		Rocket		Scrib		Crayon		
s6		Build		Crayon		Scrib		Rocket		
s7		Scrib		Rocket		Build		Crayon		
s8		Scrib		Crayon		Build		Rocket		

bl = Baseline tr = Training Phase

Table 9. Treatment Matrix for Experiment 2.

5.2.2.5 Procedure

5.2.2.5.1 Teaching

Participants received teaching on the four tasks outlined in "Equipment and Materials" above (5.2.2.3). The teaching sessions took place in the experimental room. The running order of participants, teachers and tasks was put up on the wall in the main activities room. This was checked at the start of each day and participants were taken by the appropriate teacher to the experimental room at the right time. The software was loaded or the materials for the teacher-version of the task were made ready by the teacher. The participant was sat at the appropriate table and the teaching of the tasks would begin. Teaching sessions lasted for ten minutes and participants worked at their own pace, so the number of trials per session varied. For each trial, the graded prompt procedure was used as outlined earlier.

Each participant received three teaching sessions per week for two weeks on each task, making a total of six teaching sessions on each task. The nature of the Centre's staff to client ratio and the needs of the entire group of attenders there made it necessary that only four participants have teaching sessions each day. Therefore, for each participant, teaching sessions took place every other day. The study ran for a total of 63 working days; that is, for approximately 3 months.

5.2.2.5.2 Baselines

A baseline assessment session consisted of presenting each task to the participant for five minutes in a session of approximately twenty minutes. It was asked that, after arranging the materials or loading the programme, the teacher was to leave the participant to work independently as much as possible and to intervene only as necessary.

It was arranged that baseline assessments only occurred after a maximum of a break of 1 day in the series of teaching sessions (i.e., after a series of 6 teaching sessions on a task, there could only be a break of 1 day before a baseline assessment would begin). Three baseline sessions, which took place over three consecutive days, constituted each baseline assessment (i.e., three sessions for Baseline 1, three sessions for Baseline 2, etc.). The order of task presentation and the identity of the teacher was balanced across the baseline sessions.

5.2.2.5.3 Measurement

All the baseline and teaching sessions were recorded on videotape using the video camera in the corner of the experimental room. Staff would start the camera running at the beginning of a teaching session. It was set to record on auto-focus and needed no other intervention except to switch it off at the end of a session.

These recordings were then viewed by the researcher and an observer. Selected target behaviours (detailed below) were encoded on a Epson HX-20 portable computer using software designed for behavioural observation and sampling (Felce, deKock, and Repp, 1986).

5.2.2.5.4 Target behaviours

A random sample of recordings were viewed and a range of behaviours that staff and participants demonstrated were noted. Some examples of notes of the participants' behaviours include looking at the task materials, looking around the room, manipulating the switches, eye-poking (self-injury), throwing task materials, shouting and scratching staff. Examples of staff behaviours include pointing to task, giving praise (clapping, patting on the back, saying "Well done!"), watching the participant and attempting to reduce some participants' inappropriate behaviours (by holding participants' hands down, saying "No!" "Hands down.", etc.).

These preliminary viewings, together with discussion and agreement between the researcher and observer, led to the establishment of six categories of behaviour that would be targeted and encoded. There were three categories of staff behaviours and three categories of participant behaviours, as listed below.

Teacher behaviours

1. Prompting - This category included all instances of verbal prompting, gestural prompting and physical prompting given by staff to the participant.

2. Modelling - This category included all instances of the teacher demonstrating the task (or parts of the task) to the participant. This differs from prompting in that the teacher actually performs the action in front of the participant and then prompts the participant to do the same action.

3. Reinforcement - This category included all instances of staff rewarding participants for paying attention or making a successful response. Verbal and physical rewards were clearly observable, but the concept of social reinforcement is not easily defined as a category to observe. For this reason, this category was limited to verbal and physical rewards with the assumption that these are associated with social reinforcement if given by one person to another.

Participant behaviours

1. Ontask behaviour - This category included behaviours of engagement with the task where the participant was attending either to the task, to the consequences of the task or to the teacher's prompting and modelling. For example, this includes looking at the task materials, handling the switches, looking at the computer monitor and watching the teacher perform the task.

2. Correct response - This category includes the instances when the participant made a successful response on the task at hand. Strictly speaking, it cannot be classified as "correct"; for example, there is nothing that can be either "correct" or "incorrect" in the "Crayon" task. Here it is taken to mean that the participant makes a response that is consistent with the task objective. In the "Build" task, this is to press the switch. For "Scrib", it is to move the joystick. For "Rocket" it is to place one part upon another. Lastly, for "Crayon" it is to move the crayon over the paper and leave a mark.

3. Inappropriate behaviour - This category includes any behaviours that are not appropriate to the task in hand. Examples of this may include throwing task materials across the room, hitting out, shouting and self-injury.

5.2.2.5.5 Reliability of observations

Before analysing the videotapes and encoding these behaviours, it was necessary to determine the reliability of such observations. In all, there were many hours of videotape to analyse and encode and resources did not allow every session to be observed and rated by two observers. Therefore, an estimate of inter-rater reliability was calculated for each behaviour in a randomly selected representative sample of the sessions. These sessions constituted about 1/10th of the total video time. Determination of reliability for these sessions would establish whether each observer was reliably encoding instances of the categories of behaviour. It was then anticipated that, having established reliable encoding, observers could watch, analyse and encode the videotapes independently.

Unfortunately, details of the calculation of the reliability coefficients given below are not available as they were calculated using the "Reliability" reliability programme which was contained in the behavioural observation software which ran on the Epson HX-20. A description of the program is given in Repp, Felce and Karsh (1991): "The (second) Reliability routine is for duration data...data are analysed in terms of the number of seconds each event occurred...a reliability statistic is directly related to the number of seconds of agreement. The computer scans each observer's record and calculates the number of seconds of agreement of occurrence, the seconds of agreement on non-occurrence and the seconds of disagreement for each event. Interobserver agreement percentages are then calculated for occurrence, non-occurrence, and whole session reliability for each code (event) in the traditional manner (Hartmann, 1975)."

On average, across all the target behaviours, agreement between the observers was 88.3%, with a range of 99% to 55%. This average observation reliability for the target behaviours was considered acceptable for the raters to independently rate and encode the videotapes. The videotapes for all the baseline sessions were then viewed and analysed for the target behaviours. These target behaviours were simultaneously encoded using the Epson HX-20. Thus, a continuous behavioural observation was performed that measured the duration of each target behaviour that was evident (in seconds per session).

5.2.3 RESULTS

It was considered that three factors were of relevance in determining any differences in the amount of time spent in each target behaviour. Two of these factors were whether or not the task was presented on the computer (COMP) and which type of task (TASK) was involved - a crayoning action (either on "Scrib" or "Crayon") or a building action (either on "Build" or "Rocket"). The other factor was time, across baselines 1 to 6 (BL).

It was decided to focus the analysis on three of the target behaviours: Ontask, Correct Responding and Prompting. This was because there were relationships that were possible between the variables that may have confounded the analysis. For example, it would be expected that if a participant was demonstrating ontask behaviour, they could not also be demonstrating inappropriate behaviour. Similarly, if staff were engaged in prompting, they could not also be engaged in modelling. With regard to reinforcement and correct responding, it is apparent that there would be a relationship between these two variables as follows. If correct responding increases, so would the amount of reinforcement increase. Therefore, the three measures of Ontask, Correct Responding and Prompting were selected as being representative of the behaviours occurring and they would be used to assess the amount of time spent attending to the tasks, the amount of successful responding on the tasks and the amount of help participants required during the tasks.

5.2.3.1 The effects of type of task, computer versus teacher instruction and time

The effects of the two types of task ("building" or "crayoning"), whether or not instruction was given by computer or teacher and time were assessed using a three-way analysis of variance. In order to rule out effects of the month which elapsed between the teaching phase and follow-up, the data from these phases was analysed separately and the results for the teaching phase (Baselines 1-5) and the follow-up phase (Baselines 5-6) of the study are presented separately. The analysis of variance tables are presented in Appendix 5. Unless otherwise stated, for all significant differences reported below, p was equal to or less than .01.

Results from the teaching phase (Baselines 1-5)

Ontask behaviour

For Ontask, there was a significant effect of time ($F_{(4,132)} = 11.066$) and type of task ($F_{(1,132)} = 11.221$) and type of instruction ($F_{(1,132)} = 4.651$, $p < .05$), but there were no significant interactions. Follow-up analysis [Fisher's protected test of least significant difference (in Snedecor and Cochran (1980), p.234)] revealed that there was significantly more Ontask behaviour evident in Baselines 2 and 3 than there was in the other baselines, which were not significantly different from each other (Fisher's LSD = 29.22). See Figure 2 below. Also, there was significantly more Ontask behaviour during the "building" tasks than during the "crayoning" tasks (see Figure 3 below) and during the computer instruction than during the teacher instruction (see Figure 4 below).

Correct responding

For Correct Responding, there was a significant effect of time ($F_{(4,132)} = 6.766$) and task ($F_{(1,132)} = 21.284$) and type of instruction ($F_{(4,132)} = 5.105$ (p , .05). The interaction between time and type of task was significant ($F_{(4,132)} = 4.377$). An analysis of the simple main effects revealed that there was significantly more correct responding evident on the "Crayoning" tasks than on the "Building" tasks during baselines 2, 4 and 5 ($F_{(1,75)} = 6.733$ ($p < .05$), 10.507 and 18.629 respectively). There was no difference between tasks at the other baselines. There was a significant difference for time on "Crayoning" tasks ($F_{(4,120)} =$ 10.607). The follow-up analysis revealed that during baselines 2, 4, and 5 there was more correct responding than during the other baselines, which were not significantly different from each other (Fisher's LSD = 15.85). See Figure 5 below.

In addition, there was a significant interaction between time and type of instruction ($F_{(4,132)} = 3.226$, $p < .05$). An analysis of simple main effects revealed that time was significant with computer-taught instruction ($F_{4,120)} = 7.199$) and with teacher-taught instruction ($F_{(4,120)} = 2.802$, $p < .05$). For the computer taught tasks, there was significantly more correct responding during baselines 4 and 5 than there was during the other baselines which were not significantly different from each other (Fisher's LSD = 22.44). For the teacher taught tasks, there was significantly less correct responding during baseline 3 than during the other baselines, which were not significantly different from each other (Fisher's LSD = 22.44). There was a significant difference for computer-taught instruction at baselines 4 and 5 ($F_{(1,75)} = 6.244$ ($p < .05$) and 8.516 respectively) than there was during the other baselines, which were not significantly different from each other. See Figure 6 below. No other simple main effects were significant.

Prompting

For Prompt, there was a significant effect of type of instruction ($F_{(1,132)} = 10.818$), time ($F_{(4,132)} = 4.969$) and task ($F_{(1,132)} = 6.307$, $p < .05$) and there was significant interaction of type of instruction with task ($F_{(1,132)} = 4.242$, $p < .05$). Follow-up analysis (test of least significant difference) revealed that there was significantly less prompting during Baselines 4 and 5 than there was in the other baselines, which were not significantly different from each other (Fisher's LSD = 12.34). See Figure 7 below. An analysis of simple main effects revealed that there was significantly more prompting evident during the "building" tasks than the "crayoning" tasks ($F_{(1,78)} = 14.278$) (see Figure 8 below) and on the teacher-taught tasks ($F_{(1,78)} = 10.42$) (see Figure 9 below). Follow-up analysis revealed that there was significantly more prompting evident on the "rocket" task than on the other tasks, which were not significantly different from each other (Fisher's LSD = 11.05).

Results at 1-month follow-up

These results were obtained by performing a three-way analysis of variance as above on the data from Baselines 5 and 6.

For Ontask behaviour, there was a significant effect of task ($F_{(1,62)} = 6.414$). There was significantly more ontask behaviour during the "building" tasks than during the "crayoning" tasks (see Figure 10 below).

For Correct Responding, there was a significant effect of task ($F_{(1,62)} = 25.391$) and type of instruction ($F_{(1,62)} = 11.909$). There was more correct responding evident during the

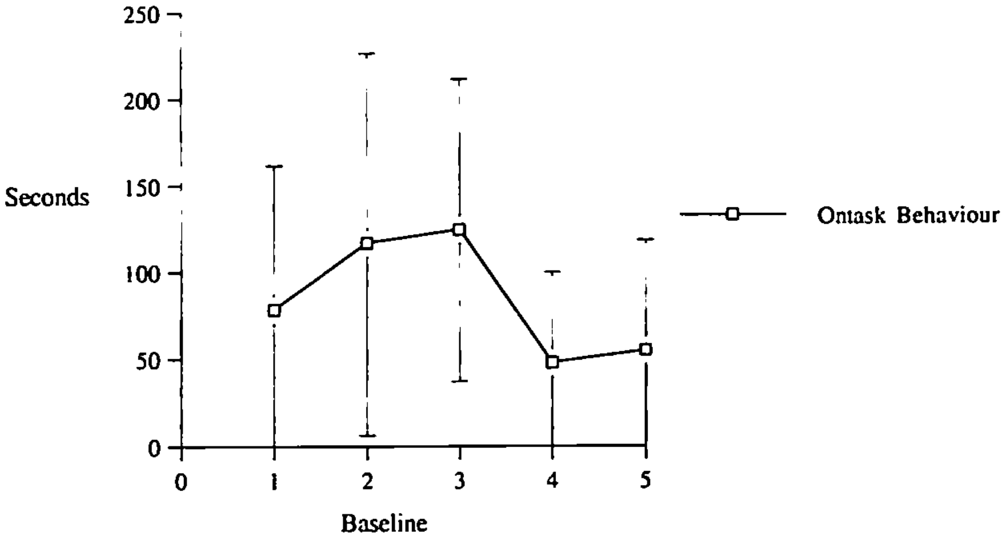


Fig.2 Mean Ontask Behaviour across Baselines 1-5

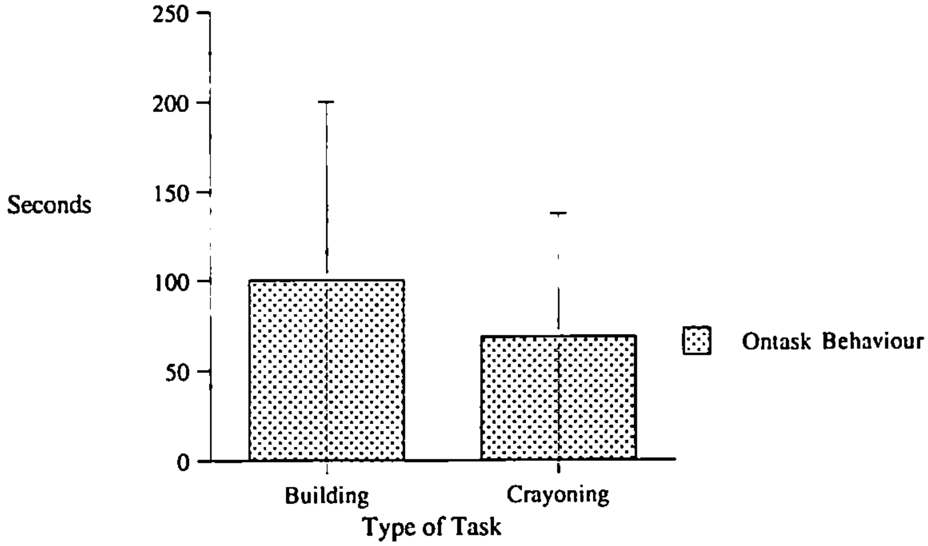


Fig. 3 Mean Ontask Behaviour by Type of Task

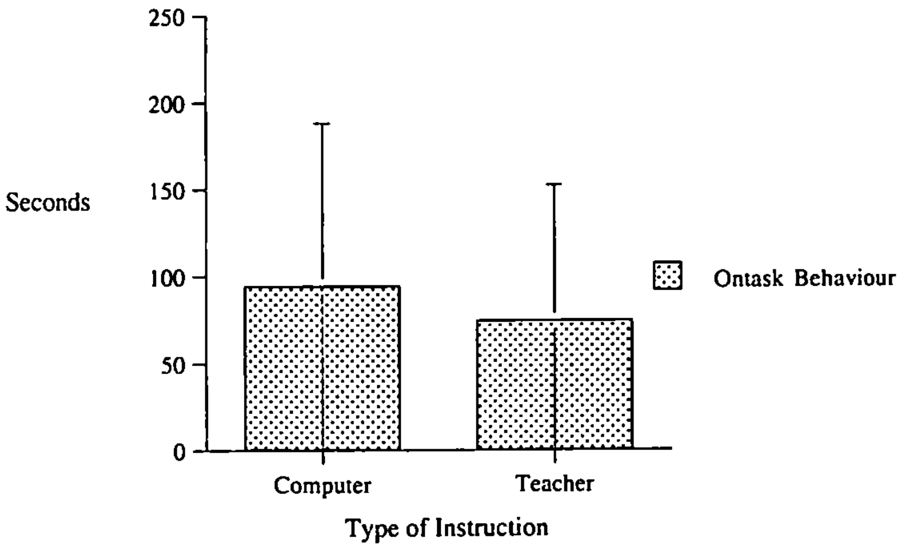
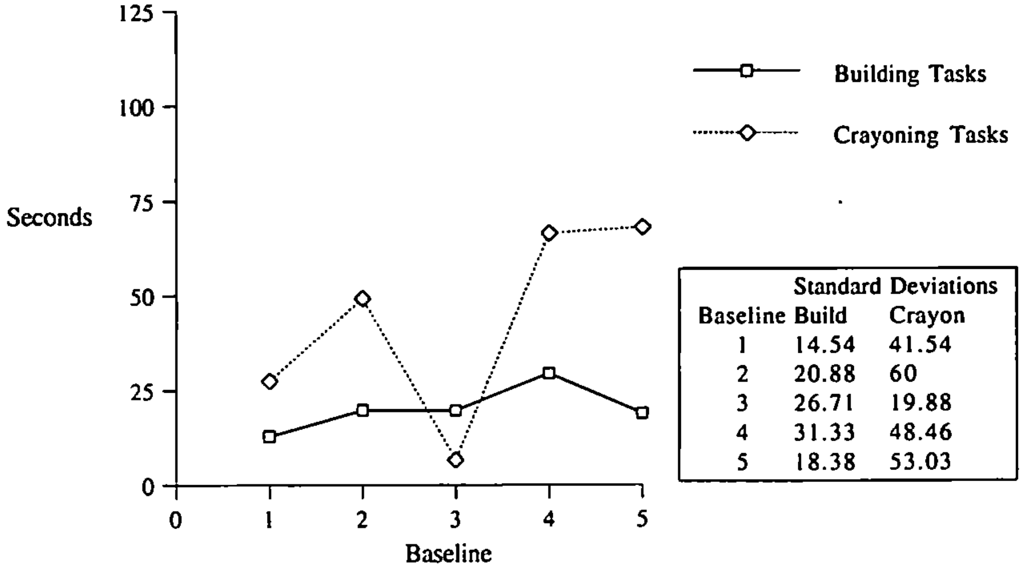
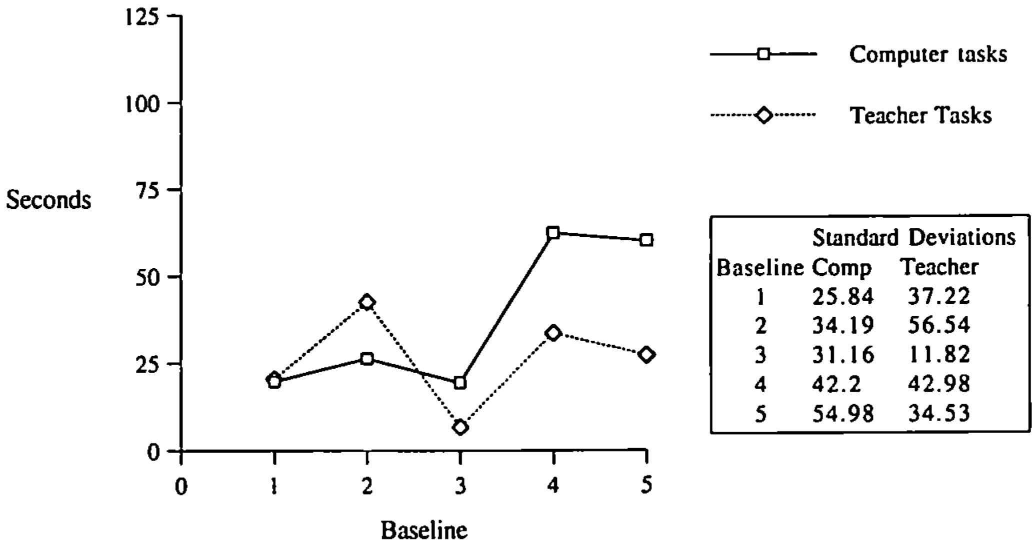


