THE AUTISTIC CHILD'S THEORY OF MIND: A COMPUTER-BASED INVESTIGATION.

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ABSTRACT

This thesis starts by reviewing the current literature on autism. The review focuses on the possibility that autistic children have a specific cognitive deficit in the development of a "theory of mind", and considers the potential for computer use with autistic children. It is argued that the computer is a novel form of presentation and a new channel of communication that might be used effectively as an investigative tool for research and as a training device.

In the experimental studies we were able to draw together these two areas of research by examining understanding of false belief in autistic children using tasks presented on computer. We were also able to use our knowledge of autistic cognition in order to design programs best suited to autistic children.

In the first experiment we tested autistic children, Down's Syndrome children and young normal children. All three groups performed equally well, using a mouse to traverse a hypertext type computer training program. They were then tested using a revised version of the "Sally-Anne" task (standard presentation) and using a computer version. For both presentations, the autistic children were found to be impaired in their understanding of false belief, whereas the Down's Syndrome children and normal children passed on these tasks. The similar pattern of results for both forms of presentation suggests that the conceptual nature of these tasks, rather than their surface form, causes the autistic children to fail. Retesting showed these results to be reliable. In the third experiment, the autistic children also failed a different test of false belief (the "Smarties" task) on both standard and computer presentations.

A minority of the autistic children showed some improvement in their performance on the computer presentations of these tasks. The possibility that the computer may be functioning as a training device was discussed.

In the fourth experiment we administered the Vineland Adaptive Behaviour Scale using autistic children and Down's Syndrome children. We found evidence to suggest that a cognitive deficit in understanding of false belief is related to adaptive behaviour, in both autistic and Down's Syndrome children. In addition, we found that despite being matched for performance on two false belief tasks the clinical groups still differed in terms of their overall adaptive behaviour scores. The implications of these findings with respect to the theory of mind hypothesis were discussed.

The fifth experiment was a small scale training study using autistic, Down's Syndrome and young normal children. All the subjects failed a

series of false belief tasks prior to training. Subjects were trained to understand false belief using a specially designed computer task. Nearly all the subjects were able to pass the Sally-Anne task by the end of training, however the autistic children differed from the other two groups on post-test transfer tasks as they were unable to generalize their knowledge to pass different false belief tasks using a different scenario. It was concluded that the autistic subjects had learned an algorithm for the Sally-Anne task, rather than the concept of false belief, during training. Finally, subjects were tested on the original false belief tasks three months after the training week. This follow up revealed that most of the autistic children retained their knowledge of the algorithm, all of the Down's Syndrome children maintained their post-test performance and all the normal subjects had either remained the same or improved.

The thesis concludes with a discussion of the experimental results as a whole in relation to the experimental hypotheses, and with suggestions for possible future research.

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LITERATURE REVIEW

In 1943, Kanner produced a paper describing a group of eleven children who he claimed shared the same unusual characteristics. The essential features he described, impairment of social relationships, stereotyped behaviour and deficits in language development, in essence remain, although perhaps in a more detailed form, as primary criteria for the diagnosis of what Kanner chose to call "infantile autism".

This review will consider some of the recent discussions of the following topics:

CHAPTER 1.
- a) Diagnosis and Identification
- b) Epidemiology
- c) Aetiology

CHAPTER 2.
- a) Research on Diagnostic Criteria
- b) Research on Cognitive Deficits

Firstly, in order to identify the type of children used in this research, we need to consider the criteria currently used to diagnose autism and discuss some of the issues concerning diagnosis which have been debated over the last forty years.

CHAPTER 1.

A). DIAGNOSIS AND IDENTIFICATION.

There has been a great deal of disagreement and confusion over the definition and diagnosis of autism. Early reports used a variety of terms; "childhood psychosis", "schizophrenic syndrome", and "infantile autism", and for many years, autism was thought to be a childhood version of adult psychosis; in particular, it was speculated to be the earliest form of schizophrenia, (Fish ,1977; Fish et al ,1968). Lack of knowledge over the underlying pathology, and the fact that the condition is so rare, contributed to the difficulty workers had in attempting to classify autism. It is important that some agreement is reached over the diagnostic terms used, so that subject selection is kept uniform across studies, and so that educational planning and provision for the autistic population can be achieved.

It appears now, however, that there is some consensus in diagnosis (Schopler, 1983), and the major systems of classification, ICD-9 (World Health Organization, 1987) and DSM-III (American Psychiatric Association, 1987), both concentrate on four main diagnostic criteria. Although we shall return to discuss these in detail (see Chapter 2) we shall, by way of introduction, briefly note some of the issues here. Rutter and Schopler (1987) describe the main criteria as the following:

1. Abnormalities in communication;
2. Aspects of deviance in the development of social relationships;
3. Restricted, repetitive and stereotyped patterns of behaviour;
4. Onset before 30 months.

These four features are considered to be the fundamental criteria for diagnosis, and although "secondary" additional features may be present, it is these that are considered to be the "core" features of autism. What makes autism all the more puzzling, as Newson (1987) explains, is that, "Every kind of impairment links to every other impairment in the syndrome. They overflow and pervade each other," and what is most characteristic of autism is, "...the interaction between different parts of the syndrome."

The autistic child's "abnormalities in communication" consist not only of delayed language development (Rutter 1980), but as more recent research has shown also includes impairment of other modes of communication such as gesture (Attwood, 1984; Chapman 1981)), facial expression and other "body language". The language impairment itself is distinct from specific language disorders such as dysphasia (Rutter, 1980), and typical features, when speech is present, include delayed echolalia (Cantwell, Baker and Rutter, 1978), and pragmatic difficulties (Bates, 1976; Langdell,1980).

It is now clear that "deviance in the development of social relationships" is an important defining feature of autism, and descriptions of the specific social disturbance have become more detailed as knowledge about social development has increased. Rutter and Schopler (1987) point out that in using this as a diagnostic criterion, social abnormalities should be measured in relation to the child's mental age. It seems that from the outset autistic children show a lack of attachment and social bonding, being apparently content in their "aloneness," and parents (may) often suspect that their child is deaf. The social impairment continues on through childhood and usually into adulthood; the long-term nature of the social impairment distinguishes autism from other conditions where an early failure in bonding has occurred. Great difficulty is experienced in forming friendships, the child never appears to develop cooperative play with others and seems to lack empathy (Rutter, 1978b). However, it is important to note that an autistic person may still show a degree of social relatedness; it is simply the deviant form of these relationships which is apparent (Volkmar and Cohen, 1985; Wing and Attwood, 1987).

There is a tendency for autistic children to engage in ritualistic and compulsive behaviour, often becoming obsessed with particular routines or objects. It is still unclear exactly what motivates this behaviour, although it has been speculated that it represents an attempt by the child to impose some order on what must be a confusing world, or it may simply reflect a rigidity and lack of creativity in thought processes (Rutter and Schopler, 1987).

The final criterion of "onset before 30 months" has received much attention recently. It has been argued that using age of onset as a diagnostic criterion is problematic since it depends on parental reports which may be unreliable (Cohen et al, 1987). It also seems likely that there is a subgroup of children who show normal development in the first few years with onset at a later stage, possibly as a result of acquired brain disease (Rutter and Schopler, 1987). It may be that aetiology is different for this group but in all other respects they share the same deficits. Furthermore, it is argued that using the term "childhood autism" to describe the condition is misleading (Cohen et al, 1987), since information on life course (Lotter, 1978) suggests that the condition continues through to adulthood. However, it is certainly the case that autism begins in childhood and by virtue of this it is a "childhood psychosis".