Fig. 4 Mean Ontask Behaviour by Type of Instruction



	Standard Deviations	
Baseline	Build	Crayon
1	14.54	41.54
2	20.88	60
3	26.71	19.88
4	31.33	48.46
5	18.38	53.03

Fig.5 Mean Correct Behaviour by Type of Task and Time



	Standard Deviations	
Baseline	Comp	Teacher
1	25.84	37.22
2	34.19	56.54
3	31.16	11.82
4	42.2	42.98
5	54.98	34.53

Fig. 6 Mean Correct Behaviour by Type of Instruction and Time

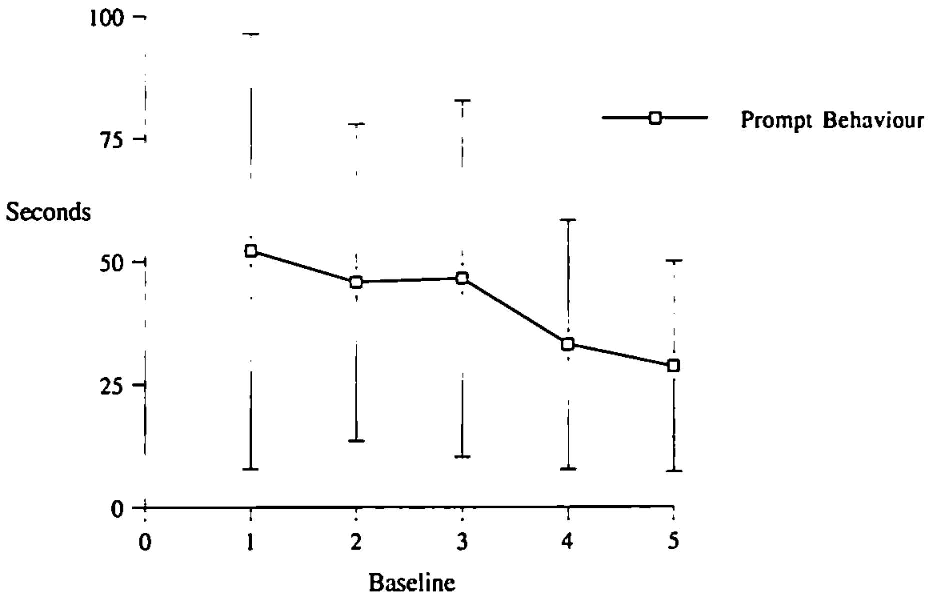


Fig. 7 Mean Prompt Behaviour across Baselines 1-5

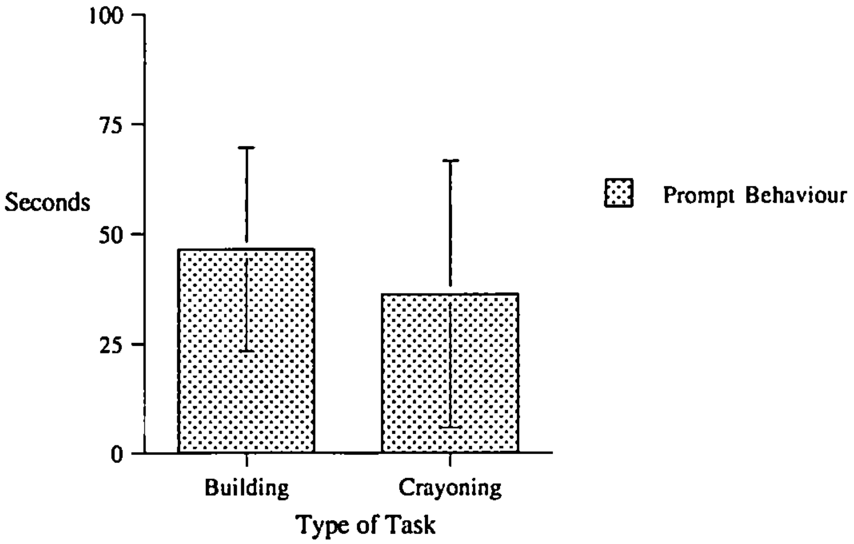


Fig. 8 Mean Prompt Behaviour by Type of Task

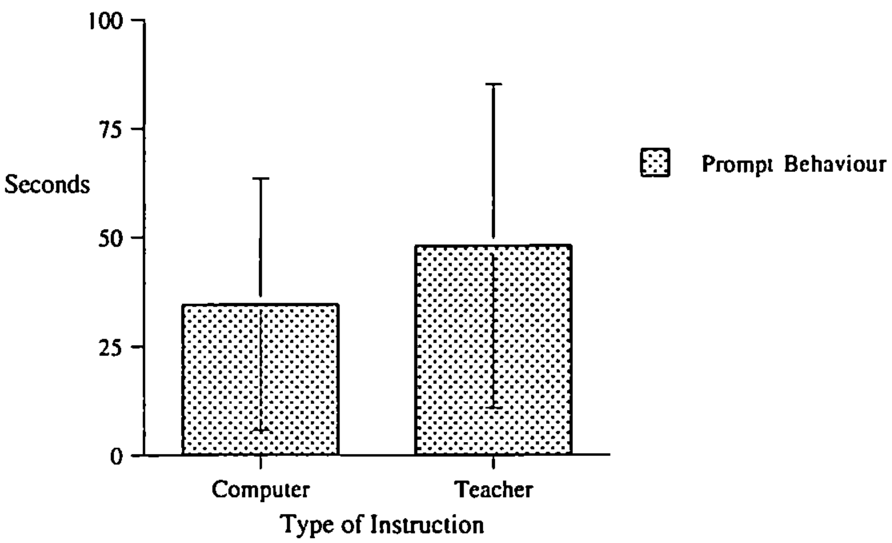


Fig. 9 Mean Prompt Behaviour by Type of Instruction

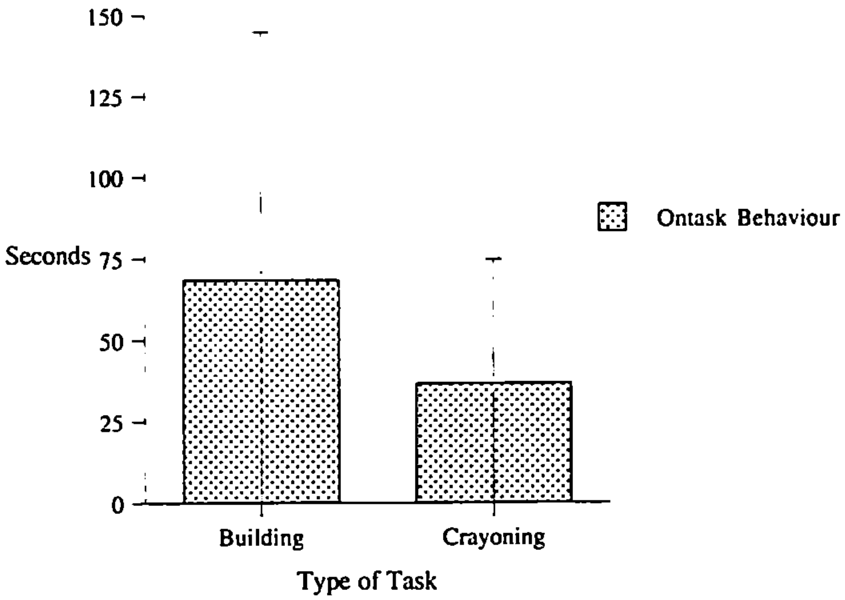


Fig. 10 Mean Ontask Behaviour by Type of Task at Follow-up

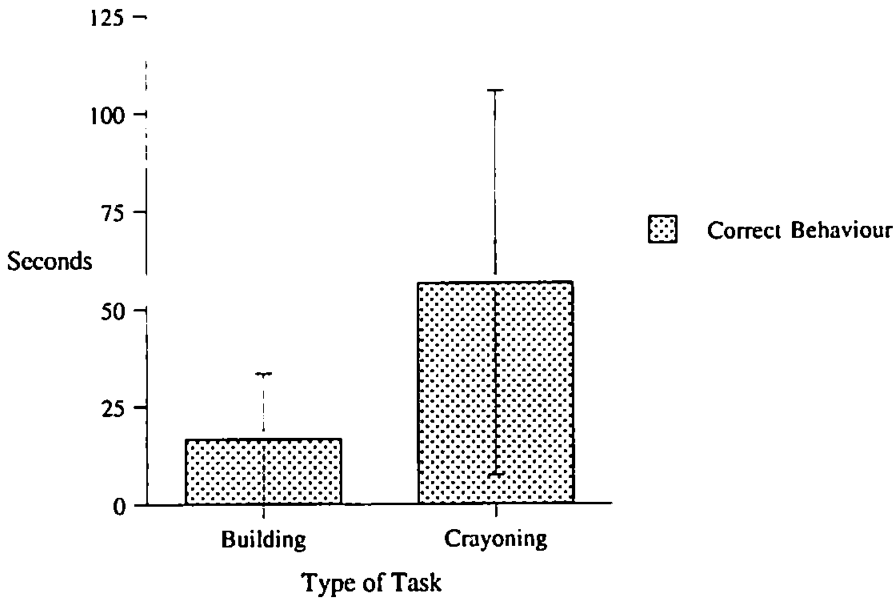


Fig. 11 Mean Correct Behaviour by Type of Task at Follow-up

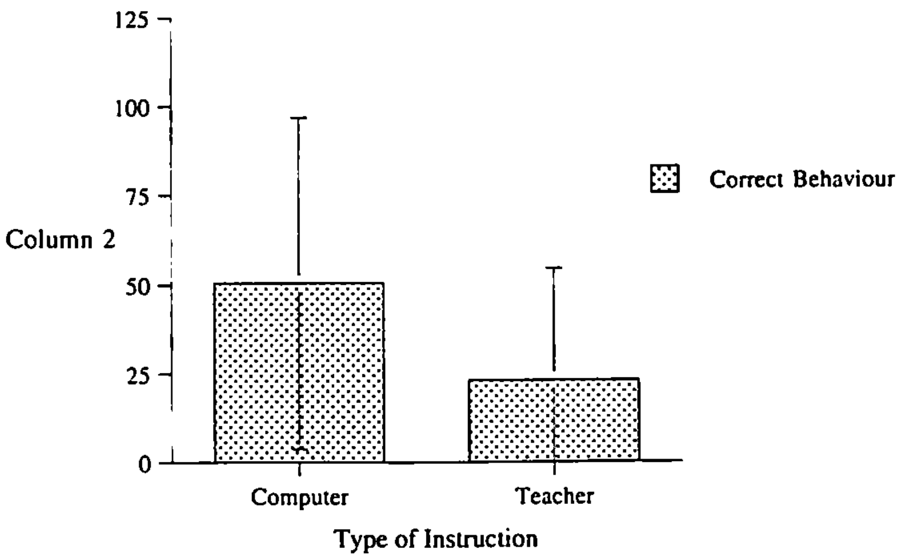


Fig. 12 Mean Correct Behaviour by Type of Instruction at Follow-up

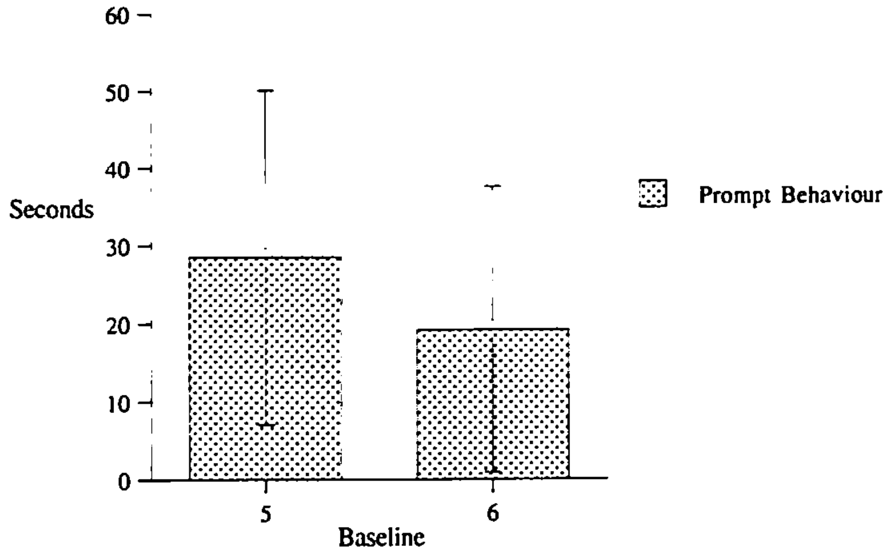


Fig.13 Mean Prompt Behaviour across Baselines 5-6

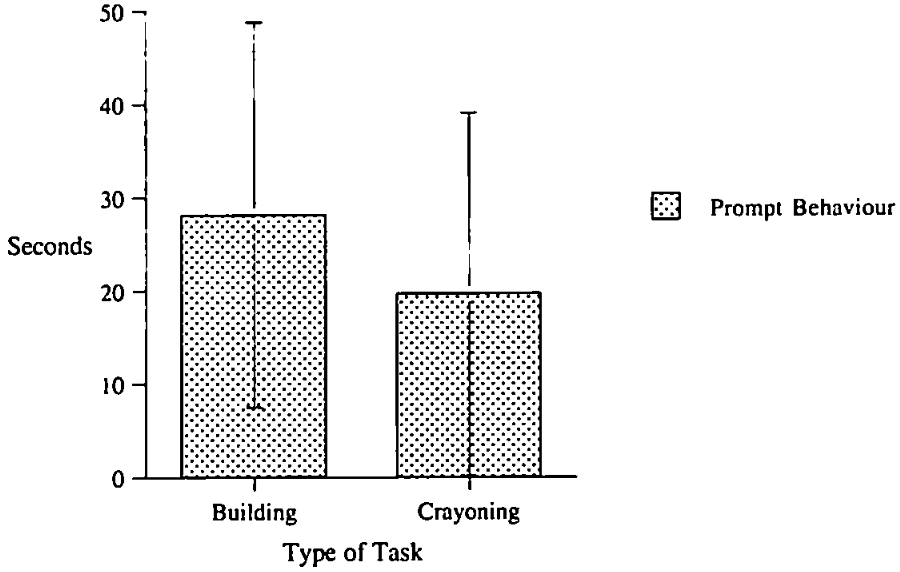


Fig.14 Mean Prompt Behaviour by Type of Task at Follow-up

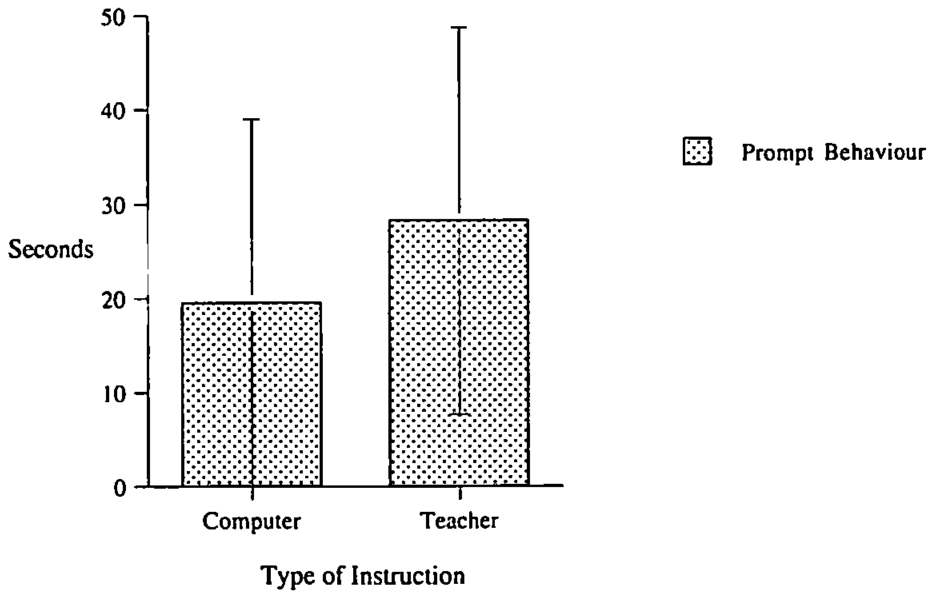


Fig.15 Mean Prompt Behaviour by Type of Instruction at Follow-up

"crayoning" tasks than the "building" tasks (see Figure 11 above). Also, at 1-month follow-up, there was significantly more correct responding on the computer-taught tasks than on the teacher-taught tasks (see Figure 12 above).

For Prompting, there were significant effects of time ($F_{(1,62)} = 8.341$), type of task ($F_{(1,62)} = 6.835$) and type of instruction ($F_{(1,62)} = 7.145$), but there was no significant interaction. There was significantly less prompting given at 1-month follow-up (see Figure 13 above) and that there was significantly less given during "crayoning" tasks (see Figure 14 above) and significantly less given on computer-taught tasks (see Figure 15 above).

5.2.5 DISCUSSION

The results from this study indicate that there are some differences in learning behaviours between computer-taught and teacher-taught tasks. During the computer-taught tasks, more time was spent attending to the tasks and less help was required while performing them. In addition, though to a lesser degree, there was more successful responding during the computer-taught tasks than the teacher-taught tasks.

The finding of the present study that there is an effect of CAL on ontask behaviour for a group of adult learners with profound learning disabilities concurs with findings from other studies which have observed collateral behaviours during CAL. However, these studies were carried out with a different group of learners. Plienis and Romanczyk (1985) found that collateral behaviours of severely disturbed children (4 of whom had learning disabilities) were greater in the teacher-taught condition than in the CAL condition. Baumgart and Van Walleghem (1987) present similar results from their study of teaching sight words to adult learners with moderate handicaps. Ryba and Webster (1983) comment on anecdotal reports of improved ontask behaviours for some children with learning disabilities as a result of using CAL.

The present study also found that learners required less help (prompting) during CAL. One other study (Dura, Mulick, Hammer and Myers, 1990) had reported on the use of prompting during CAL, but did not compare this with teacher-taught instruction. They report mixed results concerning whether or not the prompting was able to be faded out and the computer used independently. The present results show that prompting during CAL was necessary throughout the study but that the amount of help given decreased over time and this decrease was maintained at 1-month follow-up.

One of the implications of these findings is that attention, as indicated by an increase in the amount of time spent attending to the task, may be increased during CAL. Indeed, as reviewed in Chapter 2, this possible attentional factor of CAL has been proposed by many to be one of the advantages of CAL in promoting learning. If this role of increased attention in promoting learning is addressed in this study, it can be seen that, during CAL, there was an increase in the amount of correct responding but this did not occur at the same time as the increased attention. Also, there were differences in the amount of responding occurring as a function of the task regardless of which type of instruction was used to present the task. So, it cannot be concluded that an increase in attention per se resulted in increase in the amount of learning of the correct response (or successful response). However, it does seem that CAL may be linked in some way to increased attention to the task when compared with teacher-instruction. This issue is worthy of further investigation and will be returned to for further discussion later.

Another positive implication of the findings is that CAL may go some way toward establishing greater independent responding as indicated by the lesser amount of help that was needed to complete the CAL tasks. Observations in other studies (Ryba and Webster, 1983) of the increased independence of participants who were taking part in the CAL condition suggest that CAL may have wide ranging effects on behaviour that are not measured in experimental designs that concentrate on achievement gains. A desirable goal for people with profound learning disabilities is to establish independent responding. As suggested in Chapter 2, the establishing of basic responses using switches and software specifically designed for the special care population is thought to bring with it some potential for opening up new opportunities for an individual to interact with their environment. The results from this study suggest that CAL may be an activity which can go some way to fulfilling this goal. The use of CAL may not bring about completely independent responding (at no stage did the amount of prompting decrease to zero), but this study looked at relatively short-term learning for a group with such profound disabilities. It may be that using CAL could increase the repertoire of skills of an individual that are needed in order to progress to independent responding.

The results here point to some significant differences between CAL and teacher-taught instruction which have not been demonstrated in an experimental manipulation previously. However, the findings that time and type of task also had significant effects cannot be overlooked. The results from Experiment 1 suggest that participants will perform differently on different tasks regardless of whether they are computer-based or not. The present study also produced similar findings. Significantly more time was spent attending to the building tasks than the crayoning tasks and this difference cannot be accounted for by the difference in the mode of presentation of the tasks alone. It seems that two factors are implicated here. First, more time was spent ontask during the building tasks than the crayoning tasks. It could be that the building tasks were more difficult to achieve and required greater attention. Indeed, from the lower amount of successful responding in the building tasks when compared with the crayoning tasks, this is likely to be the case. Looking at these tasks, it is apparent that there were differences between them which were not adequately controlled for in the study. The crayoning tasks were very similar in the degree of manual manipulation that they required in order to perform the task. This was not so for the building tasks. The teacher-taught "rocket" task required a different set of physical responses to the computer-based "build" task. These physical responses were not beyond the capabilities of the participant, but they did require a greater effort to achieve. Once again, the difficulties in matching task response characteristics in studies such as this have arisen.

The issue of making comparisons across different modes of presentation can be perceived as a difficult obstacle in any comparison of teaching techniques. With particular regard to comparing CAL with other methods, it is inevitable that a task is changed when it is "put on the computer". Most, if not all, educational software makes an assumption that tasks which are usually teacher-taught can be transferred across to being taught by using a computer. But, in doing so, the nature of the task itself is necessarily changed.

Therefore, the question highlighted in previous chapters of "What exactly is being taught by educational software and how is this achieved?" returns for consideration. If the task is changed by bringing it onto a computer, what is it that is being learned? Is it the responses required of the computer-version of the task that are being reinforced and learned or is it the conceptual content of the task objective? Software manufacturers may make claims for the objectives of their software, but the difficulties of making comparisons across techniques mean that make these claims are extremely difficult to substantiate by comparative research. It may be true that for higher-order tasks, like spelling or maths, a test of generalisation is not so difficult. However, if one of the arguments for the use of CAL for people with severe learning disabilities is that it can provide opportunities for experience that would otherwise be unavailable to them, it is hard to conceive of how to test generalisation.

To take an example, the "Build" program may provide some abstract experience of responses being able to result in the consequent production of an "object" (the representation of an object onscreen) and the knowledge that a series of responses may have additive effects that lead to a larger event (the increased auditory stimuli and increased complexity of the visual array), but does this instance provide the same learning experience as performing manipulative behaviours of actual objects that, conceptually, have the same end? Even though these tasks may have the same objective, the computer and teacher versions of the tasks present them in different fashions. A problem is presented that, even though it is assumed that the two versions of the task have the same objective, the tasks themselves become entirely different as they are transcribed into an alternative version. If we accept the assumption that the objective remains the same (and this assumption is accepted by most software manufacturers), how do we test for generalisation in a different mode of presentation if that other mode of presentation would represent an entirely different task at a different level of difficulty?

In the present study, it is a criticism of this experiment that the conceptually analogous tasks could not really be compared as they were different in their task response characteristics. They may have had the same objective, but they were not the same task in practice. Ideally, the tasks would be matched at all levels of the task response characteristics but the fact is that this may not be possible. It can only be said that this was attempted to the greatest degree possible within the restrictions of the assumption that tasks can be transferred from one mode to another. Furthermore, consideration also had to be taken of the further restriction of the availability of commercial software that was appropriate for this group of learners.

Clearly, issues such as these do not sit comfortably with psychological models of controlled experimentation.There are two responses to this. First, some degree of discomfort with the experimental model may have to be sustained in the early stages of investigating phenomena about which little is known and which may be difficult to access (e.g., what is being learned in CAL?). It is an unfortunate fact that although violations of assumptions should be reduced as much as is possible, they may not be able to be eradicated altogether.

Second, part of the objective of the research presented in this thesis was to evaluate the real-life applications of CAL for people with learning disabilities. This brings with it the added problems associated with applied research in this area which interact with problems concerning the assumptions discussed above. Therefore, a further increase in tolerance of the violation of experimental niceties is necessary in order to begin to contribute in a systematic fashion to knowledge in the area. Such a beginning will necessarily be open to criticism, which will lead to the refinement of ideas and techniques in later studies.

5.2.4.1 The role of attention

This study found that the three target behaviours changed across time, independent of type of instruction or type of task. Ontask behaviours and successful responding increased over time and the amount of help participants required to perform the tasks decreased. One of the implications of these changes is that there are apparent benefits of one-to-one intensive instruction for this group over a period of approximately three months. Given the severity of this group's disabilities, this seems a relatively short period of time in which to see such changes. It leads again to further questioning of the component processes of learning that are involved in this change.

If the pattern of ontask behaviour over time is looked at more closely, an early increase (during baselines 2 and 3) is apparent, which then decreased as the study progressed. One way to account for this is to suggest that greater attention is needed to be paid to the tasks while they were still relatively unfamiliar. In addition, throughout the study, consistently greater ontask behaviour was evident during the building tasks, which were more difficult than the crayoning tasks, so this provides some support for the idea that this increased attention could also be related to task difficulty. If the task is more difficult, greater attention must be paid to it as it is being worked upon. Some support is lent to this idea from visual inspection of Figures 2 and 5. This reveals that during the period of greatest ontask behaviour, the amount of successful responding was at its lowest rate. However, successful responding is seen to increase after a short time lag. One explanation for this could be as follows. Initial increased attention allows salient features of the task to be discriminated which, together with subsequent repeated exposure and practise, may lead to learning or mastery of the task. In Chapter 1, the role of attentional deficits in learning disability was described. Zeaman and House (1963, 1979) proposed that people with learning disabilities possess an information processing deficit that requires them to undergo a greater number of trials prior to learning a discrimination. The tasks used in the present study were not as circumscribed as those used in traditional discrimination learning experiments, but the learning of any task requires salient dimensions to be attended to which require discriminations to be made. It is possible that the time lag between increased attention and increased correct responding is a reflection of the greater number of trials needed prior to learning the relevant necessary discriminations.

One way of describing the increased attention that is necessary during this "pre-learning" period is offered by Wood (1988). He suggests that the defect of learning is secondary to the defect of attention. The concept of attention in this instance is the active behavioural manifestation of an attentional set which requires a degree of effort and motivation. This attentional behaviour may need to be maintained in order to make use of any subsequent improvement in information processing capability.

This increase in attentional set, as indicated by ontask behaviour, followed by a subsequent increase in correct responding is noticeable for the computer tasks. (see Figures 2 and 6). Undoubtedly, this effect is confounded by the variability in the tasks and their difficulty, but there is some heuristic value in noting that the computer tasks were able to command an increased attentional set, that learning on the tasks followed on from this, and, that these significant changes in the amount of correct responding on the computer tasks was maintained at 1-month follow-up.

The ability of computer presentations to increase motivation and attention to the task has been proposed as one of the ways in which CAL offers conditions that may be advantageous to learning (e.g., Chaffin, Maxwell and Thompson, 1982; Hogg, 1984; Ager, 1985). The findings from the present study that ontask behaviour is increased during CAL support this idea. While the evidence is weaker that this attentional component directly improves learning, the explanation of learning following improvement in the attentional set which is derived from theories of attentional deficit in learning disability may give an account for this discrepancy. So, the question arises of exactly how does computer-based learning achieve an increased attentional set?

One obvious way in which any increase in behaviour (including attentional behaviour) is maintained is through reinforcement. Improvements in attention span through the use of contingent reinforcement are in evidence throughout attention training programmes for people with learning disabilities. Reinforcers such as sweets and crisps are given to the learner for directing attention (maintaining head posture and directing eye contact). Most, if not all, educational software also purports to make use of "reinforcement". On an intuitive and anecdotal level, attention is directed to the task through the use of stimulating graphics and sound. Correct responses are rewarded by the program producing "pleasing" sounds and exciting graphics. The major way in which the computer attempts to reinforce is through the use of sound and graphics. That is, educational software makes use of sensory reinforcers in the learning process.

The results from this study suggest that the sensory reinforcement provided by the programmes had an effect of increasing attention to the task. This could be interpreted as increasing motivation. Also, there was some evidence that the sensory reinforcement had an effect of increasing correct response behaviours. This could be interpreted as increasing learning. However, the increase in motivation appears greater than any concomitant increase in learning. In any case, learning also increased when social reinforcement from the teacher, rather than sensory reinforcement from the software, was provided.

This is something of a paradox and it is interesting to re-state here that most of the studies that have attempted to prove whether CAL is more advantageous over other forms of learning have been unable to do this. Only an equivalence of methods in achieving gains is found. It is clear, however, that researchers have attempted to communicate their instinct that something different is occurring during CAL. There are anecdotal reports and some empirical evidence of increased ontask behaviour, increased attention and motivation, decreased disruptive behaviour and increased independent responding while using CAL. What, then, can account for these differences?

An overwhelming difference between teacher-taught and computer-taught instruction is in the type of reinforcer that is delivered by the two methods. CAL delivers sensory reinforcement whereas teacher-taught instruction may deliver a range of different reinforcers examples of which are edibles, social attention and physical gestures of praise or reward.

It seems appropriate then to pursue an investigation of the manner in which sensory reinforcement is used a part of educational software. The following study presents an assessment and evaluation of the sensory reinforcers that are used in commercially available educational software.

CHAPTER 6

6. EXPERIMENT 3. An assessment and evaluation of sensory reinforcers used in educational software for people with severe learning disabilities.

6.1 INTRODUCTION

The findings from the previous study suggested that the use of sensory reinforcement is central to the ability of educational software to maintain the performance of a task. This chapter reports a study which evaluated the ability of those sensory reinforcers which are found in educational software to support the learning of a new task. First, a review of sensory reinforcement in learning is presented.

6.1.1 Sensory reinforcement

It is stated that a fundamental tenet of behavioural learning theory is that behaviours are acquired, altered or maintained by the reinforcement received from the environment. Early investigations of learning resulted in the identification of three kinds of reinforcer: primary positive reinforcers, primary negative reinforcers and secondary reinforcers. A primary positive reinforcer is something that is naturally reinforcing to the animal and which is related to survival, such as food or water, and to which the animal will respond to acquire. A primary negative reinforcer is something naturally aversive to the animal, such as electric shock, and to which the animal will respond to terminate. A neutral stimulus which becomes associated with either positive or negative reinforcers and takes on reinforcing characteristics is a secondary reinforcer.

However, some investigations with animals reported that various species, including rats and monkeys, could learn responses in the absence of these three kinds of reinforcer providing that sensory stimulation was provided contingent on the responses (Girdner, 1953; Butler, 1953; Butler and Harlow, 1954, 1957). Kish (1966) termed such stimulation "sensory reinforcement" and postulated that sensory reinforcers could act as a type of primary reinforcer. Further studies demonstrated that a great variety of stimuli could act as reinforcers (Campbell, 1971) and that the stimuli showed satiation and deprivation effects much like any other primary reinforcer. Later, studies began to appear that investigated the responses of humans to contingent sensory stimulation. It was demonstrated that children of all ages could learn simple responses with sensory stimuli as the only reinforcer (e.g. Antonitis and Barnes, 1961; Baer, 1960, 1961; Hutt, 1966, 1967; Rheingold, Stanley and Doyle, 1964, Stevenson and Knights, 1961; Stevenson and Odom, 1961) and that the responses acquired and maintained with these sensory reinforcers were predictably sensitive to effects such as changing the reinforcement schedule and to satiation and extinction. There began to exist a growing body of evidence that sensory reinforcers could be used to support the acquisition of responses in humans, too.

6.1.2 Learning disability and sensory reinforcement

Some of the investigations into the role of sensory reinforcement took place with children with learning disabilities. The majority of these studies were conducted in a training or treatment framework with a view to discovering what kind of stimuli would act as reinforcers, whether there would be signs of satiation, whether the sensory stimuli would be superior to other reinforcers and whether the use of sensory reinforcement would be relevant to clinical work in learning disability (Murphy, 1982). There was also some evidence that people with profound multiple learning disabilities were less likely to prefer conventional reinforcers, such as food (Spradlin, Girardeau and Corte, 1965; Spradlin and Girardeau, 1966).

Sensory reinforcers such as music, lights and vibration were found to be effective operant reinforcers of simple responses (e.g. arm raising) in "vegetative" children (Rice and McDaniel, 1966; Rice McDaniel, Stallings and Gatz, 1967). It was found that the children could learn the response and some very specific preferences for different sensory stimulation were demonstrated.

Further studies showed that some stimuli, such as light and vibration, were able to act as generally effective reinforcers when they were used with large numbers of children who were autistic or who had learning disabilities (Frankel, Freeman, Ritvo, Chikami and Carr, 1976; Rehagen and Thelan, 1972; Johnson, Firth and Davey, 1978; Byrne and Stevens, 1980; Ottenbacher and Altman, 1984). The use of sensory stimulation as a negative reinforcer (the cessation of television distortion) and punishing stimulus (the delivery of television distortion) has also been demonstrated as effectively increasing responding and decreasing hyperactivity for two participants with mild learning disabilities (Greene and Hoats, 1967).Given the difficulties of establishing generally effective reinforcers for people with learning disabilities (Whitman and Scibak, 1979), a number of systematic approaches have been taken to assess preferred reinforcers for individuals. Examples of these different methods include indirect assessment by questionnaire (Rotatori, Fox and Switsky, 1979), direct observation of time spent approaching reinforcers (Danella, 1973), establishing hierarchies by observation of response rates to different reinforcers (Byrne and Stevens, 1980; Remington, Foxen and Hogg, 1977) and comparisons of differential response rates to concurrently available pairs of reinforcers (Silva, Friedlander and Knight 1978; Glenn and Cunningham, 1984). Results from studies such as the above have shown that some learners do demonstrate clear preferences.

Whether or not a preference for any particular sensory experience is shown by the learner, the test of the putative reinforcer is whether it produces reliable increases in the likelihood of the target behaviour when it is used therapeutically (Remington and Evans, 1988). For example, Pace, Ivancic, Edwards, Iwata and Page (1985) assessed stimulus preferences and then went on to examine the reinforcer value by using these stimuli as consequences in a learning task. Generally, preferred stimuli were effective reinforcers.

6.1.3 Microtechnology, learning disability and sensory reinforcement

With the advent of microtechnology, new methods of producing and delivering sensory stimulation have become available. Indeed, most, if not all, typical applications of microtechnology in learning disability provide some form of sensory stimulation. Several investigators have examined uses of sensory reinforcement when it is used as a part of microtechnology applications. Some studies such as these were described in Chapter 2. It will be recalled that the use of microtechnology was considered especially suitable for people with multiple disabilities as it was able to create new opportunities for them to interact with the environment in a relatively simple fashion. Moreover, the relative ease of using microtechnology has made it possible to demonstrate aspects of learning in people with severe and profound handicaps where it was previously more difficult to do so. One of the characteristics of people who are profoundly handicapped is that they demonstrate extremely limited responsiveness to external stimulation (Landesman-Dwyer, 1974). Therefore, techniques which can be developed to enhance the degree of interaction may have implications for the person's level of functioning. Also, for the psychologist, techniques which more readily allow some experimental investigation of learning may have implications for a greater understanding of how best to ameliorate these learning disabilities.