Finally, diagnosis of autism can be made independently of IQ. Initially, Kanner (1943) thought that all autistic children had normal cognitive potential, but it is now known that around three-quarters of these children are also mentally retarded (Rutter, 1979; Wing and Gould, 1979). One of the problems in expressing intelligence levels though (for example from the Wechsler Intelligence Scale) is that there are large discrepancies between different types of cognitive skills. Autistic children have difficulty with tasks requiring abstraction, language and use of meaning (Hermelin and O'Connor, 1970; Rutter, 1983), but perform "better than expected" on Block Design tests (DeMyer, 1976). This profile of test scores is not used as a criterion for autism but is of interest for research on cognitive disabilities which will be discussed later (see Chapter 2).

In the next section we shall discuss some of the descriptive studies which have assessed the prevalence and incidence of autism.

B) EPIDEMIOLOGY

Epidemiological surveys can supply us with some valuable information concerning the magnitude of a disorder, who is at greatest risk and the possible aetiology. There have been five major surveys in Europe (Brask, 1972; Gillberg, 1984; Lotter, 1966; Steinhausen, Gobel, Brelinger and Wohleben, 1983; Wing, Yeats, Brierly and Gould, 1976); six have been carried out in Japan (Hoshino et al, 1982); one was carried out in Africa (Lotter, 1980); and one in the United States (Treffert, 1970). Despite the fact that many of these studies have used different methodologies, for example employing slightly different diagnostic criteria and screening procedures, the results appear to be fairly consistent.

i) Prevalence

Most surveys report an incidence of between four and five cases of autism in every 10,000 children under the age of 15, which would predict a population of around 5000 autistic children in the UK. In the study carried out by Lotter in Middlesex during 1963 (Lotter, 1966), a comprehensive multistage screening process was employed in order to identify cases. Letters were sent out to schools and institutions for the handicapped followed by a 22-item questionnaire. The final stages included a record review and personal examination of the children considered to be potential cases of autism. Out of a total of 2.25 million children between the ages of 8 and 10, 35 were diagnosed as autistic (approx 4.5 in 10,000) and 15 had nuclear features of social aloofness and resistance to change (approx 2 in 10,000). Prevalence rates for Camberwell, England (Wing et al, 1976), Fukushima, Japan (Hoshino, 1982), West Berlin, West Germany (Steinhausen, 1983) all showed similar results, with rates of approximately 2 in 10,000 "classic" cases using a more conservative definition and between 4 and 5 in 10,000 cases using a broader definition.

Wing and Gould (1979) carried out a comparative study of the autistic children and the mentally retarded population in the London Borough of Camberwell. They were interested in the incidence of children in the region who had the following "triad of impairments":

1. An absence or impairment of two-way, social interaction.
2. An absence or impairment of the comprehension or use of language (verbal and non-verbal).
3. A predominance of repetetive and stereotyped pursuits.

They calculated an incidence of 21.2 in 10,000 children showing this "triad" of impairments; of these children, it was estimated that 4.9 in 10,000 could be diagnosed as autistic, showing such distinguishing features as elaborate routines and obsessions, early onset, and specific language difficulties characteristic of autism (pronoun reversal and use of idiosyncratic phrases). Clearly, the criteria used for diagnosis can alter estimated incidence rates quite noticeably. Wing and Gould (1979) have made the suggestion that autism constitutes a distinctive sub-group of those children who show the "Triad of Impairments" described above, and that the main characteristics of autism can be found over a wide range of different mental handicaps. It is possible then that the incidence of autism is slightly higher than the early surveys suggested.

ii) Gender

All the epidemiological surveys show a higher rate of autism in boys than in girls. The male:female ratios found in most studies are between 1.4:1 and 3.4:1 (eg. Gillberg,1984; Lotter,1966), although in Fukushima, Japan, a ratio increases with IQ, in other words , autistic girls are more seriously impaired in autistic functions than autistic boys (Lotter,1966; Wing,1981), although this trend was not shown in the West Berlin study (Steinhausen et al, 1983) or the Goteberg study (Gillberg,1984).

A variety of explanations have been offered to account for these gender differences. Wing (1981) hypothesized that the language and communication impairments of autism forces both the boys and the girls to use other cognitive skills for IQ tests, and the more limited compensatory visuo-spatial skills of the girls accounts for the sex ratio:IQ relationship. Other workers have offered genetic arguments to explain the gender differences (Tsai, Stewart and August, 1981;

Wing, 1981). It remains unclear exactly why there should be a predominance of autistic boys, and why autistic girls have a lower mean IQ, but any findings in this area may reveal important clues towards aetiology.

iii) Social Class

It was originally thouhgt that the parents of autistic children were more likely to come from the upper social class and observations from early epidemiological studies seemed to support this idea (Lotter, 1966; Treffert, 1970). However, at the time of these surveys awareness of autism was not widespread and upper class parents were more likely to look for help, and receive it, which created a false impression of the social class distribution. Several authors have pointed out that recognition of the disorder has increased amongst the professional and lay persons in the middle and lower classes, and there appears to be growing financial support for treatment (Schopler et al, 1979; Tsai et al, 1982). This may explain the more recent epidemiological data, for example in Camberwell (Wing, 1980) and Goteberg (Gillberg and Schaumann, 1982), which shows no difference in social distribution between autistic cases and the rest of the population.

C). AETIOLOGY

Early causation models of autism considered the condition to be of psychogenic origin. Kanner described a "parent type", characterised as cold, intellectual and lacking in emotional warmth and it was thought that an abnormal social and emotional environment was responsible for the psychological withdrawal which led to the condition of autism (Bettelheim, 1967; and more recently Tinbergen and Tinbergen, 1983). However, there is no (available) evidence to support this notion (Cox, Rutter, Newman and Bartak 1975; Wing 1976b; Cantwell, Baker and Rutter, 1979) and it is now generally thought that autism has an organic basis. A number of observations indicate that biological factors are at the roots of the condition. For example, there is a high incidence of epilepsy (Rutter, Bartak and Newman, 1981), a high ratio of boys to girls (Gillberg, 1984; Lotter, 1966), an increased incidence of non-right handed children in the autistic population (Tsai and Stewart, 1982) and a slight increase in perinatal complications (Deykin and MacMahon, 1980).

Possible neurological, biochemical and genetic causes have been investigated, but the precise nature of the organic basis remains unclear. In their recent review, Rutter and Schopler (1987) conclude that in spite of the evidence that autism has an organic basis, it is " not usually associated with gross abnormalities of brain structure or histology " and that "the organic basis must be of some more subtle, less easy to detect, variety."

Autism probably arises from a variety of aetiologies (Ornitz, 1987) and there are signs of problems at different levels. A single genetic or biochemical cause has not been found and results are unreliable in that they vary across different studies. It is more likely then, that a root cause consists of a complex interaction of biochemical, genetic and neurological factors. It is possible however that this interaction may lead to a basic cognitive deficit which underlies the core symptomology of autism, and, if this is the case, a cognitive description of the condition might suggest approaches to treatment as well as furthering our understanding of normal cognition.