For example, microswitches have been employed so that minimal movements can bring about consequent sensory reinforcement (e.g. Haskett and Hollar, 1978; Brinker and Lewis, 1982; Lovett, 1985, 1988). These studies demonstrated that sensory reinforcement delivered contingent upon the tripping of a microswitch can be an effective reinforcer.

Further studies have employed microtechnology to assess reinforcer preferences of people with severe learning disabilities (Dattilo and Mirenda, 1987; Dattilo, 1986) and profound multiple handicaps (Wacker, Berg, Wiggins, Muldoon and Cavanaugh, 1985). The activation of microswitches by, for example, head turning, arm-raising or direct switch manipulation, resulted in visual, auditory or tactile events. Presentations of these stimuli were evaluated within a multiple-baseline alternating treatments design. Reinforcer value was indicated by increases in the duration of responding and differential responses across types of stimulation suggested reinforcer preferences (Wacker et al., 1985; Datillo, 1986; Datillo and Mirenda, 1987). The results from these investigations demonstrated that the reinforcement preferences of people with severe and profound handicaps can be assessed systematically using microtechnology.

Other studies have examined the ability of sensory reinforcement to support more complex learning paradigms. Lovett (1988) and Haskett and Hollar (1978) report clear supportive evidence that children with profound and multiple handicaps are able to discriminate schedules of contingent from non-contingent sensory reinforcement when microtechnology is implemented to aid their ability to respond. Lovett (1988) used nursery rhyme music as a discriminative cue to indicate the presence or absence of contingent reinforcement. The available putative reinforcer was to travel a short journey in a small battery-driven car, which was operated by the child's movement breaking an ultrasonic beam. Response rates during periods of contingent reinforcement increased steadily and declined during non-contingent periods. Additionally, response rates increased and declined in accordance with the presence or absence of the discriminative cue indicating contingent reinforcement, and this was reversed when the cue was used to indicate non-contingent reinforcement. Thus, Lovett concludes that participants showed "clear signs of discrimination learning" whilst using the electro-mechanical car.

Haskett and Hollar's (1978) work did not use deliberate discriminative cues; rather, they were interested in observing more naturalistic learning. Two different sensory reinforcers were evaluated separately in two different studies. In the first, participants were able to operate a lever in order to obtain visual stimulation (illumination of the experimental setting) and, in the second, auditory stimulation (selections from Handel's "Messiah"). In both cases, the reinforcers were presented in both response contingent and response non-contingent conditions. Discrimination of contingent from non-contingent schedules was demonstrated by three participants. Results from both of the above studies indicate that sensory reinforcement can be used effectively to enable people with profound handicaps to show differential responding to contingencies (both with and without the benefit of deliberate discriminative cues).

The use of microtechnology to enable people with severe and profound disabilities to demonstrate their preferences has resulted in some practical applications that allow them to gain control over their environment. Wacker, Wiggins, Fowler and Berg (1988) taught learners to demonstrate their preferences for different reinforcers. Subsequently, this selection of consequences via a microswitch was extended so that learners could make specific requests of educational and care staff for preferred activities, such as drinking or playing.

6.1.4 Summary

So far, it can be said that sensory reinforcement is well established as an effective reinforcer for people with mild, severe, and profound and multiple disabilities. It has been demonstrated empirically to support the acquisition of simple behaviours such as lever pulling and microswitch activation. It has been demonstrated to support discrimination learning. Also, preferences for differing stimuli have been shown. When combined with 'enabling' microtechnology, empirical evidence has been gained that has contributed to knowledge of learning in people with profound handicaps. Given adequate means with which to interact, they are able to respond actively, to learn and to assert some degree of control over the environment.

6.1.5 Educational software and sensory reinforcement

It has been stated throughout this thesis that most, if not all, educational software makes use of sensory reinforcement. The very act of using conventional educational software via a computer and screen monitor means that most of the stimuli are presented visually, together with some adjunctive auditory presentation. If educational software is analysed in terms of behavioural learning strategies, it is observed that, almost without exception, sensory reinforcement in the form of visual and auditory reinforcers are used to reward correct behaviour or responses. The learner makes a correct response and images and music are presented immediately after the response has been made. Presumably, the aim of this contingent stimulation is to reinforce the response. These contingent sensory events are used also as an means by which to modify incorrect responses. This can take the form of delivering a putative "punishing" tone or of providing a meaningful image that is assumed to have negative connotations (e.g. a picture of trains crashing, walls falling down, objects disappearing, etc.) These "negative" images may be presented contingent on an incorrect response. Unfortunately, many anecdotal reports are made of learners preferring the negative images to the positive images that are presented for correct responses; thus , some learners are more likely to persevere with making wrong responses which are possibly deliberate. An understanding of operant theory, and particularly the use of reinforcement, can explain this. The presentation of a stimulus, even if it is supposed to be a "negative" image, is still the presentation of a positive reinforcer contingent upon the response and, thus, should increase the likelihood of the behaviour occurring. However, it should also be said that not all software makes inadvertent reinforcing responses. Other programs may ignore incorrect responses or present instead a short period of silence and inactivity on the screen, followed by the next presentation of a learning trial.

It is evident that sensory reinforcement is widely implemented in educational software, often with disregard for the principles underlying the use of reinforcement. Its extensive employment is not matched by extensive empirical investigations. Its use has not been validated, rather it is an assumption that the sensory events that are employed on the software are able to reinforce (or extinguish) the desired behaviour. This may or may not be stated directly but phrases are seen in software catalogues and documentation which point to the underlying assumptions that the content of the software can result in some sort of achievement. Examples of these phrases taken from recent documentation include: "Exciting graphics and sound!", "Enjoyable and rewarding", "Captures attention, maintains and enlivens concentration and provides appropriate reinforcement".

It is true that many of these descriptive phrases refer to the assumed ability of the software content to motivate the learner and this is considered usually to be an intrinsic process. However, it may also be assumed that an increased motivation to behave should result in an increase in behaviours. If educational software purports to teach, then an increase in responses to the software might be taken as an increase in learning. However, the empirical evidence presented throughout this thesis leads to the conclusion that such assumptions remain unwarranted. An increase in behaviours may not be the same as an increase in learning, since learning entails acquiring new behaviours within the operation of a contingency. In the instance of increased behaviours while using software, the increase in the behaviours may not be under the control of the contingency appropriate to the software's objective. An increased motivation to perform some response cannot be said to equate with an increase in learning a specific response. (Though it may be that increased exposure to the situation could be a starting point for learning.)

The previous experiment demonstrated that switch activation behaviours do indeed increase while using the computer; that is, performance of a simple task increases. However, it is unknown whether these same sensory events which may motivate increased performance are able to support more complex learning behaviours. The question raised here is whether sensory reinforcement is able to enhance the acquisition of new skills rather than merely maintain the performance of a relatively simple behaviour. It could be argued that the next step after learning simple stimuli-response-reward relationships is the ability to respond selectively to stimuli which will result in a reward - that is, to perform discriminations. Discrimination is important because it enables us to perform behaviours adaptively in that we attend selectively to the relevant stimuli for the task at hand. Once we have learned to make basic responses to stimuli, the ability to discriminate stimuli leads us to further behaviours such as responding to and interacting with environmental demands.

Thus, simple discriminations serve as prerequisites for more complex skills. [See, for example, Repp and Karsh (1991)].

With regard to studies of discrimination for people with severe learning disabilities, it is known that sensory reinforcement can support the acquisition of simple behaviours and it is known also that can support certain forms of discrimination learning such as distinguishing response-dependent and response-independent contingencies (Lovett, 1988; Haskett and Hollar, 1978) and activating different types of switches to obtain different reinforcers (Datillo, 1979). However, the largest component of educational software is the need to accomplish visual discrimination; that is, the ability to distinguish between two (or more) visual stimuli. In educational software at all levels, visual discrimination is required to make sense of the material presented on the screen. In addition, it is frequently required in order to operate the means by which to respond to the software, e.g. using a Concept Keyboard overlay or selecting the appropriate keys from the keyboard. (There may also be some spatial discrimination required in these tasks.)

Software for people with severe learning disabilities also requires visual discrimination to make sense of the onscreen display, but this task is often secondary to the ability to use switches to operate the program. A major goal of software of this level is to teach that switch activation leads to some kind of reward (response) and, commonly, a single switch will operate the program. However, single switch operation programs are limited in their scope and, once reliable single switch operation is established, one of the possible progressions to make would be to be able to use programs which require more complex switch operation, e.g. pressing one of two response keys on the keyboard or differently coloured areas of a Concept Keyboard, etc.

There is some evidence that sensory reinforcement can support such visual discrimination learning of people with learning disabilities. Johnson, Firth and Davey (1978) found that vibration was more effective than social praise when used to reinforce visual discriminations. The stimuli were presented as objects or pictures in front of the subject and a verbal request was made for the subject to correctly identify the named object or picture. Sensory reinforcement was reported to result in a faster rate of learning than social praise.

Two other studies specifically employed computer-assisted procedures to investigate visual discrimination learning, using specially written software. McDermot, Harsant and Williams (1986) and Strand and Morris (1986) used a computer to present visual discrimination tasks. These tasks were to select S+ (the stimulus which, when selected, would result in the presentation of the reinforcer) over S- (when selected, does not result in the presentation of the reinforcer) when the two stimuli were presented visually on the computer screen. Correct responses were rewarded with tunes (Strand and Morris, 1986; Mc Dermot et al., 1986) and "flashing coloured lights" (McDermot et al., 1986). These authors report successful discrimination learning, but they also employed edibles (Strand and Morris, 1986) and stimulus fading techniques to aid the learning of the discrimination (McDermot et al., 1986; Strand and Morris, 1986). Results from these studies indicate the potential of sensory reinforcement to support learning of the discriminative behaviours that are required of the learner when engaged in learning from educational software.

The present study aims to address the lack of empirical investigation into the use of sensory reinforcement when it is used as a part of CAL for people with severe learning disabilities. The issue raised here is whether or not the "reinforcers" that are an integral part of commercially available educational software are indeed able to support the type of learning required of this software (visual discrimination learning) rather than just maintain performance of an already acquired skill (switch activation).

Furthermore, most commercially available software makes use of paired auditory and visual reinforcers and there is a lack of evidence regarding the relative effectiveness of these two different types of sensory stimulation. So, this study will also make a comparison of the effectiveness of visual reinforcers when presented alone, auditory reinforcers presented alone and presentations of paired auditory and visual reinforcers.

To recap, the aims of the present study are two-fold. The questions addressed are :

1. Can the sensory reinforcers used in commercially available software for people with severe learning disabilities support learning a visual discrimination task?

2. Is there a difference between presentations of auditory reinforcers alone, visual reinforcers alone and paired auditory/visual reinforcers in any ability to support learning of the task?

6.2 METHOD

6.2.1 Participants

Three participants in the previous experiment took part. These learners were selected because they had learned reliable switch activation behaviours (using the box switch) during the previous study. In addition, they were considered by their instructors to be suitable for further experience and training using CAL. All three participants were male and aged 19 years, 23 years and 28 years. Two of the participants had highest measurable scores on the Griffiths' Developmental Scales (Griffiths, 1954) of the 24 months developmental level on the Eye & Hand Coordination and Performance subscales. The remaining subject scored at the 21 months level on the same subscales. On the Personal-Social subscale, all three participants scored at around the 18 months developmental level.

6.2.2 Setting

The study took place in the day centre for adults with profound and multiple disabilities as outlined in the previous study. The room used remained the same, except that the position of the equipment was changed.

6.2.3 Equipment

6.2.3.1 Switches

A simple visual discrimination task was presented using two switches. These switches were of the same dimensions and construction as the box switch of the previous study, with one difference - the lids were made from translucent perspex. Each box contained two 12V, 2.2W lamps, one red and one white. Each bulb could be illuminated independently of the other. When illuminated, the light would shine through the lid and create the impression of a "lit" switch which could be either white or red. The ambient light was the same regardless of whether the switch was lit by the red or white bulb. Pressing the lids of the switches would activate a microswitch inside the box and operate the putative reinforcement.

6.2.3.2 Software

A piece of software was developed for the BBC-B microcomputer system. This program performed three functions.

1. It operated the illumination of the switches and controlled the presentation of experimental conditions.
2. It provided the reinforcers contingent upon the participant's manipulation of the switches. These reinforcers were separate visual, auditory and visuo-auditory events which were selected from commercially available software. There were four of each type. These were selected from a pool of thirty sensory events (ten of each type) which were judged by three observers to be typical of reinforcers available on software for people with severe learning disabilities. Examples of these include stationary images of familiar objects (a house, a car), moving abstract multicoloured images, recognisable tunes, whirring noises and combinations of similar events.
3. The program recorded the participants' switch activations and counted the number of presses in each condition. In addition, it calculated the proportion of correct presses (selection of S+) and the rate of pressing in each condition.

6.2.4 Experimental design

A replicated N=1 design was employed. This was a multiple treatment design with repeated measures. In a single session, each participant received training on the discrimination task during each of three experimental conditions: Condition 1 - Visual Reinforcement; Condition 2 - Auditory Reinforcement and Condition 3 - Visual-Auditory Reinforcement. The computer controlled the randomised presentation of the conditions.

6.2.5 Procedure

Each particpant was presented with the two switches. These were placed approximately 20cm apart on a horizontal line in front of the participant within their easy reach. A screen monitor was placed centrally in the participant's line of sight behind the switches. The computer system controlling the apparatus was placed out of sight from the participant.

At the beginning of the study, a brief training program was undertaken with each participant, which was as follows.

6.2.5.1 Training phase

The aim of this phase was to familiarise the participants with the availability of two switches that could be pressed. Up until this point, they had only ever had access to one switch and perseveration of single-switch activation was a possibility. During this preliminary training, one of the two switches was illuminated with a single bulb and the participant was prompted, using the graded prompt procedure, to press the lit switch. The location of the lit switch was randomly altered. If the lit switch was pressed, social praise and attention was given. If the unlit switch was pressed, there was no consequent response and a new trial was presented. This training took place until the participant demonstrated the ability to consistently press one of the switches.

6.2.5.2 Experimental phase

During the experimental phase, the participant was presented with the visual discrimination task. The participant was seated in front of the two switches; one lit by the red bulb and one lit by the white bulb. The red switch acted as S+ and its location was randomly determined by the computer. Each trial consisted of both switches being lit for 10 seconds. If no response occurred, the bulbs went out, and a new trial was presented. If a response was made within that time, the bulbs went out, and the relevant contingency was provided as follows. Activation of S+ resulted in 7 seconds of reinforcement being delivered. The length of the reinforcing event was determined by calculating the average length of reinforcers available on commercial software. Activation of S- resulted in no stimulation for 7 seconds. After completion of that trial, a new trial was presented. Reinforcement could only be obtained if a press was made while the switches were lit. Any additional presses made were of no consequence.

Each participant participated in two sessions daily. Each session comprised a series of 4-minute presentations of each sensory reinforcement condition with a space of 30 seconds between each condition. So, each training session lasted about 15 minutes. The presentation of conditions during the sessions was randomised by the computer. Throughout the experimental phase, the graded prompt procedure was used. Upon presentation of a trial, participants received an initial verbal prompt, "Press the red switch, ______." If a press did not result, this was followed by pointing to the red switch and repeating the verbal prompt. If required, physical prompting was used subsequently. A note was made of any prompting that was necessary.

6.3 RESULTS

A separate analysis was performed on the data for each participant. The data concerning the proportion of correct trials was subjected to an angular transformation before being entered into the analysis. The effect of the type of reinforcement on the proportion of correct trials and the rate of pressing was assessed using analysis of variance, using the sessions across time as pseudo-participants. The criterion for significance was set at $p < 0.01$. [For a discussion of the use of analysis of variance with single participants, see Hersen (1990) and Kazdin (1984)]. The analysis of variance tables are presented in Appendix 6.

Participant 1: John

John attempted the discrimination task a total of 827 times. Of these attempts, 280 responses (34%) were during the auditory condition, 267 (32%) were during the visual condition and 280 (34%) were during the visual-auditory condition. In total, John made 443 (53%) correct responses. A two-tailed binomial test revealed that this was not significantly different from that which would be expected by chance ($p = 0.7188$).

Additionally, there was no significant effect of type of reinforcement on the proportion of correct responses ($F_{(2,50)} = 0.5870$, $p > 0.01$) or on the rate of pressing ($F_{(2,50)} = 2.6020$, $p > 0.01$). See Figures 16 and 17 below.

Participant 2: Brian

Brian attempted the discrimination task a total of 942 times. Of these attempts, 324 responses (34%) were during the auditory condition, 302 (32%) were during the visual condition and 316 (34%) were during the visual-auditory condition. In total, Brian made 499 (53%) correct responses. A two-tailed binomial test revealed that this was not significantly different from that which would have been expected by chance ($p = 0.984$). Additionally, there was no significant effect of type of reinforcement on the proportion of correct responses ($F_{(2,50)} = 0.3873$, $p > 0.01$) or on the rate of pressing ($F_{(2,50)} = 1.1350$, $p > 0.01$). See Figures 18 and 19 below.

Participant 3: Roger

Roger attempted the discrimination task a total of 468 times. Of these attempts, 177 responses (38%) were during the visual condition, 148 (32%) were during the auditory condition and 143 (30%) were during the visual-auditory condition. In total, Roger made 229 (49%) correct responses. A two-tailed binomial test revealed that this was not significantly different from that which would have been expected by chance ($p = 0.984$).

Additionally, there was no significant effect of type of reinforcement on the proportion of correct responses ($F_{(2,50)} = 0.3190$, $p > 0.01$) or on the rate of pressing ($F_{(2,50)} = 3.3460$, $p > 0.01$). See Figures 20 and 21 below.

Prompting

All participants needed initial prompting but, after approximately the first 3 or 4 trials of each session, this was no longer necessary and participants attempted the task independently.

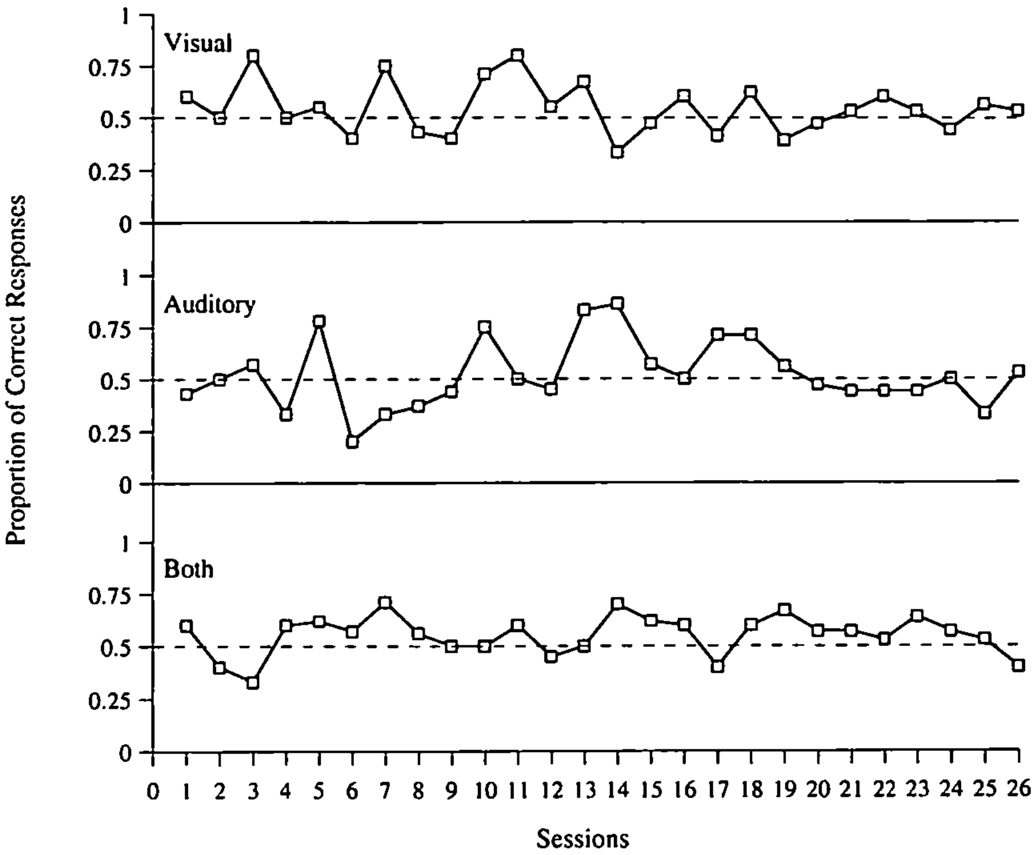


Fig. 16. John's Correct Responses under Different Conditions of Sensory Reinforcement

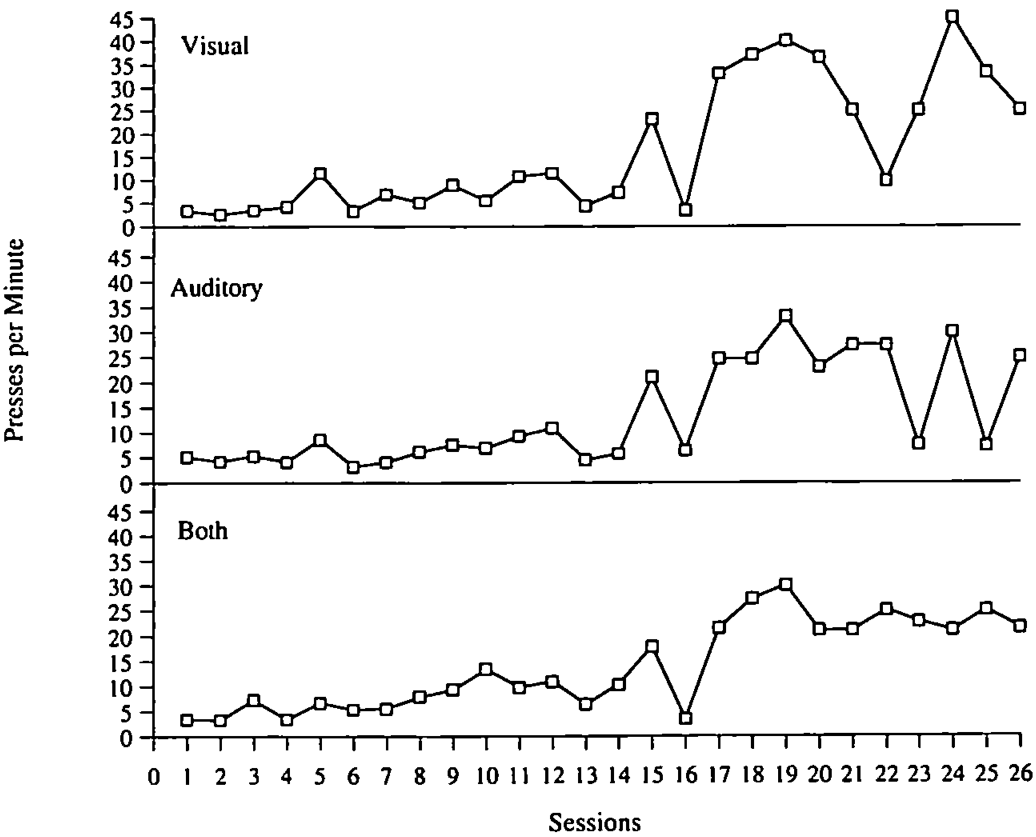


Fig. 17. John's Rate of Pressing under Different Conditions of Sensory Reinforcement

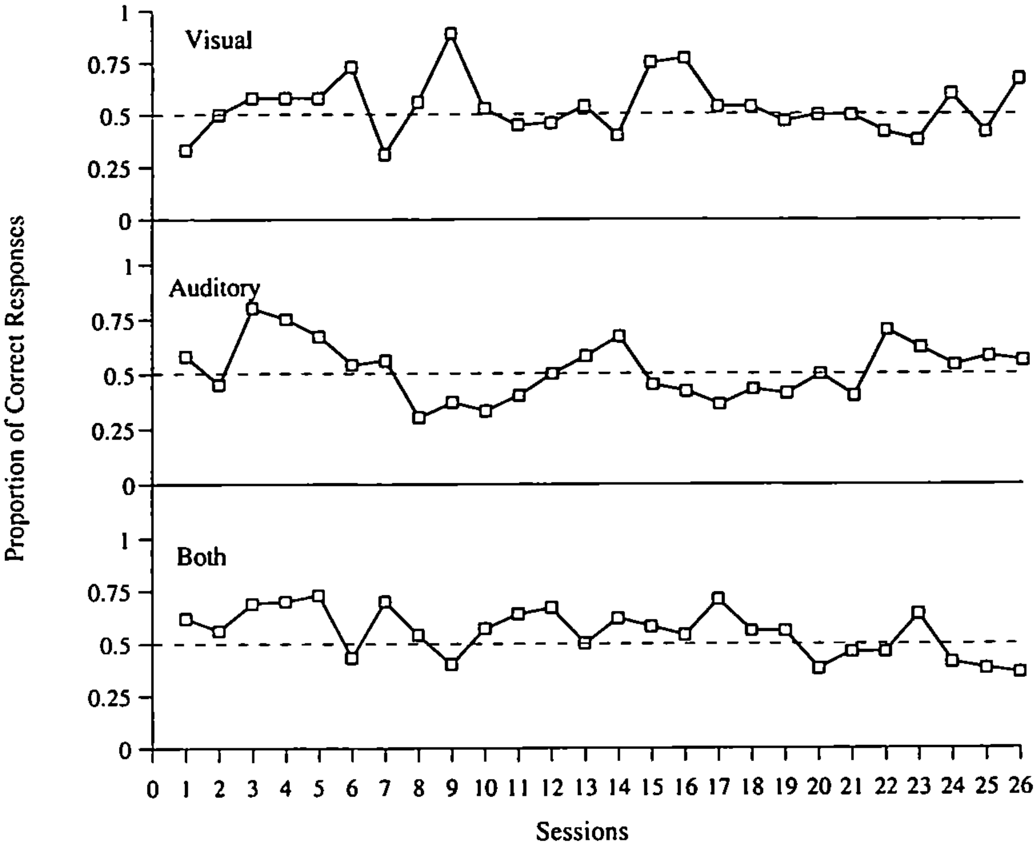


Fig. 18. Brian's Correct Responses under Different Conditions of Sensory Reinforcement

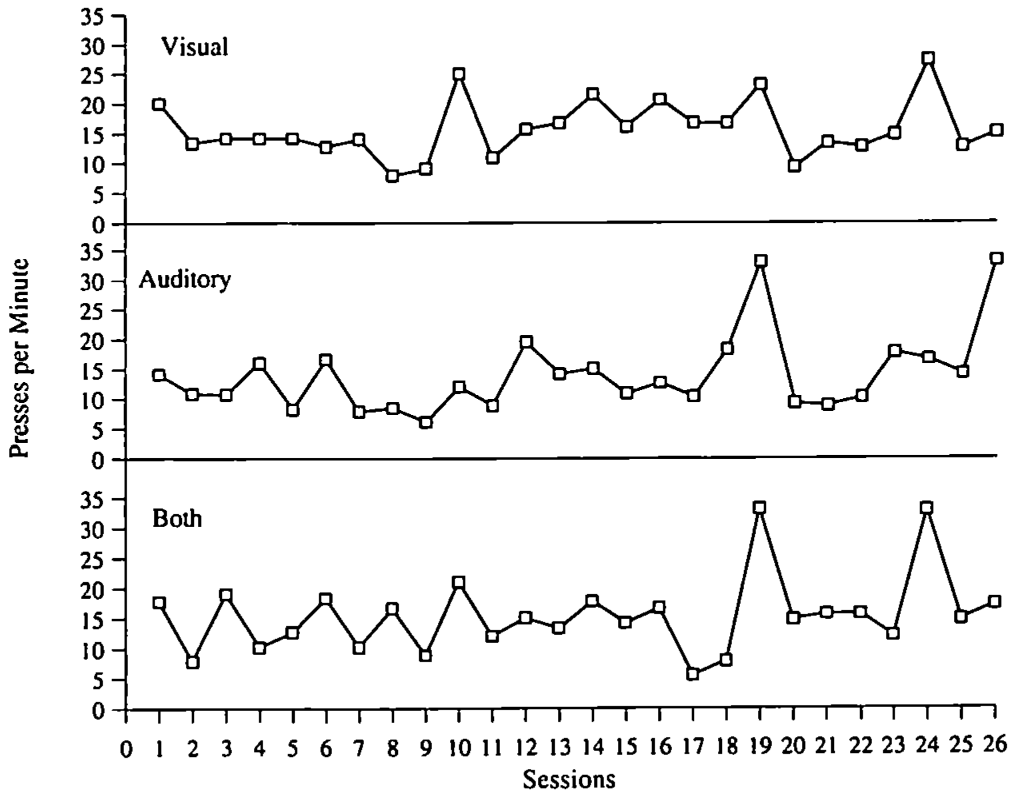


Fig. 19. Brian's Rate of Pressing under Different Conditions of Sensory Reinforcement

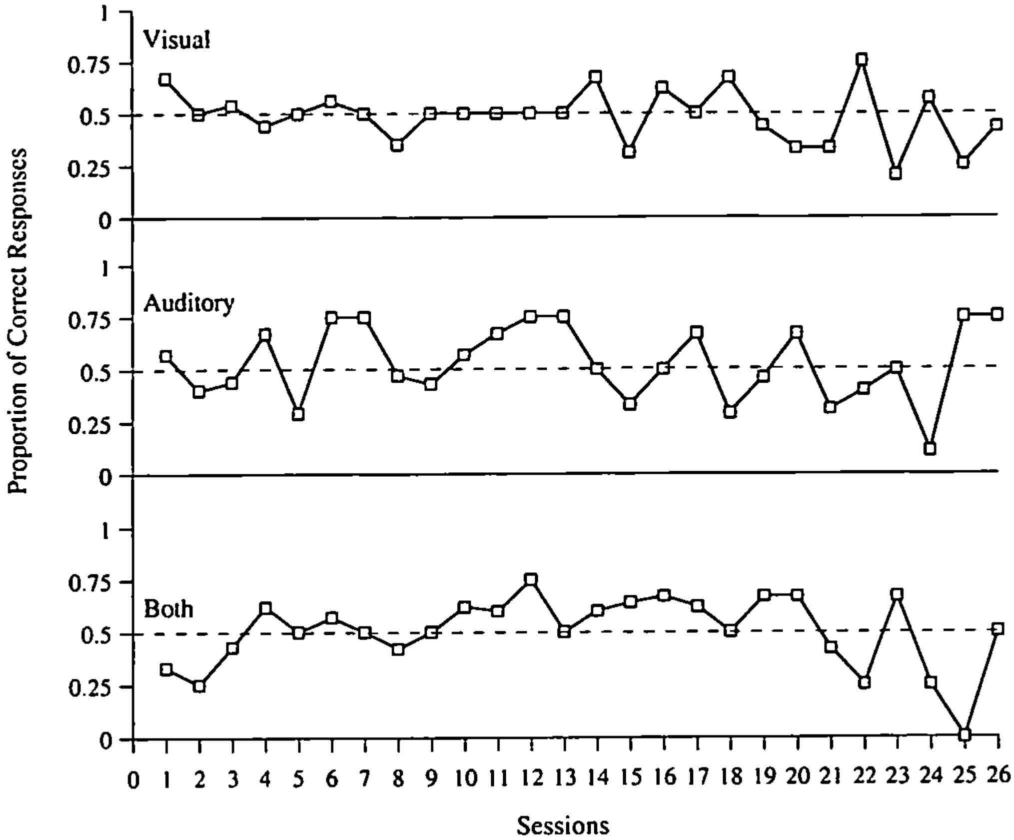


Fig. 20. Roger's Correct Responses under Different Conditions of Sensory Reinforcement

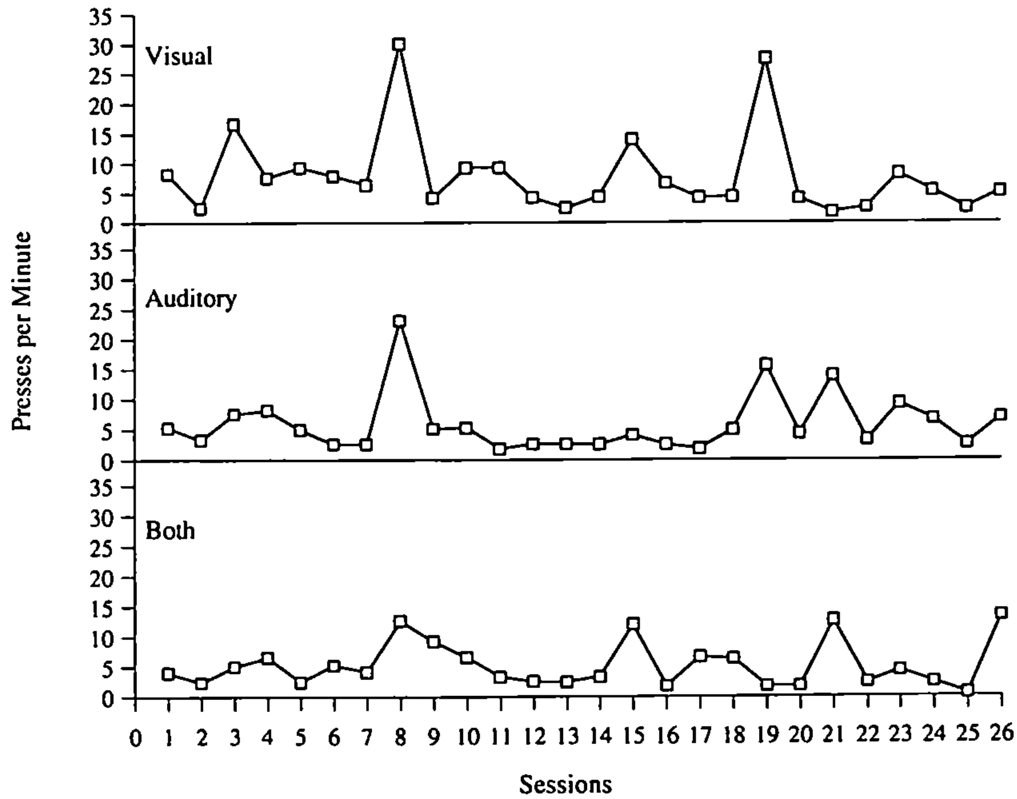


Fig. 21. Roger's Rate of Pressing under Different Conditions of Sensory Reinforcement

6.4 DISCUSSION

The results of this study demonstrate that there were no differences for any of the participants on the proportion of correct responses and the rate of switch activation depending on the type of sensory reinforcer presented during the discrimination task. Thus, the type of sensory reinforcer available had no differential effect on establishing the discrimination. This finding suggests that the sensory reinforcers were unable to support the learning of a simple visual discrimination task and leads to the possibility that the sensory reinforcers which are typical of those available on commercially available educational software are unable to support learning of the type of task which is demanded by the use of conventional computer-assisted learning.

It may be said, however, that the sensory reinforcers did maintain performance on the simpler task of activating a switch. All participants attempted a large number of trials and most of these trials were undertaken independently without the need for prompting. However, contrary to previous findings (e.g. Datillo, 1986; Wacker et al. 1985), no clear differences in terms of discrimination learning or response rates were shown by any of the participants for any particular type of sensory reinforcer. It seems, therefore, that the paradox of sensory reinforcers being able to maintain performance rather than motivate learning of a new task for this group of learners remains. The possible reasons for this will now be discussed.

First, it could be said that the discrimination task was just too difficult for people with severe/profound learning disabilities. The discrimination task was devised to be comparable to the type of discrimination task that might be found in an educational software package for people with severe learning disabilities. It required participants to discriminate colour rather than form, and the discrimination of coloured lights would perhaps have been an unfamiliar task (object and form problems being more common as "everyday" discrimination tasks). It has been demonstrated that form problems are solved faster than colour (Zeaman and House, 1979) and the lack of any relevant form stimulus dimensions may have increased the difficulty of the task to a level where it could not be solved within the number of trials attempted. However, this type of task is not uncommon in educational software (e.g., distinguishing or discriminating different blocks of colour onscreen, as in a "pre-reading" colour matching task). It may be prudent to consider what the relevant task dimensions are and whether they are determining a level of task difficulty that may be too great for the learner to be able to accomplish.

Second, it is generally accepted that people with learning disabilities may take many more trials to criterion while engaged in learning a discrimination (Zeaman and House, 1979). The rate at which discriminations may be learned has been found to improve if stimulus fading (Terrace, 1963a, 1963b, 1966) and stimulus shaping (Sidman and Stoddard, 1967) are employed in the teaching techniques. The discrimination task used in this study did not employ such techniques and may be criticised for not taking into account the known difficulties with "trial-and-error" discrimination training in people with learning disabilities. However, the desire (and necessity) for the research to parallel as closely as possible the parameters of most educational software needs to be remembered here. It is doubtful that any commercially available educational programmes employ teaching strategies such as the "errorless-learning" technique (based on Terrace's work); most adhere to "trial-and-error" methods. Therefore, this experiment followed suit in an attempt to evaluate the reinforcers' ability to support learning during such a paradigm.