In this section then, we will be considering some of the more promising findings from recent studies and looking at aetiology in the context of what light it might shed on cognitive deficits.

i) Studies of Biochemical Functioning and Genetics

Biochemical studies have looked at a wide range of neurotransmitters and neuroendocrine systems related to neurotransmission in the central and peripheral nervous system. Theories of neurochemical aetiologies may potentially identify a specific and effective drug for treatment.

Recent reviews of this area conclude that consistent and replicated differences in biochemical functioning between autistic and normal populations have not been found (Young et al, 1982; Ornitz, 1987). Those findings which were mentioned included an increase in whole blood 5-HT (the most well replicated), abnormalities in peptide excretion and in neuroendocrine functioning and some evidence to suggest that central dopamine turn-over may be increased.

It has long been thought that there is some genetic contribution to the cause of autism. Biochemical studies have failed to identify a particular genetic marker responsible for the expression of autism, so that investigations of familiality have had to concentrate on twin studies and family studies.

An early family study by Rutter (1968) calculated the incidence of autism in siblings at two per cent. Although this may appear to be a small figure Rutter noted that this was fifty times higher than the incidence expected from the normal population.

The twin studies of Ritvo et al (1985) produced some striking results, highly suggestive of genetic factors. They reported a concordance rate of 95.7% for MZ twins, compared to 23.5% for DZ twins. However, these studies have a number of faults associated with them (Rutter and Schopler, 1987). It is not clear what biases were operating in the selection of their sample since it relied on voluntary participation. The DZ sample included opposite-sexed twins which, given that there is a sex difference in the frequency of autism, skews the results. Finally, DZ twins are approximately twice as frequent in the general population as MZ twins and yet the sample used included more MZ twins than DZ twins.

Folstein and Rutter (1977) studied 21 same-sex pairs where at least one twin was autistic. Their sample included ten DZ twin pairs and 11 MZ pairs. Four sets of MZ twins were found to be concordant for autism while none of the DZ twins were concordant. This significant difference suggests that genetic factors are of importance in the expression of autism. However MZ twins were not always fully concordant which suggests that other non genetic factors are involved. Folstein and Rutter developed the hypothesis that several factors interact to produce the phenotype of autism, but the underlying genetic liability was for a milder cognitive impairment. On closer examination of the twin pairs used in their study it was found that in addition to the four autistic MZ twins, five other MZ twins showed some cognitive impairment, in other words 9 out of the 11 twins were concordant for some sort of cognitive impairment. In contrast only 1 out of 10 DZ twins showed any cognitive impairment. August, Stewart and Tsai (1981) found a cluster of cognitive disabilities in siblings of autistic children, which also suggests that a cognitive impairment may be inherited.

These studies then, suggest that there is no unitary biochemical or genetic cause of autism; it seems that there may be some cognitive deficit worth looking for. Let us look in more detail at the studies of neurological functioning to see if they can tell us anything about possible cognitive deficits in autism.

ii) Studies of Neurological Functioning

Neurophysiological studies of cortical and subcortical events have been carried out. Cortical dysfunctions may be relevant to autistic disturbances of higher cognitive functioning such as language and communication. Neurophysiological investigations of cortical events have included electroencephalogram studies (EEG), radiological studies (eg computerised tomography, CT) and event-related-potential studies. Incidences of epilepsy in autism have also been examined. In addition associated neurological disorders have been considered and a number of neuropathological studies undertaken. Finally, comparisons with adults with known lesions have been made in an attempt to pinpoint an area of cortical dysfunction.

ii.a) Cortical functioning

Many of the hypotheses concerning the localizing of neuropathology in autism have focused on left-hemisphere dysfunction.

Workers such as Ricks (1975), Hermelin (1976), Blackstock (1978) and Prior and Bradshaw (1979) claim that abnormalities of information processing observed in autistic children are suggestive of a dysfunction of the left hemisphere. Prior (1979) argues that the language disability shown by autistic children (Bartak, Rutter and Cox, 1975) is a result of a dysfunction of the left hemisphere. Similarly, the profile of sub-test results for the Wechsler intelligence scale demonstrated by DeMyer (1976) was thought to be a reflection of left hemisphere dysfunction. More recently however, these studies have been subject to criticism. Arnold and Schwartz (1983) point out that these results may have been obtained by chance (for example, Prior and Bradshaw, 1979) or that the measures used may not have been valid (for example, Blackstock, 1978). Furthermore Fein, Hume, Kaplan, Lucci and Waterhouse (1984) argue that the division of cognitive tasks into right and left hemisphere functions is an artificial and arbitrary exercise. They also point out that the profile of language deficits in autism (eg, particular difficulty with pragmatics) does not suggest left hemisphere dysfunction.

Experimental studies of cerebral lateralization have also been attempted. Electroencephalogram (EEG) studies have produced some promising results. Small (1975) measured the mean integrated EEG voltage over each hemisphere and found that the voltage over the left hemisphere did not show the normal increment over the right hemisphere. During linguistic tasks it was found that for 7 out of 10 autistic children there was a lack of left hemisphere EEG activation which normal children show under such conditions (Dawson, Warrenberg and Fuller, 1982). Abnormal patterns of cerebral lateralization were also found in EEG studies of autistic children during sleep (Ogawa et al, 1982). One study of the maturation of ear advantage suggests unfavourable lateralization (James and Barry, 1983); using reaction times to monaural presentation of tones they demonstrated a developmental delay in ear advantage. However, dichotic listening studies, as reviewed by Ornitz (1987) do not consistently support the cerebral lateralization hypothesis. Also, experiments using radiological techniques such as computerised tomography (CT) have not produced consistent findings to support the hypothesis (Damasio, Maurer, Damasio, and Chui, 1980; Rosenbloom et al, 1984; Tsai, Jacoby and Stewart, 1983).

There is further evidence of cortical dysfunction and structural abnormalities in autism. A number of experiments have reported that abnormally small P300 waves are produced in response to target stimuli requiring an active response (Courchesne et al, 1984; Niwa et al, 1983), although the total number of children tested has been small and interpretation of these results is therefore difficult. In a minority of autistic patients CT scans have shown abnormal structural configurations (Campbell et al, 1982; Gillberg and Svendson, 1983) which may suggest that there is a subgroup of autistic children in which the autism is associated with a structural brain abnormality (Ornitz, 1983). The general increase in incidence of abnormal EEGs and the greatly increased risk for the development of seizures (see Golden, 1987) are also suggestive of a primary cortical dysfunction in autism.

Hypotheses of cortical dysfunction have been derived from comparisons between autistic behaviour and that of neurologically damaged adults and experimentally lesioned animals. Using this process of reasoning by analogy, Delong (1978) drew comparisons between autistic children and adults with Kluver-Bucy syndrome and Korsakoff's amnesic syndrome, which involve bilateral temporal lobe damage. It is thought that the temporal lobes are important for integrating visual information with that from other sensory systems as well as being relevant to the control of language and memory. In addition the temporal lobes connect to the limbic system which relates to motivational control and emotion (Walsh, 1978). It is proposed, then, that bilateral temporal lobe damage is a major causal factor in autism. This hypothesis was extended further by Damasio and Maurer (1978) who suggested a dysfunction of the mesolimbic cortex and associated neostriatal structures. Both of these hypotheses appear quite plausible, but it should be emphasised that they were derived solely by a process of reasoning by analogy, which naturally has many pitfalls, and that there is as yet no clear cut neuropathological or neurophysiological evidence showing localization of seizures or damage in these areas.

Postmortem examinations have failed to define consistent (lesion or) lesions (Rutter and Schopler, 1987), although this may be due to limitations of histological techniques. Ritvo et al (1985) have made some quite promising findings however. They identified decreased cerebella Purkinje cell counts in each of four patients examined and point out that, including other studies (eg. Bauman and Kemper, 1984), a total of six out of seven patients examined so far have shown decreased Purkinje cell counts, although this still represents a small sample.

ii.b). Subcortical functioning

Hypotheses of subcortical functioning consider disturbances of sensory modulation and motility as primary causal factors in autism. Although these disturbances are not considered to be major diagnostic criteria for autism, under-reactivity or over-reactivity to sensory stimuli, preoccupation with spinning objects and hand flapping are observed in a majority of autistic children, predominantly between the ages of 2 and 4 years (Ornitz, 1978). Most of the points of transfer of sensory input are located in the brainstem and diencephalic structures (Ornitz, 1983) and these areas have received recent attention with regard to aetiology. Neurophysiological investigations have included autonomic studies, brainstem auditory evoked response (BSER) studies and vestibular studies.

Autonomic response studies discriminate between autistic populations and controls (Hutt et al, 1975; James and Barry, 1980a; Kootz and Cohen, 1981) and the increased reactivity of autonomic responses is thought to be related to autistic disturbances of sensory modulation (Ornitz, 1974). It is proposed that the deficit in autonomic habituation is linked to the autistic child's inability to "filter" trivial sensory information, which consequently affects selective attention.

Vestibular response studies have also produced different results for autistic populations than for controls. In particular, they have demonstrated abnormal visual-vestibular interactions for autistic subjects, even in the absence of visual fixation (Ornitz et al, 1974).

Studies of brainstem auditory evoked responses (BAER) have not produced consistent results to support the hypothesis of brainstem dysfunction. However, a number of studies have recorded prolonged brainstem transmission times (BSTTs) in a minority, possibly a subgroup, of autistics (Fein et al, 1981; Gillberg et al, 1983). Ornitz (1987) reasons that this may reflect the fact that BAER is the response to a pathological change in tissue or in a specific group of neurons. In contrast, the autonomic and vestibular abnormalities are more likely to reflect a common brainstem system dysfunction that underlies the autistic behavioural syndrome.

In summary, studies of neurological functioning have produced some promising findings involving both cortical and subcortical pathophysiology in autism. Cortical functions are thought to be related to higher order cognitive functioning, whilst subcortical functions are thought to be related to sensory modulation and motility functions. However, it is difficult to separate cortical and subcortical influence on cognitive behaviour as they are so closely associated with one another.

The complex pattern of genetic, biochemical and neurological factors which appears to be implicated in autism means that a simple physiological model of the condition is unlikely to be forthcoming. There are indications that a cognitive level of explanation may provide a simpler and, perhaps, more applicable description of the condition.

In this thesis we shall be examining a possible deficit in higher order cognitive functioning, a basic deficit in "theory of mind" (Premack and Woodruff, 1978), which may be the province of cortical functions. By considering cognitive functions it may ultimately be possible to describe a functional impairment more fully.

CHAPTER 2.

A). RESEARCH ON DIAGNOSTIC CRITERIA

This section examines the main criteria used for diagnosing autism, looking particularly at more recent research.

i). Abnormalities in Communication

Autistic children show an unusual pattern of linguistic skills which seem to be unique to the group (Rutter, 1978a). It is not surprising then, that the language deficiency in autism has received a great deal of attention and was at one time considered to be at the very root of autistic withdrawal (Rutter, Bartak and Newman, 1971). Early descriptions of autism, including Kanner's (1943), made note of deviant language characteristics such as mutism, literalness, echolalia, pronoun reversal, metaphorical substitution and failure to use speech for communicative purposes. These features are still recognised as the core properties of the communication deficiency in autism (Rutter, 1987).

A deficit in communicative functioning can be seen in autistic children even at the early preverbal stages. Bartak, Rutter and Cox (1975) report a lack of preverbal pointing, showing, or turn taking. Autistic children's intentional acts at a 24 month level are limited to requesting and protesting (Wetherby and Prutting, 1984) whereas in normal development complex forms of expression are present. The preverbal communication seen in autism, then, does not involve those acts requiring joint attention and reference (Paul, 1987).

The communication deficit is not confined to language. Autistic children are also impaired in their use of gesture, facial expression and other "body language" and the timing of these (Newson, 1977). Ricks and Wing (1975) found that autistic children with well developed language capacities were still impaired in their use and understanding of gestures, facial expression, head nods and smiles normally used to support conversational exchange. More recently Attwood (1984) and Ohta (1987) have confirmed the impairment in the use of gesture and Langdell (1981) has identified an impairment in face perception.

Before discussing the speech impairment suffered by autistic children it is important to stress that between 28% (Wolff and Chess, 1965) and 61% (Fish, Shapero and Campbell, 1966) of these children are mute. Furthermore, mute autistic children do not spontaneously develop gestural or other means of conveying complex messages. Attempts to teach language using operant conditioning have been ineffective (Howlin, 1981). A number of other language teaching programs have met with limited success; plastic symbol systems (Premack and Premack, 1974), written word communication systems (La Vigna, 1977) and a computerised written system (Colby, 1973). Perhaps the most successful and widely used systems at present, though, are manual signing systems (Bonvillian and Nelson, 1976; Salvin, Ralph, Foster and Lovejoy, 1977; Barrera, Loboto-Barrera and Sulzer-Azaroff, 1980). Although some communicative gains are reported using manual sign language, as Schuler and Baldwin (1981) point out, it is signed vocabulary items that are learned rather than any grammatical combination of signs and the learning of these signs is unlikely to lead to the acquisition of speech. Single words for expressing wants and needs may be learned, but these alternative modes of teaching language do not seem to lead to an increase in spontaneous communicative behaviour outside the training session.

One of the most striking features of the deviant speech in autism is the occurrence of echolalia. This consists of the repetition of a word or sentence which may be immediate (occurring straight after another's utterance) or delayed (when stored utterances are repeated in new, usually inappropriate contexts). Despite the frequent occurrence of echolalia in autism, it is not synonymous nor unique to the syndrome, being found in a wide variety of other conditions such as dementia, congenital blindness, acquired aphasia and also in the early language development of some normal children (Fay and Schuler, 1980).

Although some echolalia may appear non-functional it is now thought that immediate and delayed echolalia can serve communicative functions. Prizant and Dunchan (1981) proposed six communicative functions that may be served by immediate echolalia. These functions were turn-taking, assertions, affirmative answers, requests, rehearsal to aid processing and self-regulation. Hurtig, Ensurd and Tomblin (1982) suggested that echolalia may be used by autistic children as a crude but effective means of maintaining conversational flow. There are also instances when delayed echolalia may be considered functional, for example, it may be used to request recreations of scenes (Prizant and Rydell, 1984). Shapiro (1977) and Carr, Schriebman and Lovaas (1975) noted that autistic children were more likely to echo questions they did not understand or did not know how to respond to.