There are only a few published studies which do demonstrate the ability of sensory reinforcers to support visual learning under trial-and-error conditions (e.g. Johnson, Firth and Davey, 1978). However, this type of discrimination task is frequently required when using educational software and it is of importance to be able to demonstrate that the characteristics and procedures of these educational programmes are actually able to support the type of learning for which they have been designed.

The fact that this experiment used a classic discrimination paradigm may account for the contradiction between these findings and those of Lovett (1988) and Haskett and Hollar (1978), for example. Essentially, a classic discrimination task involves a relatively short space of time in which to distinguish the reinforced from the the non-reinforced lever. In contrast, other studies have allowed participants to remain in either contingent reinforcement or non-contingent reinforcement periods for a substantial length of time, rather than using a classic discrimination task, and conclusions that discrimination learning has occurred have been made by comparing performances between-sessions. Contingent and non-contingent conditions were not incorporated in this study because it was designed to imitate applications of CAL as much as possible. Further research which addresses basic research questions concerning the role of sensory reinforcement in CAL may usefully be extended to include these conditions.

To recap, it was found that the available sensory reinforcers were unable to support this learning, thought they did maintain performance of the switch activation behaviours. Drawing on some of the theoretical formulations regarding learning and learning disability, it is possible to commence discussion of some of the potential issues may underlie this discrepancy between performance and learning.

O'Connor and Hermelin's (1978) work has suggested that people with learning disabilities have a modality bias in information processing and that this is a positive bias in the visuo-spatial modality compared to the auditory-sequential modality. It is an intriguing possibility that, if the modality through which a task is presented can affect task performance, then the modality through which reinforcement is presented could similarly affect performance. Sensory reinforcement may be sufficiently motivating to result in continued performance of the task, but may be actually interfering with the information coding that is presumed to accompany learning.

Such a cognitive orientation is not usually presented in behavioural work; however, many behavioural theorists now contend that changes in responding during operant tasks occur because the learner learns that their behaviour causes the reinforcer to occur, and a central information-processing mechanism is implicated (Dickinson, 1980). If people with severe learning disabilities do possess such a cause-detection mechanism, and if they also possess a "coding bias" for stimuli, then it is possible that if both the cause and effect stimuli are presented in the same modality this might result in difficulties regarding the appraisal of the relatedness or predictability of events. It may be that reinforcers (effects) need to be presented in a different modality to the task (cause) in order to present quite clearly the relational difference between the cause and the effect. This could be viewed as being similar to the necessity for reinforced and non-reinforced responses to be clearly differentiated so that the discrimination between the two may be perceived and learned.

Of course, this supposition is entirely hypothetical and arises out of interested questioning into the processes that may be occurring during the acquisition of behaviour that is both presented and reinforced using the same stimulus modality. It is open to empirical investigation through the experimental manipulation of same versus different modality comparisons. Indeed, in this experiment, the auditory condition allowed presentations of a different modality reinforcer to the visual modality of the task. However, the findings suggest that this different-modality presentation was not superior to the same-modality presentation in supporting learning of the discrimination. Two possibilities may account for this. First, the relative scaling of the power of the reinforcers is called into question. The auditory reinforcers used may not have been as salient as the visual reinforcers, therefore any benefit in performance due to using distinct stimulus/reinforcer modalities under the auditory condition would be masked by the greater reinforcing potential of the visual reinforcer under the visual condition. The relative value of the reinforcers was unknown and would need to be determined through an experimental assessment similar to those studies which assessed hierarchies of reinforcers (e.g., Dattilo, 1986). Second, the nature of the task is also called to account. The experiment was designed to be similar to a standard task contained in educational software and it has already been stated that, as an initial task, such a discrimination task may be too difficult and some pre-training might be required. It may be that the ability to demonstrate discrimination learning would need to be reliably established first before extending an experiment to include same versus different modality comparisons of task and reinforcer presentations.

A further experiment would include pre-training on discrimination task so that participants would be known to be able to complete such a task. Also, some assessment of the relative salience of the reinforcers would be undertaken, perhaps by examining responses rates under different sensory reinforcement conditions. The tasks and sensory reinforcers would be presented in combinations of same and different modalities so that the effects of intermodal presentations could be investigated. For example, a balanced design which presented both auditory reinforcers for visual discrimination tasks and visual reinforcers for auditory discrimination tasks would be employed. Considering the extensive use of sensory reinforcement conditions in computer-assisted learning, it would be of considerable interest to systematically evaluate learner's performance under a basic programme of manipulations of different conditions of sensory reinforcement.

It is disappointing that this present study can only be discussed from a position of confirmation of the null hypothesis. However, the questions that the study raises of whether it is possible for the commercially available sensory reinforcers to actually support learning are vital ones to answer. The basic paradigms and parameters of reinforcement under computer-assisted conditions remain under-researched. For example, Lovett (1988), in his study of discrimination learning which used sensory reinforcement, makes the point that the external observer may not easily perceive the putative reinforcer. It was outlined earlier that his participants were able to operate a self-carrying battery-powered buggy and he asks "what was the sensory reinforcer?". It could have been any one of a number of possible stimulus events - the movement of the buggy, the movement of the air on their faces, the whirring noise of the wheels or the changes in light stimulation as they passed between areas of shadow.

Similarly, it is easy to assume that the visual and auditory events provided by educational software contingent on responses "must" be the reinforcers. However, there are other sensory events occurring, too - the "click" of the switch, the cool, smooth feel of the panel and the way in which it can be moved. During this present study, it was observed that Roger would smile while rocking the panel back and forth extremely gently and would appear quite "lost" in pleasure from this. This rocking could be so gentle that it would not trip the microswitch and the designated "reinforcers" for switch manipulation would not even be produced. At other times, it seemed that another subject, John, would only be attending to the switches and the way in which, when pressed, they might change colour; the contingent onscreen events could have been inconsequential in his action of activating the switch.

During the use of conventional software, other sensory events occur that are not those which are stipulated as reinforcers. for example, the clicks of the keyboard, the feel of the Concept keyboard, the action of the keys, etc. This difficulty has been acknowledged before in the sensory reinforcement literature and possibly it can not be resolved adequately as long as the operation of manipulanda is required to obtain the reinforcer. Even when the operation of manipulanda is not required (e.g. Lovett's work required an ultrasonic beam to be broken), the isolation of the reinforcers has proved difficult.

Strictly speaking, reinforcers can, by definition, only be empirically determined rather than inferred. In the case of people with learning disabilities, it is often suggested that they are empirically determined for the individual. This would require that the use of microtechnology does not limit itself to providing what are presumed by software programmers to be reinforcing events. Rather, a programme could include a pre-training selection of reinforcer "menu" that actually evaluated reinforcer effectiveness. This could be achieved by a shorter form of some of the experimental methods in studies of reinforcer preference. For example, switch activations could obtain the presentation of a reinforcer for a few trials, then the reinforcer would be changed. A simple tally of responses to the different reinforcers would allow some measure to be taken of its potential effectiveness. For each individual, the program could then implement only those reinforcers which have been evaluated in this way.

Thus, reinforcers may be identified through behavioural observation. The accounts of participants' behaviours above also suggest that there may be some benefit in making direct observations of collateral behaviours, such as smiling, vocalising and rocking, to evaluate the effects of the sensory events presented with CAL. This has been addressed previously by Lovett (1988) and Sturmey, Woods and Crisp (1991), who used changes in collateral behaviours as evaluative measures of the effects of the delivery of sensory consequences and found these to be a useful indicator. Such measures require considerable effort to collect and probably could not be systematically incorporated into the everyday evaluation of CAL by, for example, instructors (although they are frequently used in anecdotal reports). But, they have a greater heuristic value in the understanding of learning by learners with special needs than the usual measures of the effectiveness of CAL, such as number of correct responses.

6.5 CONCLUSION

Sensory reinforcers provided by commercially available software designed especially for people with severe learning disabilities was unable to support the learning of a new, relatively simple task. However, these reinforcers did maintain performance of established switch activation behaviours. Theoretical accounts of learning and information processing may aid in the understanding of this discrepancy between operant and differential responding.

In itself, this ability of the reinforcers to maintain responding in a group of learners for whom it may be difficult to provide opportunities for interaction with the environment can be viewed as a positive finding. One of the implications is that, with repeated exposure and practise, learning may occur if behaviours are observed over a longer period of time than that which was allowed for in the present study. During this time, it may be more useful to make direct observation of changes in collateral behaviour as an indicator of the effects of sensory stimulation.

CHAPTER 7

7. THE DISCUSSION

It is appropriate to begin this discussion with a review of the research presented in this thesis. In the first chapter, the concept of learning was identified as central to our understanding of learning disability. The two main schools of psychological thought which have contributed to this understanding, behavioural and cognitive, were reviewed. Chapter Two then examined the claims made for computer assisted learning (CAL) when it is used with people with learning disabilities. It was acknowledged that the contributions from psychological theories of learning may provide a method of inquiring into CAL's use and efficacy. Evidence from studies which set out to demonstrate the effectiveness of CAL was reviewed and it was concluded that there was insufficient cause to accept unreservedly the value of CAL in special education. It was suggested that further evaluative research needed to be undertaken, and this is the purpose of this thesis. Most previous evaluative work has been undertaken with children, but the focus of the work here was the application of CAL in special education for adults with severe learning disabilities.

Chapter Three attempted to give a "state-of-the-art" view of the use of CAL for adults with learning disabilities. It started with a look at software evaluation and summarised the literature on the evaluation of educational software. This was seen to be applicable largely to mainstream educational software, hence, an evaluation scheme was proposed for software that is aimed at adult special education. A version of this was used in an evaluative survey of establishments that provide adult special education. The findings of this survey suggested that educational software is badly lacking with regard to its implementation of sound instructional methods. In addition, it may not fit well with the objectives of adult-centred care, development and education.

However, purchasers of software did not report many serious complaints or criticisms. So, it appeared that there is some discordance between three major issues which underlie the use of CAL. This discordance can be described as a lack of fit between that which is known about psychological models of learning and learning disability, that which is suggested by the evaluative criteria pertaining to educational software, and, the manner in which CAL packages are implemented and expected to perform in everyday settings.

With this in mind, a special research need was identified. This was to attempt systematic investigations of CAL for adults with learning disabilities within the bounds of its everyday use. That is, to evaluate commercially available software and to utilise psychological models of learning to guide understanding of its use and effectiveness.

Chapter Four was concerned with discussing the methodological issues and difficulties inherent in this type of applied evaluative research with a special population. For the purposes of discovering the obstacles and highlights of such research, a pilot study was undertaken. It was found that it is possible to collect systematically data concerning commercial CAL in a care setting, with the cooperation of care staff. The particular application of CAL was found to increase its target objective (vocalising) for one of the two learners with whom it was used.

The two studies reported in Chapter Five employed experimental methods to compare CAL with conventional teaching. The first study employed a range of tasks to allow a comparison of different methods of instruction over a broader range of skills than in previous work. It was found that there were no significant differences between the different teaching methods, and this concurs with previous findings. However, it was suggested that traditional educational outcome measures (achievement gains) may not have been sensitive enough to any changes in behaviour that might have been occurring. Therefore, the second study changed the focus of the outcome measures and monitored changes in both staff and learner behaviours - prompting, correct responding and ontask behaviour. These were found to be more useful in examining differences between CAL and conventional teaching.

The results from this second study suggested that learners spent more time attending to the task, needed less help and, to some extent, made more successful responses during CAL conditions than during conventional teaching. The reliance of educational software on sensory reinforcers was postulated as underlying the ability of CAL to support consistent attending to the task and to maintain simple responses, such as switch activation behaviours. This role of sensory reinforcement was addressed in the final experiment.

The final experiment investigated the sensory reinforcers typical of those found in commercial software. The previous study had suggested that these could support performance of a behaviour, but could they support learning of a more complex task? Visual, auditory and visual-auditory pairs of reinforcers were evaluated within the context of a visual discrimination task. Results from this study indicated that these sensory reinforcers were not effective when employed as the positive reinforcer for the correct solution of the discrimination task. The participants did not learn the discrimination. However, the performance of the switch activation response was maintained.

Taken as a whole, the studies reported here suggest that there may be some evidence which supports the notion of CAL being different to conventional methods of teaching and that CAL may possess characteristics which are able to motivate learners with learning disabilities and to provide them with experience of interaction with the environment. However, it is clear that these findings are of a small magnitude. They must be qualified and set within the overall context of the evaluation of CAL. This is a function of this chapter.

This Discussion will continue by setting the findings of the research into the context of the three issues which were said to underlie the use of CAL in special education - psychological models of learning, the evaluative criteria of educational software and the implementation of commercially available CAL in a day-to-day setting.

7.1 The relationship of the research to psychological models of learning

The models of learning outlined in Chapters One and Two provide the basis for grounding the findings of the current research. To recap, the behavioural premises guiding CAL came out of the work of Skinner (1958) on programmed learning. Learning can be explained by the processes through which behaviours are acquired and controlled by contingencies of reinforcement and punishment in the environment. These contingencies can be programmed in order to shape behaviours and establish gradual progressions of more complex behavioural repertoires. Attributes of programmed learning can be seen in modern applications of CAL. For example, the student's emission of the response, its immediate reinforcement and giving the learner feedback on their errors.

Second, the cognitive theorists see the application of CAL as providing opportunities for interaction with the environment which may not otherwise be available. The role of this interaction in enabling psychological development and the acquisition of knowledge is seen, for example, in the work of Neisser (1976), who suggests that most objects and events in the environment are meaningful and that knowledge of these meanings must come from interaction with the environment. There is little direct evidence for this, but it is suggested that deprivation of this experience leads to a retarded acquisition of the knowledge. One of the fundamental tenets of cognitive models is that knowledge is derived from action. Microtechnology provides the means to act upon the environment; hence, it provides the means to obtain information.

Essentially, a combination of these behavioural and cognitive ideas aroused great hopes and enthusiasm for the potential of CAL; the potential lying in the idea that microtechnology could provide some means of amelioration for physical limitations, enable interaction and give access to powerful behavioural strategies for change. However, as the research evidence shows, this potential has yet to be adequately demonstrated.

It is probably important to emphasise here that the ideas presented in this discussion have been developed through investigations across a range of learning disability but, ultimately, they are being related to people who have severe/profound learning disabilities. With reference to those who are less disabled, there is an increasing literature concerning CAL as adjunctive instruction to special education for learning-disabled school pupils. The evidence from this type of study suggests that CAL can be a valuable medium through which to provide repeated independent practice. However, the present research is mostly concerned with those who are far less able. CAL for this group of learners is attempting to provide experience of fundamental interaction, rather than practice of educational skills.

The hypotheses discussed below regarding the underlying mechanisms of learning are outlined with respect to this use of CAL rather than to its use as an additional classroom resource.

The findings from Experiment 2 suggest that CAL does have the ability to maintain interaction with the environment as demonstrated by participants' continued switch pressing. Moreover, this interaction is focussed, as borne out by the finding that participants spend more time attending to the task during CAL. Thus, there is some evidence for the motivating effect that has been suggested as one of the advantages of CAL in special education. In everyday language, the increased attention to the task and greater likelihood of interaction that occurs during CAL conditions can be described as increased motivation.

Taken together, the findings of Experiment 2 and 3 that performance is maintained yet new learning does not necessarily occur, implicate the role of attention and sensory reinforcement in CAL's ability to maintain performance rather than to support learning for people with severe learning disabilities. Wood (1988) suggests that attentional set is an active behavioural manifestation which requires effort and motivation. The findings from Experiment 2 demonstrate that CAL increases this behavioural activity. Zeaman and House (1963, 1979) contend that, in order to learn, this attention must be directed to the relevant salient stimuli. Learning disability may be viewed as a difficulty with this direction of attention and, therefore, learning disabled people require more trials prior to learning. Here, the findings of Experiments 1 and 2 call into question the ability of typical, commercial CAL packages to direct attention to the relevant stimuli as no increase in learning was observed. There is increased attention to the task, i.e., attention to the many stimuli in the space in front of the participant, but this may be an increase in attention which is related to an increase in arousal, rather than increased direction to the relevant stimuli.

Even if the salience of the relevant stimuli is manipulated so that perceptibility is increased by narrowing the choice of stimuli as in Experiment 3 where participants had a 2-choice discrimination task, the research has demonstrated that learners were unable to learn to discriminate the relevant stimulus. Moreover, the sensory reinforcers which were consequent to the relevant stimulus were not sufficient to establish the control of discriminative behaviour. The work of O'Connor and Hermelin (1978) describes a visuo-spatial coding bias, which operates for people who have severe learning disabilities and which may influence performance and learning. This suggests that the modality in which tasks are presented determines the manner in which information is subsequently encoded. Commercial CAL presents tasks almost entirely in visual terms.

Drawing on the work of Dickinson (1980), which implies a central cause-effect information processing mechanism in learning, it was suggested that events which are presented in the same modality are more difficult to appraise in terms of their relational differences. If stimulus dimensions and stimulus-reward effects are presented via sensory stimulation in the same modality, their relatedness may be more difficult to perceive. Thus, the difference between cause and effect may not be easily detected and the relationships between stimuli and reward may not be learned. This explains the failure of visual sensory reinforcement to support learning the visual discrimination task in Experiment 3.

So, stimulus modalities may interfere with learning. Clearly, this has important implications for the use of commercial educational software, which relies on sensory stimulus presentations to both present and reward tasks. Furthermore, these presentations are often made up of multiple sensory stimuli - complex visual stimuli which are accompanied by auditory presentations. Sensory stimulation may well motivate attention and performance but, from the theories discussed here, there are apparent reasons why such presentations may effectively hamper, rather than encourage, learning. This may help in the understanding of the observations that CAL may be "stimulating and rewarding", yet the increases in learning that would be expected from increased motivation have been so difficult to demonstrate.

In sum, the psychological models of learning discussed above, which draw on a range of theoretical suppositions, can usefully aid in the exploration and understanding of the use of CAL with adults who have severe learning disabilities. Largely, they have enabled the analysis of underlying mechanisms of learning through this medium. They cannot be said to be predictive of an individual's specific course through opportunities to interact with the environment by using microtechnology, though they may point to implications for the further implementation of CAL. Before turning to discussion of these implications, it is necessary to acknowledge that there are methodological issues to be accounted for and into which context the findings of the present research must be placed. These will be discussed next.