Echolalia may have a constructive role in language acquisition. Studies in the language development of normal children have shown that echolalia plays an important role in the development of vocabulary and in the development of conversational skills (Paul, 1987). It may function as an important stage between the comprehension and production of language (Dyer and Hadden, 1982). Baltaxe and Simmons (1977) proposed that the bedtime soliloquize of an eight year old autistic child (delayed echolalia) may be functional, the stored utterances being used as a base for analytic linguistic operations which the child was in the process of acquiring. Similar behaviour can be observed in the bedtime soliloquies of some normal two year olds (Weir 1962). Examples of echolalia in normal young children are of particular importance since they demonstrate its role in normal development and suggest that it is not necessarily deviant. Bloom (1970) observed echoing in some normal children and noted that the utterances were selective, containing advanced forms not used in spontaneous speech, again suggesting that echolalia may be important for early language learning. One hypothesis as to the function of echolalia is that it represents a form of "gestalt" processing in early language development, unanalysed language chunks being produced, as part of the learning process, with little appreciation of their internal structure. Young normal children vary along a continuum from those who use a mixture of analytic and "gestalt" to those who use entirely "gestalt" processing (Peters,1980). Normal children gradually rely more on an analytic strategy for language acquisition whilst autistic children rely on "gestalt" processing to an extreme degree (Paul, 1987).

The language disorder in autism can be distinguished from that in developmental receptive dysphasia (Bartak, Rutter and Cox 1975; 1977). In a systematic comparison between autistic and dysphasic children these authors showed that the two groups differed significantly in their linguistic and cognitive handicaps. Autistic children had :

1. Greater comprehension deficits;
2. Deviant characteristics such as inappropriate, immediate echoes, delayed echolalia, metaphorical language and paucity of spontaneous remarks;
3. Impaired social usage.

It was concluded that autistic children had unique language difficulties, being particularly impaired in the area of pragmatics in contrast to dysphasics whose main problems were with syntax and semantics. Before considering the difficulties autistic children have with language use, let us first examine other areas of language development.

Phonological development in autistic children remains unimpaired (Bartolucci, Pierce, Streiner and Eppel, 1976) and articulation is also often reported as either normal or precocious with a slight distortion of rhythm and sometimes overprecision of pronunciation (Pierce and Bartolucci, 1977; Bartak and Rutter, 1975). Indirect evidence of a deficit in semantic development can be found in the studies of Hermelin and O'Connor (1967, 1970) which suggest that autistic children make little use of meaning in recalling verbal material. Simmons and Baltaxe (1975) also present evidence of impaired semantic skills although their study lacked data on controls. The experiments of Tager-Flusberg (1985), however, suggest that the representation of semantic knowledge in autistic children does not differ from subjects matched for mental age. It should be noted also, that autistic children often develop large vocabularies and in some cases take an obsessive interest in words and word meaning.

Studies of syntactic development in autistic children suggest that it follows the same pattern as that observed in normal children but proceeds at a slower pace, lagging behind normal development (Tager-Flusberg, 1981; Bartak et al, 1975, 1977; Pierce and Bartolucci, 1977). More recently Paul and Cohen (1984b) have looked at the syntactic skills of adult autistics and suggested that syntactic development may reach a plateau of performance below that of retarded controls matched for non verbal IQ.

Difficulty with pronominal reversal is also a typical feature of speech in autism. Particularly a failure to reverse pronouns, for example shifting "you" to "I". This is considered to be a problem of tracking shifting reference in deictic terms, which may be related to deficits in understanding another's point of view (Fay, 1971).

The vocal quality, intonation, and stress patterns in autistic speech are often deviant (Ricks 1975). Intonational peculiarities in speech vary from monotony (Fay and Schuler, 1980), to unusually high frequency speech, harshness and poor control of volume (Provnost, Wakstein and Wakstein, 1966) all of which hamper communication. It has also been observed that autistic children fail to take advantage of stress cues in their speech (Frith, 1966; Baltaxe, 1984) which is of importance to communication.

There have been few studies of language comprehension, but the work that has been done suggests that this is also an area of impairment for autistic children. Autistic children perform poorly on standardized tests of language comprehension (Bartak et al, 1975, 1977; Paul and Cohen, 1984b) and show poor sentence comprehension (Tager-Flusberg, 1981b) in comparison to retarded and aphasic controls matched for non verbal mental age.

Although some difficulties are found in these aspects of autistic language development, syntax, semantics and phonology remain largely unimpaired in comparison to pragmatic aspects of their language (Bartak, Rutter and Cox, 1975; 1977; Cromer, 1981; Tager-Flusberg, 1981; 1985). Let us examine the area of pragmatics in more detail then, since it appears to be a specific problem for autistic children and, as we shall discuss later, may reflect some underlying basis to the syndrome.

Pragmatics can be defined as the communicative use of speech and gesture in a way appropriate to social context (Bates, 1976). Indirect reports of a deficit in this area appeared early in the literature. Kanner (1943) noted a failure to use speech for communicating meaning to others, but studies looking specifically at pragmatic skills in autism have been more recent. Baltaxe (1977) reported that autistic subjects often failed to shift out of the hearer role to become a speaker and also failed to follow "conversational postulates" of acceptability and politeness (Bates, 1976). In addition, Baltaxe noted that autistic adolescents tended not to "foreground and background" their utterance, for example by the use of definite and indefinite articles, making it difficult for listeners to differentiate between old and new information.

Langdell (1980) examined the speech of autistic children and noted a tendency to ask embarrassing questions; inappropriate use of a pedantic and formal style of speech in an informal context, particularly by higher level autistic children, was also identified. Langdell described other examples of pragmatic deficits in autistic speech. When autistic children start talking to someone, they fail to use appropriate boundary markers, for example "Hello", which, it was argued, was due to difficulties in taking another person's point of view. This may also explain the difficulty autistic children had modifying their accounts, when reporting events, according to whether the listener had been present or not.

Another pragmatic skill which autistic children have difficulty with is turn taking in conversation (Fay and Schuler, 1980). For example autistic children tend to interrupt the speaker inappropriately (Pacci-Cooper, Curcio and Sacharko, 1980) and fail to signal turn taking using eye contact (Mirenda et al, 1983). There is also a tendency to remain in the speaker's role (Bernard-Opitz, 1982; Paul and Feldman, 1984) or in the respondent's role (McCaleb and Prizant, 1985) for too long, violating Grice's (1975) "maxim of quantity".

Wetherby and Prutting (1984) examined the range of speech acts (Austin, 1962) displayed by autistic children. They noted an absence of requests for information, acknowledgements of others, showing off and commenting. Some speech acts were used however, although these were limited to requests for objects and actions or, were in the form of a protest. They concluded that autistic children were able to regulate an adult's behaviour to obtain objects, or to obtain an environmental end, but they were unable to draw attention to themselves, or to an object, as an end in itself.

There is some evidence, however, that autistic children do attempt to use language in a communicative way. In a case study by Bernard-Opitz (1982), communicative performance was found to vary across different settings with different interlocutors, which indicated some social awareness in the use of language. Hurtig, Ensurd and Tomblin (1980) examined persistent and perseverative questioning behaviour in autistic subjects and concluded that although this did not serve the purpose of requesting information, it was communicative in that it functioned as a means of initiating interactions. Ball (1978) and Caparulo and Cohen (1977) also argue that autistic children seem to recognize the function of language which serves to inform others. In addition it is argued that echolalia is used to request, protest and affirm (Prizant and Duchan (1981), which may also be thought of as examples of using language communicatively. If our definition of pragmatics, used earlier, hinges on "..the communicative use of speech and gesture.." then we must consider whether these are in fact examples of communicative behaviour.