7.2 Methodological concerns

Few studies have been able to demonstrate the efficacy of CAL, and most have attempted this by investigating its superiority over other methods of instruction. However, there are methodological difficulties in attempting this sort of comparison study, which are further compounded by the problems of applied research with a special population. It could be concluded, then, that the dearth of empirical evidence is attributable in part to the lack of an adequate methodology.

The present research has employed a variety of empirical approaches to the evaluation of CAL and it is possible to make some assessment of their relative success or failure and to comment on the lessons learned. Some of these specific issues were discussed in relation to each study; here, there will be an overview.

In order to begin to frame this evaluation, a survey of current uses of CAL in adult-care establishment was undertaken. This was largely a qualitative approach and enabled a great deal of information about different pieces of software and how they were implemented to be gained.

However, the sorting of this data into meaningful patterns was problematic. This could be attributed to the small sample size, but was more likely to be due to the lack of a more pre-planned systematic approach. This qualitative approach could be made more rigorous by, for example, assigning a rating scale to each of the evaluative criteria representing the principles of effective teaching and learning. In so doing, an overall "evaluative rating" for a piece of software could be calculated and software packages could be more easily compared, but flexibility, breadth and naturalistic relevance may have been sacrificed.

The strengths of the approach here, though, was that a more real picture was obtained of the use of software. Thus, it did not specifically aid evaluation in terms of learning principles, but did point to the wider issues facing educators and highlighted the discrepancy between learning theory and practice. It also allowed the perception of a mismatch between the discontent with software expressed by the purveyors of "evaluative theories" and the satisfaction which was largely expressed by the consumer. In other words, a questionnaire which quantitatively demonstrates the inadequacy of the implementation of learning principles may well lead the respondent into saying they were dissatisfied with the software. But, with a qualitative approach, most respondents reported being happy with the packages. This may not be a desirable situation to a researcher who would prefer to see better learning principles guiding CAL, but does help in the understanding of why CAL may get used (and fairly extensively) even though its effectiveness is questionable.

The remainder of the research addressed itself directly to quantitative investigations of CAL. All of the difficulties of applied evaluative research reviewed in Chapter Four, such as heterogeneity of participants, small numbers of participants and the multidimensional nature of the behaviour under study were anticipated and met. Looking back over the studies, it is clear that these issues can be considered to be weaknesses and thus, these studies fall prey to the same criticism of "a lack of methodological rigour" that was levied at the body of studies reviewed in Chapter Two. However, these methodological difficulties have long been acknowledged in learning disability research and it is recognised that the studies need not be considered invalid even though these problems are encountered.

The greatest difficulty encountered was that of being able to make meaningful comparisons, particularly between the different methods of instruction in Experiments 1 and 2. The pragmatics of designing analogous tasks for comparison was discussed in Chapter Five and it was concluded that this was a theoretically desirable, but, practically almost impossible feat to achieve. With regard to evaluative research, this difficulty can be got around by accepting that CAL-taught tasks and teacher-taught tasks are so different that the ecological validity of comparison studies can be questioned, particularly with regard to achievement gains. These traditional outcome measures lose their meaning in the evaluation of CAL for people with severe learning disabilities. A more useful approach was that of a finegrain functional analysis of the different behaviours under each condition. This is still a comparison, but one which focuses on "within-task" (within-series) data and analyses in order to investigate the effectiveness of CAL. An example of this was the way in which the observational data from Experiment 2 was able to frame possible processes occurring during CAL and to generate new hypotheses for testing.

The lack of equivalence between tasks becomes of much greater importance in the practical implementation of CAL for its everyday use. Consider the process by which tasks get "put on the computer" - that is, they are observed to be of educational import, possibly in a teacher-taught model, and a comparable computer task is designed and the software written. It is a distinct possibility that tasks are "computerised" with little knowledge of their validity when compared to the original teacher-taught version of the task. This research has demonstrated some of the difficulties with establishing the validity of comparing tasks; tasks change in the process of transcribing them. Similar issues have been encountered in the area of psychological testing when tests are computerised (British Psychological Society, 1984). The methodological issues for research that arise from this have been discussed here and the implications for implementation and development of CAL will be discussed later.

These problems with comparison were compounded by the additional difficulty of having to draw conclusions about these comparisons from data obtained from a heterogenous group of participants. The issue of heterogeneity of participants and, related to this the small number of available participants, is fully acknowledged as problematic in learning disability research (Schindele, 1985) and it is circumvented to some extent by recognition of what can be very great differences between individuals and the fact that each person's special needs are of paramount importance, rather than those of the group. However, this philosophy could render observations taken from single participants as unable to contribute to knowledge of an overall area of study. The generalisability of the findings from single-subject and small-group studies relies on repeated empirical demonstration - validity is actively demonstrated rather than assumed (Kazdin, 1984; Morley and Adams, 1989). Findings must be compared and similarities and differences noted.

This research took as its starting point the lack of empirical demonstrations and attempted to implement them. Consideration of the difficulties enabled the research to develop, and even progress, to a point where constructs revealed by the weaknesses were refined and became points of impetus and growth. For example, the multidimensional nature of the tasks, the difficulties with transcribing tasks and of making comparisons between them meant that data from Experiment 1 did not further generalisable knowledge or inquiry to any great extent. But, this very multidimensionality became the source of focus in Experiment 2 and this investigation served to inform of processes that underlie participant's interaction with CAL.

On the whole, the research presented here supports the usefulness of multi-element within-subject designs, concerning either single-subjects or small groups, in order to assess interventions with a group of learners from a special population. The observation of multiple behaviours was more informative than noting only "educational achievement gains". The observation of collateral behaviours such as smiling, vocalising and stereotypic movement would be a useful addition to the catalogue of observed behaviours, particularly for assessing the learning behaviours of individuals with severe and profound learning disabilities.

A comment on the employment of these designs concerns the usefulness of statistical analysis in this type of research. The current research presented fairly rigorous statistical analyses, whose appropriateness could be questioned. Tests such as analysis of variance could be argued to be out of place in small-n evaluative research, especially when it is concerning learning experiments where it is acceptable to use visual inspection of the data and statistical analysis has been suggested to be unnecessary (see, for example, Sidman, 1960; Kazdin, 1984). But, it is hoped that such approaches may be warranted when there is a recognition that the area under investigation is relatively unresearched and that, in order to facilitate interpretation and to promote knowledge and study of the area, experimental investigations must be maintained even in the full knowledge of some violations of the experimental model (Hersen, 1990).

A final comment on methodology relates to the applied nature of the research. One of its aims was to assess the implementation and efficacy of CAL in its everyday format and its everyday setting. Taking the research into care establishments brought with it particular obstacles, such as staff resistance and their feelings of being threatened. This was problematic for many reasons, but not least because the conduct of the research was so dependent on the help and cooperation of care staff. A number of ways of dealing with this were developed.

First, the process of introducing the research to the establishment was made at all levels of the system - from managers to ancillary and peripatetic staff. Second, staff were given a research briefing of the study's hypotheses, aims and methodology in introductory seminars. Any staff directly involved in the research as instructors or helpers were also given any necessary additional training. There was also a debriefing session held at the end of the study. Third, the researcher spent time in the establishment learning about its routine, the attenders (and likely participants) and doing the tasks of care staff. This was for two reasons:

1. It was of great benefit in designing the studies to be as good a fit as possible with the establishment's routine.

2. When staff were required as instructors in the studies, this inevitably created a manpower crisis on the unit and the researcher was able to contribute to the care tasks and, above anything else, this enabled the studies to be completed.

It should be remembered that this type of applied "one-to-one" research with people with severe/profound learning disabilities is extremely time-consuming and labour-intensive. These studies were of a medium-term duration (3-4 months) given the nature of the participants' disabilities and the fact that learning was being observed. When conducting research on a unit for this length of time which changes the usual routine, it is essential that adequate groundwork is done if the study is to become a natural part of the establishment for that time. This lowers the tension for care staff, participants and the researcher, and this may have an effect on the outcome of the study, especially if both staff and participant behaviours are being observed. Consider, for example, the importance of the emotional atmosphere when such behaviours as ontask, prompting and rewarding are taking place.

It may have additional benefits, too. The day care unit in which Experiments 2 and 3 took place decided to continue with a CAL programme after the studies had finished. The staff adapted to new routines, modified the CAL interventions and designed recording sheets in order to monitor changes. The attenders had access to a new activity, which they could take part in if they wanted. Some of the table-top activities were also modified to incorporate some of the principles which staff felt they had learned from the study. In sum, taking care over the implementation of the study resulted in valuable outcomes, other than those of fulfilling the needs of the researcher.

7.3 The relationship of the research to software evaluation criteria

The evaluative criteria outlined in Chapter Three focus on three subsections; fundamental program characteristics, instructional concerns and principles of learning and teaching. It will be apparent by now that the psychological principles of learning that educational software for learning disabled adults purports to embrace have come under considerable scrutiny from this research. Therefore, it should be sufficient to give a brief summary here of the important points arising from the research concerning this evaluative subsection, and to then discuss the other two subsections.

Although most software makes use of behavioural principles in its presentation, these need to be empirically researched in order to investigate their effectiveness in CAL packages. It is not sufficient that they are assumed to work; this research has given reason to doubt even the most basic assumption. For example, if the criteria of "Is the program motivating?" is examined, the following can now be said; it may well appear to the person filling out an evaluation form that the software would be motivating, and the findings of Experiment Three have demonstrated that motivation may be important to engage the learner, but motivation alone does not necessarily mean that the program will be able to support learning.

Ideally, all the criteria which relate to various principles of learning and teaching should be separately researched to see if, when placed in the context of a CAL package, they do indeed guide learning in the way their supporting theories would predict. For example, the role of feedback, the role of shaping and chaining, the role of stimulus control and response generalisation, the role of retention and recall, the role of modelling by example, etc. Clearly, some of these principles will apply more to learners who are less disabled than those who participated in the current research.

In general, there is a need for a "task analysis" of CAL tasks, which would be followed by experimental investigation of the principles guiding the practise. It is interesting to recall that this empirical demonstration has been repeatedly called for, and that pen-and-paper evaluations have consistently rated software badly on the implementation of learning principles, but that, for the most part, this empirical evaluation of these principles remains undone. The current research may illustrate that this type of empirical research is no small task. In the light of this, it is perhaps not surprising that systematic evaluations are still lacking.

The criteria which relate to fundamental program characteristics include the technical aspects of the hardware, the operational concerns, the directions for use and the execution time. Overall, the research points to the need for software for adults with severe learning disabilities to be much more flexible and, perhaps, to be much more simple in its operation. The challenge for program writers would be to create software which is much more adaptable to individual need (for example, it would be able to change pace, change graphics and sounds, change level of difficulty).

Also, screen content and design needs close attention. Currently, software relies heavily on written visual content, which may be entirely irrelevant to people with severe learning disabilities. Indeed, one of the fundamental findings of this research is that all the sensory content of software and accompanying switches needs to be more carefully considered. Ideally, their design and implementation would, again, be based on empirical findings. At the very least, research on CAL sensory reinforcer preference and the possible reinforcing properties of switches themselves could provide useful pointers to more adequate software design.

Lastly, the area of instructional concern covers the criteria relating to the prerequisite skills needed, objectives of the program, the skills being taught and the accuracy of content. Here, the research has highlighted the lack of fit between most available software and the day-to-day concerns of the adults for at whom the software the software is targetted. There is little coherence between the ideas of what needs to be taught, why it needs to be taught and to what use it will be put if it is mastered by the learner. The available packages seem to have grown out of available programming resources and ideas rather than some idea of an overall curriculum for development and education. This may be one of the reasons that CAL can appear to to be little more than "just another activity".

However, this is not to say that CAL should never be used in a recreational or leisurely fashion, but programs that fit in with usual activities and goals of day-care centres for adults could be established. Suites of programs are now in circulation that are established on an overall framework. For example, for learners with severe/profound disabilities, the COMPACT (British Institute of Learning Disabilities) programmes aim to develop basic interaction with the environment and to teach switch behaviours and stimulus-response relationships in a hierarchical fashion, but these still lack evidence of their efficacy.

Evidence of attainment of objectives need to be carefully considered. This research has questioned whether the comprehension of the content of the educational material versus the ability to comprehend and perform the physical responses that are required to use the package are one and the same thing. For example, participants could attain a correct response through a manifestation of the physical actions required to obtain a reinforcer, but this cannot be taken to mean that they have understood the educational content of the program. If CAL is to be used to teach traditional educational skills, there needs to be some test of generalisation.

However, for learners with severe/profound disabilities, it could be argued that CAL is providing an experience that is of value in and of itself and that gains through this medium may not be generalisable to other situations, at least in the first instances of learning interactions with the environment. This may be a reasonable argument, but again, it requires validation and verification.

In general, the current research highlights the need for most of the evaluation criteria not to be taken at face value. There is a world of difference between evaluating a piece of software by using an evaluation form and noting its good and bad points and evaluating software by using it consistently over a substantial period of time and observing its effects. Obviously, not every piece of software can be evaluated by conducting experimental trials, but the principles incorporated in software should be evaluated in this fashion. And, perhaps, every piece of software should be adequately piloted, reviewed and revised, in consultation with psychological and educational opinion, before it is mass marketed.

7.4 The relationship of the research to the development, evaluation and implementation of CAL: Implications for the future

The scope of evaluating CAL for adults with severe learning disabilities is very wide indeed. The research presented in this thesis began with an overview of psychology's contribution to learning and learning disability and ended with an examination of one of the learning principles incorporated in software (i.e., the use of sensory reinforcement). This scope means that it would be impossible to justifiably discuss the implications for the many aspects of CAL which have been touched upon, and this part of the discussion will be confined to direct implications from the current research.

It can be said that evidence concerning basic components of CAL and resultant processes is lacking and that there are so many different issues which are guiding principles and practise that it is indeed difficult to perform research which can easily present coherent answers to such an extensive area. It is perhaps best to illustrate where and how psychology can apply itself by taking a recent example of encouragement to use microtechnology for learners with learning disabilities, and to comment on this.

Mackay (1991) writes a chapter concerning the implications of stimulus equivalence for the development of adaptive behaviours for those who have severe learning disabilities. The ability to match stimuli (or acquisition of stimulus equivalence) is an important prerequisite for reading. Mackay suggests that presentations of stimuli can be readily automated via a computer - "thus, practical methods are available for introducing rudimentary reading tasks to many severely handicapped individuals without the continuous involvement of a teacher". Indeed, there are many matching programs available in the range of educational software for those with severe learning disabilities.

This ability for CAL to provide frequent repetition of material in a tireless fashion was considered to be one of its advantages. And, people with learning disabilities are known to require more trials before, for example, learning of a discrimination takes place. Therefore, it seems that if tasks requiring frequent repetition can be practised with a computer, this will be a good thing. However, this necessitates that a task, which is usually teacher-taught, is transcribed into a format where it can also be presented on the computer. For example, the task of matching cards (containing forms and colours) becomes the task of identifying forms and colours on a screen which match and to use a switch to demonstrate knowledge of the match or mismatch.

A brief look at this suggestion reveals a number of difficulties identified in the current research. These will be summarised here, then discussed further. First, the present research has called into question the ability of the CAL systems (use of switches and reinforcers) to support this type of visual discrimination learning. It also questions whether it is a discrimination of onscreen stimuli or a discrimination of manipulanda that is being established. It also asks whether it is the matching that is being practised or merely the behaviours required to operate the software. There is also reason to doubt Mackay's hope that learners can achieve relatively independent practise; the findings of the evaluation survey are that instructor intervention is required far more often than is supposed. How then can implications from this research contribute to resolving some of these problems?

The concern over the equivalence of CAL-tasks and teacher-tasks was first raised in Experiment One. Here, a comparison was attempted which required the development of analogous tasks both on and off the computer. It was concluded that the transcribing of tasks alters them to the extent that assessments of what is being learned, and hence comparisons of the methods, are difficult to make. Would it be better to teach tasks on a computer? The evidence here suggests that participants did not achieve differently between the two conditions. Therefore, in terms of achievement gains, there is no reason to infer that CAL is a more appropriate medium for learning.

However, the findings from Experiment Two suggest that the behaviours occurring during CAL are different and that pursuing these differences allows further questions to be generated. For example, what is being learned during CAL; are the "educational concepts" being practised or are participants simply getting better on the behavioural responses required to operate the software? To answer this, we can use a behavioural framework and investigate whether the consequences of the tasks have any effect on the behaviours that are being performed.

Here, we see two actions coupled together - the performance of motor responses to operate the software and the software's presentation of consequences, usually visual and auditory stimuli. This coupling together of responses is an underlying feature of CAL. In both the learning literature and the evaluation literature, this is identified as being of importance. The learning literature refers, in behavioural terms, to the necessity for repeated trials and practice of responses, presumably to learn contingencies. In cognitive terms, repeated action upon the environment enables knowledge to be derived. In software evaluation terms, software is more likely to be rated as being of high quality if it demonstrates characteristics of being easily physically accessible (i.e., the movements that are required to work it) and being well-presented on screen.

This coupling of physical responses to software consequences is one of the basic issues involved in CAL that has not been adequately addressed. It has been shown during the current studies that responses can be prompted so that learners can operate a variety of switches, but this left the question of whether it was the physical action or the contingent operation of the software that was being learned. Conventional "off-the-shelf" CAL systems offer a low degree of flexibility and require the learner to make pre-determined responses. Another way of proceeding would be that responses were able to develop through the manner of shaping and reinforcing the existing response repertoire of the learner, leading to the gradual acquisition of more complex responses. The CAL system would initially adapt to the learner and together learner and computer would lead each other to more complex routines, rather than the learner having to comply from the outset with the systems limitations. This could be argued to resemble more closely the way in which intellectual development progresses, with a gradual adaptation to the environment. However, this is a debate concerning the development of cognitive versus behavioural achievements and their relative validity. It is related to the cognitive and behavioural frameworks behind the implementation of CAL discussed in Chapter Two, but its resolution is beyond the realms of this discussion. Suffice it to say that there should be some thought given to the flexibility of CAL systems.