Clearly some definition of "communicative" behaviour is required. Baron-Cohen (1988) points out that in Speech Act Theory (Austin, 1962; Searle, 1965) communicative behaviour consists of "complex intentions", in other words it involves a speaker's intentions to affect a listener's intentions or beliefs. The examples above (Hurtig et al, 1980; Prizant and Duchan, 1981) focus on the speaker's intentions alone. It would seem more accurate, perhaps, to describe autistic children's language as instrumental rather than communicative (Baron-Cohen, 1988).

In contrast to the difficulties autistic children have with pragmatic skills, young normal children display pragmatic competence from a very early age (Wellman and Lempers, 1977; Furrow, 1984) and a normal range of speech acts are displayed by language delayed children (Rom and Bliss, 1981; Ball, 1981), Down's syndrome children (Coggins, Carpenter and Owings, 1983) and mentally handicapped adolescents (Price, Williams and Sabsay, 1979; Bedrosian and Prutting, 1978).

Autistic children, then, are especially deviant in the area of pragmatic functioning (Tager-Flusberg, 1981; Baron-Cohen, 1988). Furthermore, pragmatic deficits can be seen in gesture (Bartak et al, 1975; Attwood, 1984; Wetherby and Prutting, 1984; Ohta, 1987) which suggests that its basis is more than a surface linguistic problem.

To summarize, we have seen that the language profile of autistic children is unlike that of any other language delayed or developmentally delayed clinical group. For those autistic children who can speak, a common feature is echolalia, which is now thought to be functional, perhaps playing a role in the language acquisition process. Some autistic children may develop competence in phonology, syntax and semantics, but the main area of deviance is with pragmatics. Later (see Chapter 3) we shall discuss the possibility that this language profile may reflect a basic cognitive deficit in autism.

ii). Impairment in Social Relations

The social impairment observed in autistic children is one of the most striking features of the syndrome. In Kanner's (1943) early descriptions of autism, difficulty with social relationships are emphasised as a cardinal feature. Deviance in the development of social relationships is now used as an important diagnostic criterion in the major classification systems (WHO,1978; APA,1980). However, despite the importance of this area of development, it is only in the last ten years that detailed attention has been paid to it, as it has been considered a "secondary symptom" and research on cognitive deficits and communication deficits have taken precedence. As Volkmar (1987) points out though, even if the social factors are not "primary", they may still be of importance in defining the syndrome and they may provide insights to help us understand the role of social factors in relation to other aspects of development.

Studies of early development in autistic children (Ornitz, 1977, 1978; Volkmar et al, 1986) show severe early social deficits and follow up studies (Rutter, Greenfield and Lockyer, 1967; Rumsey, Rapoport and Sceery, 1985) testify to a lifelong and persisting social impairment in autism. Wing and Gould (1979), in their epidemiological survey, categorised this social impairment into three types: social aloofness, passive interaction, and active-but-odd interaction. In other words, not all autistic children are aloof and withdrawn since those in the active-but-odd group do approach and attempt to interact with others. What makes this category unusual is that the interactions are inappropriate, as Baron-Cohen (1988) describes, being "undertaken to indulge some repetitive, idiosyncractic preoccupation, showing no interest in the other person's needs." Aloofness and detachment appear to be more marked in younger childhood (Wing, 1981) and indeed it may be that there is a developmental progression through these categories, from "aloof" to "passive" in "social responsiveness" and from "aloof" to "passive" to "odd" in "rate of initiation" (Lord, 1984).

Despite the severity of the impairment in social relations then, autistic children are not all totally detached and withdrawn. For example, autistic children do appear to be capable of taking account of other people's behaviour. Hopkins and Lord (1981) observed the number of initiations and responses to interactions in autistic subjects in an attempt to measure which of the three social impairment categories (Wing and Gould, 1979) each child fell into. They found that this could be determined by the age, sex, familiarity and diagnosis of who the child was interacting with. Similarly, when Clark and Rutter (1981) measured social behaviour in terms of "degree of compliance" they found differential social responsiveness to varied tone of voice and varied interpersonal demands. Autistic children also do show some attachment behaviour, for example, proximity-seeking after reunion with a caregiver (Sigman and Ungerer, 1984), eye contact and reaching after tickling in 3 to 6 year olds (Sigman et al, 1986) and gestural requests for social routines (Wetherby and Prutting, 1984).

One of the problems in this area of research is the differential definition of "social behaviour" across various studies. In the examples above, Hopkins and Lord (1981) used "number of initiations and responses to interactions" whilst Clark and Rutter (1981) used "degree of compliance". A full discussion of definition here would be beyond the scope of this thesis, but it is perhaps worth noting the work of Damon (1979) and Frye (1981) who describe social behaviour more thoroughly in terms of "mutually intentional relations" in their detailed discussion of normal child development. Using this approach, it has been found that autistic children show significantly less "joint attention" than matched controls, and "show" or point to toys less often (Mundy et al, 1986; Sigman et al, 1986; Loveland and Landry, 1986).

Let us now consider the experimental studies of social understanding that reveal a particular profile of impairment for autistic children.

There is some evidence of "eye-gaze avoidance" in autistic children. Hutt and Ounsted (1966) and Richer (1976) found that autistic children looked at people's faces less than controls. However, this quantitative measure may be misleading as Hermelin and O'Connor (1967) demonstrated that autistic children simply have shorter, more frequent fixations for all types of stimuli, not just faces. Perhaps a more important aspect of eye gaze, which appears to be impaired, is its social use. Mirenda, Donnellan and Yonder (1983) found qualitative differences between eye gaze use in autistic and normal children. They found that during monologues, autistic children tended to look for longer and more frequently.

In tests of face-recognition autistic children were unimpaired in their ability to recognise their peers in photographs (Langdell, 1980). Langdell also found that when only the lower half of a face was shown autistic children made fewer errors than controls in face-recognition; in other words they were less dependent on the upper part of the face (the eye region) for recognition, suggesting that they may use a different strategy for face recognition.

Hobson (1986a, 1986b) tested autistic children's understanding of emotions. He looked at the ability to match emotional expressions from different modalities and found that autistic children made more errors than controls in choosing schematic faces to match videotapes showing emotions expressed in gesture, vocalization or context. However, recognizing emotions in one modality appears to be less difficult. Autistic children were able to sort photographs of faces with different emotional expressions significantly above chance (Langdell, 1981). Jennings (1973) and Weeks and Hobson (1987) found that autistic children preferred to sort photographs according to non affective stimuli (such as different hats) than by emotional indices; this was in contrast to normal controls who preferred to sort by emotional expression. Recognition of age and sex was also found to be impaired (Hobson, 1983, 1987) although sex recognition alone was not found to be impaired (Weeks and Hobson, 1987; Ableson, 1981).

Autistic children seem to be unimpaired in visual self-recognition, being able to understand their own reflection in mirrors (Ferrari and Matthews, 1983; Dawson and McKissick, 1984; Baron-Cohen, 1985). This has been interpreted as showing that they have some concept of self as a separate physical object of their own perception. It should be noted though that autistic children do not show the shyness and embarrassment in front of a mirror (Baron-Cohen, 1985; Spiker and Ricks, 1984) usually observed in normal children (Amsterdam and Greenberg, 1977) and in Down's children (Mans, Cichetti and Sroufe, 1978).