No matter what the meaning of the eventual achievement, there is a need to focus on the process by which CAL means to engender the acquisition of this achievement. Educational software relies on sensory presentations of content and on sensory reinforcers. One of the fundamental issues considered by this research is "What reinforcement is provided and how is it functioning?" in the CAL teaching situation. Educational software's reliance on sensory stimulation is focussed on the screen presentations, rather than on the hardware. A great deal of effort has gone into developing "enabling" hardware to allow interaction between handicapped users and the computer, but the possibility that these switches, and their operation, may provide sensory stimulation, too, is largely overlooked. This research suggests that these switches are providing considerable sensory stimulation. In some instances, it seemed that manipulation of the switches was sufficient in itself to maintain behaviour and that the software's consequences of the switch manipulation; i.e., the changes occurring onscreen as a result of pressing the switch, may or may not even have been attended to. No measures were taken of eye contact with the screen that could be compared to measures of tactile contact with the switches. A task in assessing the relative impact of onscreen consequences as compared to switch manipulation would be to collect data of this nature.

This lack of data concerning basic behaviours during CAL means that there can be no certainty about what contingencies are operating to reinforce and maintain behaviour. It is possible that different, less observable contingencies than simple "stimulus-putative reward" relationships maintain switch pressing. Some of the these could be stated thus: "Switches feel nice." "Making the actions that work the switches is rewarding." "Pressing makes the switches change." "I must press when this person has brought me into the room." It could be suggested that it is the learning of these relationships, rather than the target objectives of the software, which is influencing participant's performance.

Here, a further set of questions is raised which concerns control of behaviour. For example, is it the presence of the computer or the instructor, is it the actions of using switches or is it actually the parameters of the software that are controlling the behaviour? At the present time, it is assumed that software has the ability to affect a behaviour. However, a study by

Salend and Santora (1985) illustrated that access to the computer was able to act as a reinforcer for appropriate social behaviours in a group of learners with mild-to-moderate learning disabilities. This access was to educational software rather than games, so it was not the opportunity to avoid work that was the motivating factor. Rather, it suggests that just being given the opportunity to operate computers may be motivating outside of any direct influence on the learning of behaviours or educational concepts.

This research has been critical of the assumption that increased motivation leads directly to increased learning. Yet, increased motivation per se may be a worthwhile goal for learners for whom it may be very difficult to find stimulating material. However, it is not sufficient to assume that it will lead to learning without there being any evidence for this. The concern expressed here is that CAL may be attractive initially because of its ability to motivate and to increase performance, but this may or may not lead to eventual learning. Indeed, any increased motivation and performance could revert to original levels again over time. Studies of the type presented here would need to be lengthened considerably so that long-term changes could be assessed. This would be particularly the case given greater degrees of disability.

We can see then that a simple suggestion to use CAL presented tasks carries with it many implications which bring attention to the fact that it is not a simple matter to teach tasks to learners with severe learning disabilities by using a computer. This is not to say that suggestions, such as Mackay's, for the use of CAL are worthless; far from it, they correctly identify the potential of CAL, but they cannot at this stage be supported by the current evidence regarding CAL's efficacy. The basic research is lacking and there is not enough known about the mechanisms underlying CAL to encourage such use without sufficient evidence to warrant it.

7.5 Future research directions

A number of directions are suggested for future studies in order to obtain such evidence concerning the use of CAL. Almost all of the issues discussed above are amenable to experimental manipulation, and a systematic investigation of variables in a programme of basic research is called for. First, specific program parameters could be examined in order to find out what elements are maintaining behaviour. For example, effects of different presentations of program content, different sensory reinforcers and the various schedules of reinforcement on acquisition of responses, response rates and ontask behaviour should be investigated. Second, switch parameters should be similarly examined. For example, effects of different shapes, textures and mechanical action of switches on behaviours should be investigated. Third, a comparison of the reinforcing properties of the physical responses required to operate the software and the reinforcing properties of the response-reward relationships could be examined by routinely including a non-contingent condition in evaluation studies. Fourth, stimulus control studies should be undertaken in order to find out what stimuli are being discriminated by the learner and which are controlling their operation of the software. For example, effects of being prompted to work or engage, effects of being left to work independently, effects of the salience of stimulus dimensions of the switches or the screen content would be of interest with respect to motivation to engage with the CAL system. Lastly, there is also a need to assess the generalisation of responses learned through CAL to behaviour outside of a CAL environment.

While these questions should be of interest to those who advocate the use of CAL and investigations of its efficacy, there is little doubt that a basic research programme of this type would be lengthy, labour intensive and would carry with it all the difficulties inherent in applied research with a special population. It would also require resourcing, and the amount needed would be quite considerable.

The responsibility for the development and, just as important, the evaluation of CAL packages for special education does not rest with any one body. Some developments may be supported by organisations such as the National Council for Educational Technology and may be more likely to be better informed. Others may come from interested individuals, and yet others directly from commercial companies. In the latter instance, it seems that commercial CAL can be sold to educational and care establishments just on the basis of commonsense and a smattering of learning or educational theory. If customers are satisfied with the software and are implementing CAL, and their learners are engaging with it, then it is easy to see why effective evaluations, which would be expensive, are not carried out. In the former instance, there are examples enough of underfunding for research purposes, resulting in a lack of evaluation.

However, the results of the current research and the body of evidence reviewed earlier suggest that such evaluations are needed in order to develop and implement CAL better. The initial development of CAL came out of theories of learning. These theories are well established and their principles are known to be effective in changing behaviour. Microtechnology has the ability to link the learner with these principles. Therefore, its use is of great potential benefit. However, for all the reasons discussed earlier, this potential continues to remain underexplained and underexplored. Until there is an established body of evidence and literature on the psychological and educational effects of using microtechnology in learning, its ability to contribute to the activities and lives of people with severe learning disabilities will remain limited in scope.

APPENDIX 1

" Software For Adults With Severe Learning Disabilities "

Hello...I am asking for your help in a survey evaluating the use of microcomputers in establishments for adults with severe learning disabilities. Any information given is confidential and no individual participants will be identified in any report of the survey. If you cannot give answers to any of the questions, please leave them out and go on to the next one.

First of all - a few details:-

Establishment..
Instructor..

What type of disability are you involved with?...

How many hours a week does your establishment use computer based

activities?..

On average, how long is a typical session using the computer?
....

What are the three programs you use most often? Who are they published by? How much do they cost? How did you obtain them?

1...
....

2...
....

3...
....

Overleaf there now follow some more specific questions about the software. Please answer them for the piece of software you use most often.

Please return this questionnaire to:
Sarah Baldrey
Dept. of Psychology
FREEPOST
Plymouth Polytechnic
Drakes Circus
PLYMOUTH PL4 8AA

No stamp is required.

Please answer each question with yes, no, don't know or not applicable. Comment in greater detail if required. If necessary, continue overleaf and number the question. Where asked to indicate options, draw a circle around any which are applicable.

Hardware

Please indicate which of the following you used:
a) Cassette b) Disk c) Monitor d) TV e) Colour f)Monochrome g) Switches (please give details)
....

Have you made any modifications to the standard equipment in order to use the program?..
....
....

Objectives

Are the objectives of the program clearly stated?...................
If they are not stated are they self-evident?........................

What are the objectives of the program?
....
....

To what extent are these objectives achieved? (Ring a number on the scale 1-5, 5 is highest)

A large extent 5 4 3 2 1 Not at all

Does the program improve any other skills (Please ring) a)Motor/physical b) Attentional/ motivational c) Scholastic d) Language e) Self help/social f) Other (please specify)...............

Use of the Program

Describe briefly what the program does including the elements of the task and the rewards...
....
....
....
....
....
....

Does the program use (please ring) a) Drill & Practise b) Reward Training c) Modelling d) Game playing e) Exploration/Discoveryf) Other (please specify)..............................

Are the instructions clear to the instructor and/or students?.................................
Did you use the program for (please ring) a) Individuals? b) Groups? c) Instructors use?

How much instructor intervention was needed? I.e. how often per session did you have to help/reset the program/supervise?..
Can the program be used in a noisy, busy room?...

Is it easy for the student to make the wrong response by accident?..

Does the program survive inappropriate key presses?..................

Suitability for Students

What ability range is the program suitable for? (Eg. special care,mild learning disability etc.)...

Does the program require (please ring) a) Reading skills b)Writing skills c) Number skills d) Comprehension of speech/language e) Production of speech f) Other (Please specify)..................

What sensory or motor handicaps can the program be used with?
....

What span of attention is required of the student? (please ring)
a) Very variable b) 0-10s c) 11-30s d) 31s - 1 min e) 1-2min f)more than 2 min

Is the program age-appropriate for your students (in terms of graphics, vocabulary, concepts, etc.)?...

Presentation and Motivation

Was the screen layout attractive?..

Have you any specific criticisms of screen design and sound?
....
....

Did the students find the program a) Entertaining? b) Stimulating?

Did the program sustain interest after initial use?..

Was the feedback for correct and incorrect responses clearly different?
....

Is the feedback for an inappropriate/incorrect response rewarding?
....

Does the program help to correct wrong responses? (Eg. by prompting, repeating or making the task easier)..

Amendment of the Program

Is there a choice of graphics used to present the task?...

Is there a choice of rewards (eg. type, number and duration of reward)?
....

Are there suggestions for changing the programs operation to suit individual needs?
....

Can the pace at which the program works be altered or controlled?
....

Can you set the length of sessions? ....

Can you keep a record of performance (on disk, tape or printout)?
....

Are there any other record keeping features and what are they?
....
....

Do you consider the program educationally sound?
....
....

Does the program do something conventional methods do not do?
....
....

How could the program be improved?
....
....
....

Any other comments
....
....
....
....

APPENDIX 2i

Experiment 1 - Participant Verbal Questionnaire

1. What do you think of the work you have been doing with me?

2. What things do you like about the computer?

3. What things don't you like about the computer?

4. Would you like to do work on the computer everyday?

5. What's the best work to do on the computer?

6. Would you like to work with anyone on the computer?

Experiment 1 - Verbal comprehension test

1. You like other people to hurt you.

2. It snows in the summer.

3. You like to eat rotten food.

4. You like to feel happy.

5. You like doing things you enjoy.

Analysis of Variance Table for Experiment 1.

Source	SS	df	MS	F	p
Between Ss	1.253	5			
Groups (blocks)	1.253	5			
Replications	0.187	1			
AB(from Rep 1)	1.044	2			
AB^2 (from Rep 2)	0.0208	2			
Ss within groups					
Within Ss	1.289	12			
A	0.373	2	0.1865	4.6859	ns
B	0.319	2	0.1595	4.0075	ns
A x B	0.4378	4	0.1095	2.7513	ns
AB (from Rep 1)	0.2166	2			
AB^2 (from Rep 2)	0.2212	2			
Residual	0.1592	4	0.0398		

Pre-Computer Training: Client Screening

This form is designed to record early reactions to a computer programme. In case a client is having a 'bad' day, it is advisable to give a second chance. Please allow each client up to 15 minutes to work on the programme.

CLIENT:.. SETTING:...
KEYWORKER:......................................PERSON DOING THE TRIAL:..........................
NAME OF PROGRAM:................................ SUBPROGRAM:.......................................
LEVEL OF PROGRAMME AT START (if applicable):........ TODAY'S DATE:...............

1. Attention To The Screen Without Prompts?
   Most Of The Time   About Half The Time   Rarely   Avoided Screen Or Distressed

2. Attention To The Screen With Prompts?
   Most Of The Time   About Half The Time   Rarely   Avoided Screen Or Distressed

3. Prompts Used Most
   Rarely Used   Verbal   Gesture   Modelling   Physical

4. Attention To The Computer's Sounds Without Prompts?
   Most Of The Time   About Half The Time   Rarely   Distressed By Sounds

5. Attention To The Computer's Sounds With Prompts?
   Most Of The Time   About Half The Time   Rarely   Distressed By Sounds

6. Which Switch Was Used?..

7. Use Of The Switch Without Prompts?
   Most Of The Time   About Half The Time   Never

8. Use Of The Switch With Prompts?
   Most Of The Time   About Half The Time   Never

9. Prompts Used Most
   Rarely Used   Verbal   Gesture   Modelling   Physical

10. Length Of Attention In The Session?
   Over 15 Mins   10-15 Mins   5-10 Mins   Under 5 Mins   Distressed

Summary And Comments:

Analysis of Variance Tables for Experiment 2.

Baselines 1-5

Variate: Ontask

Source	df	SS	SS%	MS	F	p
Subject stratum	7	470514	39.49	67216	.	
Baseline (BL)	4	157440	13.21	39360	11.066	.01
Task	1	39912	3.35	39912	11.221	.01
Comp	1	16543	1.39	16543	4.651	.05
BL.Task	4	2144	0.18	536	0.151	ns
BL.Comp	4	15511	1.30	3878	1.090	ns
Task.Comp	1	77	0.01	77	0.022	ns
BL.Task.Comp	4	21308	1.79	5327	1.498	ns
Residual	132	469498	39.40	3557		
Total	151	722434	60.63	4784		
Grand total	158	1192948	100.12			

Variate: Correct

Source	df	SS	SS%	MS	F	p
Subject stratum	7	42981	15.60	6140		
Baseline (BL)	4	28366	10.29	7091	6.766	0.01
Task	1	22307	8.1	22307	21.284	0.01
Comp	1	5350	1.94	5350	5.105	0.05
BL.Task	4	18350	6.66	4587	4.377	0.01
BL.Comp	4	13524	4.91	3381	3.226	0.05
Task.Comp	1	8	0.00	8	0.007	ns
BL.Task.Comp	4	6501	2.36	1625	1.551	ns
Residual	132	138341	50.21	1048		
Total	151	232747	84.47	1541		
Grand total	158	275728	100.07			

Analysis of Variance Tables for Experiment 2.

Baselines 1- 5

Variate: Prompt

Source	df	SS	SS%	MS	F	p
Subject stratum	7	61618.1	34.16	8802.6	.	
Baseline (BL)	4	12630.6	7.00	3157.6	4.969	0.01
Task	1	4007.8	2.22	4007.8	6.307	0.05
Comp	1	6874.6	3.81	6874.6	10.818	0.01
BL.Task	4	5576.8	3.09	1394.2	2.194	ns
BL.Comp	4	1605.7	0.89	401.4	0.632	ns
Task.Comp	1	2696.0	1.49	2696.0	4.242	0.05
BL.Task.Comp	4	1626.2	0.90	406.5	0.640	ns
Residual	132	83884.7	46.50	635.5		
Total	151	118902.5	65.91	787.4		
Grand total	158	180520.7	100.07			

Baselines 5-6 (Follow -up)

Variate: Ontask

Source	df	SS	SS%	MS	F	p
Subject stratum	7	87397	36.94	12485		
Baseline (BL)	1	508	0.21	508	0.200	ns
Task	1	16268	6.88	16268	6.414	0.01
Comp	1	429	0.18	429	0.169	ns
BL.Task	1	824	0.35	824	0.325	ns
BL.Comp	1	133	0.06	133	0.053	ns
Task.Comp	1	9129	3.86	9129	3.599	ns
BL.Task.Comp	1	475	0.20	475	0.187	ns
Residual	48	121749	51.46	2536		
Total	55	149516	63.20	2718		
Grand total	62	236913	100.14			

Analysis of Variance Tables for Experiment 2.

Baselines 5-6 (Follow-up)

Variate: Correct

Source	df	SS	SS%	MS	F	p
Subject stratum	7	15729.6	14.51	2247.1		
Baseline (BL)	1	3007.6	2.77	3007.6	3.034	ns
Task	1	25172.4	23.21	25172.4	25.391	0.01
Comp	1	11806.6	10.89	11806.6	11.909	0.01
BL.Task	1	1362.2	1.26	1362.2	1.374	ns
BL.Comp	1	524.8	0.48	524.8	0.529	ns
Task.Comp	1	2124.5	1.96	2124.5	2.143	ns
BL.Task.Comp	1	1249.0	1.15	1249.0	1.260	ns
Residual	48	47586.3	43.88	991.4		
Total	55	92833.5	85.61	1687.9		
Grand total	62	108563.1	100.11			

Variate: Prompt

Source	df	SS	SS%	MS	F	p
Subject stratum	7	12531.2	48.89	1790.2		
Baseline (BL)	1	1363.7	5.32	1363.7	8.341	0.01
Task	1	1117.5	4.36	1117.5	6.835	0.01
Comp	1	1168.2	4.56	1168.2	7.145	0.01
BL.Task	1	16.6	0.06	16.6	0.101	ns
BL.Comp	1	476.2	1.86	476.2	2.913	ns
Task.Comp	1	972.1	3.79	972.1	5.946	ns
BL.Task.Comp	1	139.7	0.55	139.7	0.855	ns
Residual	48	7847.5	30.62	163.5		
Total	55	13101.5	51.11	238.2		
Grand total	62	25632.7	100.00			

Analysis of Variance Tables for Experiment 3.

Participant: John

Variate: Proportion of correct responses

Source	df	SS	SS%	MS	F	p
Trials	25	6.2486	29.91	0.2499	0.874	
Reinforcer	2	0.3360	1.61	0.1680	0.587	ns
Residual	50	14.3062	68.48	0.2861		
Total	77	20.8908	100.00	0.2713		
Grand total	77	20.8908	100.00			

Variate: Rate of Pressing

Source	df	SS	SS%	MS	F	p
Trials	25	7890.04	84.10	315.60	11.679	
Reinforcer	2	140.62	1.50	70.31	2.602	ns
Residual	50	1351.11	14.40	27.02		
Total	77	9381.76	100.00	121.84		
Grand total	77	9381.76	100.00			

Participant: Brian

Variate: Proportion of correct responses

Source	df	SS	SS%	MS	F	p
Trials	25	4.4734	22.99	0.1789	0.609	
Reinforcer	2	0.2959	1.52	0.1480	0.504	ns
Residual	50	14.6873	75.49	0.2937		
Total	77	19.4566	100.00	0.2527		
Grand total	77	19.4566	100.00			

Analysis of Variance Tables for Experiment 3.

Variate: Rate of Pressing

Source	df	SS	SS%	MS	F	p
Trials	25	1794.35	64.87	71.77	3.860	
Reinforcer	2	42.19	1.53	21.09	1.135	ns
Residual	50	929.61	33.61	18.59		
Total	77	2766.15	100.00	35.92		
Grand total	77	2766.15	100.00			

Participant: Roger

Variate: Proportion of correct responses

Source	df	SS	SS%	MS	F	p
Trials	25	17.4851	35.73	0.6994	1.126	
Reinforcer	2	0.3965	0.81	0.1983	0.319	ns
Residual	50	31.0614	63.46	0.6212		
Total	77	48.9430	100.00	0.6356		
Grand total	77	48.9430	100.00			

Variate: Rate of Pressing

Source	df	SS	SS%	MS	F	p
Trials	25	1417.69	60.89	56.71	3.53	
Reinforcer	2	107.50	4.62	53.75	3.346	ns
Residual	50	803.24	34.50	16.06		
Total	77	2328.43	100.00	30.24		
Grand total	77	2328.43	100.00			

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