In tests of perceptual role-taking, autistic children were found to be unimpaired (Hobson, 1984; Baron-Cohen, 1985). However, autistic children performed significantly worse than matched controls in tests of conceptual role-taking (Baron-Cohen Leslie and Frith, 1985), being impaired in their ability to predict where a person would look for an object they had left in one location, but which had been moved to another location in that person's absence. This was interpreted as a failure to attribute beliefs to others, which involves using a "theory of mind" (Premack and Woodruff, 1978). Further evidence of a failure to attribute mental states was demonstrated with a picture-sequencing task (Baron-Cohen et al, 1986) and using a gift-choosing paradigm (Dawson and Fernald, 1987). We shall examine these ideas in more detail later (see Chapter 3) as this thesis is particularly concerned with the "theory of mind" hypothesis.

Imitation ability has also been tested in autistic children. DeMyer et al (1972) found that imitation of body movements was at a lower level than imitation of object use. However, imitation ability appears to be related to mental age (Van Smeerdjick, 1981) and seems to be unimpaired at lower levels but impaired at higher levels (Jones and Prior, 1985). Curcio (1978) and Hammes and Langdell (1981) concluded that although imitation of abstract gesture is difficult for autistic children, on the whole imitation is not an autism-specific impairment.

It seems that the social deficit persists throughout the lifetime of an autistic person with an inability to take part in two-way reciprocal interaction. Despite this bleak picture however, it should be emphasised that it is the quality and nature of the social relationships, rather than their complete absence, that is aberrant. The experimental studies of autistic children's social understanding reveal a specific profile of impairment unlike any other clinical group. Face recognition, mirror self-recognition and perceptual role-taking appear to be unimpaired, whilst there is severe impairment in the intermodal matching of emotional expressions, conceptual role taking and imitation of symbolic gestures. If children's cognitions are the primary determinants of their behaviour (Cairns, 1979) then this profile of impairment may offer some clues as to a basic cognitive deficit underlying autism.

iii). Ritualistic and Compulsive Phenomena

In young autistic children there is a tendency to engage in restricted, repetitive and stereotyped patterns of behaviour (Rutter and Schopler, 1987). There is a tendency to impose a rigid routine on a wide range of day-to-day activities. The stereotyped behaviour applies to autistic children across a whole range of IQs (Bartak and Rutter, 1976). In their review, Rutter and Schopler (1987) list a variety of ways in which stereotyped behaviour may be shown. It may include:

a) an encompassing preoccupation with stereotyped and restricted patterns of interest
b) attachments to unusual objects
c) compulsive rituals
d) stereotyped and repetitive motor mannerisms
e) preoccupation with part-objects or non-functional elements of play materials
f) distress over changes in small details of the environment

The meaning of these ritualistic and compulsive phenomena remains obscure. Stereotypical behaviour is not exclusive to autism and can be found in other mentally retarded and hyperactive children (Berkson and Mason, 1963; Hutt and Hutt, 1970; Thelan, 1979). Some authors have speculated that stereotypies may be symptoms of a neurological or biochemical abnormality (Robbins and Sahakian, 1979; Robbins, 1982), whilst others have argued that they reflect a rigidity in thought processes (Newson, 1987) or an attempt to impose some order on an otherwise confusing world (Rutter and Schopler, 1987).

The stereotyped behaviour tends to diminish as the child grows (Gillberg and Schaumann, 1981) or more complex routines may develop. The autistic child is highly resistant to any attempts to interfere with or change a routine or ritual, often responding with temper tantrums which may be quite violent. Obsessions may develop for unusual objects or subjects (in this author's experience this may range from cassette players to cranes) which the child will draw constant attention to and talk about incessantly.

Attempts to eliminate or discourage these behaviours, including physical punishment (Risley, 1968; Koegel and Covert, 1972), sensory extinction (Ricover, 1978), jogging (Kern et al, 1982) and behaviour modification (Marchant et al, 1974), have met with some success. An adequate explanation for these behaviours however, has not yet been put forward and it remains unclear how these compulsions and rituals may be related to cognitive deficits or to other aspects of development in autism.

In this section we have seen that autism is characterised by a particular profile of social impairment and language impairment. It should also be emphasised that these impairments overflow and pervade one another, the social use of language being a specific impairment and problems with two-way reciprocal interaction being a particular aspect of the social deficit.

In the next section we shall discuss the research on cognitive development in autism and later examine proposals for a basic cognitive deficit that might underlie the behavioural impairments.

B). COGNITIVE DEFICITS

In recent years, the significance of cognitive functioning in autism has become clear (Rutter, 1983). Autism is often associated with mental retardation, with approximately two thirds of autistic children achieving IQ scores on standardised tests in the mentally retarded range (see section 2). It is not surprising, then, that some cognitive deficits will be present. However, using appropriate controls (chronological-age matched and mental-age matched), it has been possible to examine cognitive deficits that are specifically associated with autism.

One popular early hypothesis of cognitive dysfunction was the "stimulus overselectivity hypothesis" (Lovaas et al, 1971). Research suggested that autistic children may selectively attend to one restricted source of information, to the exclusion of others, perhaps attending to a minor feature of the environment whilst ignoring relevant features. However, this type of responding does not appear to be specific to autism since it can be observed in non-autistic retarded children (Anderson and Rincover, 1982; Gerstan, 1983). Although this is still of importance, for example Fein, Tinder and Waterhouse (1979) have suggested that selective attention may be guided by higher-level perceptual processes so that different features of attention may be relevant, this thesis is more concerned with those processes which are unique to autism and so it is those features that we will concern ourselves with here.

i). Perception

In a review of their early experiments on perceptual functioning, Hermelin and O'Connor (1970) concluded that autistic children do not show any abnormalities in lower processing levels of perception, performing according to their level of cognitive development. Nevertheless, it does seem that autistic children perceive the environment in a different way from normal individuals, as can be seen from their abnormal responses to sensory stimuli (see Frith and Baron-Cohen, 1987 for a review), and what appear to be signs of lower level dysfunction may be explained more powerfully in terms of higher-level cognitive dysfunctions (eg selective attention, relating general knowledge to perceptual input, interpreting input as meaningful).

Hermelin and O'Connor carried out a series of experiments to investigate possible higher level cognitive dysfunctions. They compared autistic children with deaf and blind subjects as well as normal and retarded controls, in order to examine whether cognitive problems might be related to more specific coding problems. In particular they hypothesized that spatial and temporal mental codes might each be associated with more immediate sensory codes for visual and auditory information. In a task requiring subjects to recall visually presented letters, in which spatial and temporal orders of presentation varied independently, the order of recall revealed that deaf and autistic children were more likely to use visual coding, whilst normal children used temporal coding (Hermelin and O'Connor, 1975; O'Connor and Hermelin, 1975). Strategies of recall were also examined in a task which allowed subjects to use either touch or fixed spatial location to encode words; blindfolded normal children were more likely to use spatial location, whilst blind and blindfolded autistics used touch (Hermelin and O'Connor, 1971). It was concluded that autistic children use their low level processing functions, which are specific to the sensory modality, rather than their higher level functions, which use abstract codes. It seems that autistic children do have mental images and representational systems, but do not tend to recode visual and auditory stimuli into higher level temporal or spatial codes (ie moving from sensory to abstract codes), as normal children do. In other words it is this higher level of cognitive functioning that is deficient (Hermelin, 1978).

Various patterns of perceptual ability have been examined. On tests of object permanence autistic children have been found to perform in accordance with their mental age (Sigman and Ungerer, 1981). Hobson (1984) also found that this was true for the number conservation task and the three mountains task (Piaget and Inhelder, 1956). Psychometric data has been gathered from standard tests such as the WISC, Leiter, and Merrill-Palmer tests. Peak performance was observed on the subtests of Block Design and Object Assembly, in contrast to poor performance on verbal tests (Dawson, 1983; Lockyer and Rutter, 1970; Tymchuk et al, 1977).

The observation of peak performance and sometimes exceptional "islets of ability" is an unusual and baffling one. There have been reports of extraordinary drawing ability (Selfe, 1977; 1983), musical talent (Rimland, 1978) and powerful calendar memory, calculation and rote memory (Rimland, 1978). Various authors have attempted to explain these abilities by proposing that autistic don't recode sensory stimuli into abstract codes so that they are able to echo and reproduce relatively unprocessed stimuli, which may enhance performance on certain tasks (Selfe, 1983; Frith and Baron-Cohen, 1987). Also, with regard to musical ability, it is interesting to note that given a free choice between musical and verbal information autistic children prefer music, in contrast to normal children who like both (Blackstock, 1978). It is also interesting that autistic children perform particularly well on the embedded figures task, this may be due to basic level processes being allowed to function without the selective control of higher order functions (Shah and Frith, 1983). It seems, then, that autistic children show deficits in tasks which require a recoding of stimuli.

The perception and recoding of meaningful stimuli has been investigated. Hermelin and O'Connor (1976b) looked at recall of words when presented in meaningful sentences compared to recall of words presented in random strings. For normal children, presentation of words in meaningful sentences enhances recall. Although autistic children did show this effect in reduced form, compared to retarded and normal children, matched for mental age, autistic children showed superior recall for random strings and inferior recall for sentences. This has also been confirmed by other authors (Aurnhammer-Frith, 1969; Fyffe and Prior, 1978; Ramondo and Milech, 1984). Perception of meaningful information then seems impaired in comparison to perception of non-meaningful information. This also applies to non-linguistic, abstract material, as Frith (1970a, 1970b) showed, using coloured chips; autistic children's performance was unimpaired relative to controls when recalling unstructured random material.

Patterns of salience, then, do not seem to work in the same way for autistic children as for non-autistic children. Those aspects of the environment which are relevant and meaningful in normal perception, do not seem to be so for autistic children. Whatever determines this relevance would seem to be an important cognitive deficit in autism.

There appear to be no deficits in discrimination learning (Hermelin and O'Connor, 1970; Prior, 1979) or in short term memory (Hermelin and O'Connor, 1970; Fyffe and Prior, 1978). It has been observed that autistic children are less likely than mental-age-matched controls to imitate spontaneously (Bartak, Rutter and Cox, 1975; Sigman and Ungerer, 1984a, 1984b), although some imitation of body movement and speech, for example echolalia, does occur.

Rutter (1983) summarized the cognitive skills of autistic children and noted special difficulties in sequencing, abstraction and coding functions, with few deficits in spatial performance, perceptual organization, and attentional short term memory skills.

ii). Symbolic Play

Autistic children show a striking lack of pretend play (Baron-Cohen, 1987; Rutter, 1978; Sigman, Ungerer, Munder and Sherman, 1987; Ungerer and Sigman, 1981; Wing et al, 1977). Pretend play is also sometimes referred to as "symbolic" play, which we shall discuss the definition of later, and is contrasted with "functional" play which involves using objects in ways appropriate to their conventional function. Symbolic play is thought to develop at 20 months of age (Piaget, 1954) in normal children. Wing, Gould, Yeates and Brierly (1977) found that symbolic play could be observed in mentally handicapped children with mental ages above 20 months, but that autistic children were the only group that showed a poverty in symbolic play in children with a mental age *of over 20 months. In a review by Wulff* (1985), it was concluded that "the autistic child's play is striking in its lack of fantasy and all other aspects of symbolic play".

Leslie (1987) points out that primary representational abilities such as object concept and causality are not impaired in autism relative to mental age (Baron-Cohen, Leslie and Frith, 1986; Curcio, 1978; Ungerer and Sigman, 1981), furthermore, the ability to pretend is not impaired in other forms of retardation, such as Down's syndrome (Hill and McCune-Nicolich, 1981). It would seem then that lack of pretend play is a deficit specific to autism. This was also confirmed by Baron-Cohen (1987). In his experiment he outlines a clear definition of pretend play, which is worth noting; pretend play occurs when:

1. The subject is using an object as if it were another object and/or
2. The subject is attributing properties to an object which it does not have, and/or
3. The subject is referring to absent objects as if they were present.

Using this definition of pretend play Baron-Cohen (1987) confirmed that autistic children are severely impaired in their ability to produce pretend play, in contrast to non-autistic retarded and normal controls.

Although the absence of pretend play in autism remains an area of dispute (see Lewis and Bowcher, 1988), the overwhelming evidence points to an absence of pretend play as a specific impairment in autism.

The dysfunction in pretend play is often interpreted as being due to an inability to abstract concepts and to store these abstraction symbolically (Sigman et al, 1987). It would seem likely that some higher order cognitive dysfunction is responsible. In the next chapter we shall look more closely at a theory of the mechanisms of pretending, proposed by Leslie (1985). He argues that the ability to engage in pretend play may require that the child have some "metarepresentational" capacity which allows the cognitive system to register that it is in the pretend mode. It is argued by Leslie (1985) and others (Baron-Cohen et al, 1985, 1986) that this "metarepresentational" capacity is also important for the development of a "theory of mind" (Premack and Woodruff, 1978). In the next chapter we shall examine the proposal that an impairment in "theory of mind" is a basic cognitive deficit in autism.

In summary, it would seem that the cognitive dysfunctions in autism occur at the higher rather that the lower level of processing. Those processes used for deriving abstract information, for sequencing material and for transforming information into symbolic representations appear to be most affected. However, although a great deal of progress has been made and we now know more about the cognitive deficits specifically associated with autism, it is still unclear how these deficits may be related to the abnormalities in social functioning (see section 4b).

The "theory of mind" hypothesis (Baron-Cohen, Leslie and Frith, 1985, 1986) attempts to draw together various psychological processes relevant to socialization which may be impaired and proposes a basic cognitive deficit which begins with impaired "metarepresentational" capacity and affects specific social skills, pragmatics of language, and pretend play. It is this basic cognitive deficit that will be discussed in the next chapter and examined further in this thesis.

CHAPTER 3.

A COGNITIVE DEFICIT.

Introduction

In this chapter we will describe a new theory, proposed by Uta Frith and her colleagues, which attempts to explain the specific impairments of autism. We will go on to examine some of the precise predictions that this theory makes and describe recent studies which support the theory. Finally, we will deal with some of the criticisms and queries concerning this theory before describing how the research in this thesis fits in with the current picture.

A triad of impairments and a single cognitive deficit

As we have seen in chapter 1 a confusing feature of autism is that it may occur together with other impairments, in other words, what we might consider to be "pure" autism may or may not have other handicaps imposed upon it. Possibly this combination with other handicaps results from widespread brain damage. However, an important epidemiological study of Wing and Gould (1979) has enabled us to identify a constellation of three features that are always present, regardless of additional handicaps. The triad of impairments proposed by Wing (1988) consists of social impairment, communicative impairment and an impairment of imaginative activity with substitution of repetitive behaviour. These three impairments are thought to be the core features of autism.

There is also a consensus of opinion that autism has a biological origin (see Chapter 2). In addition we have described how autism can be found in the normal population but is more commonly found in the mentally handicapped population. However, autism only affects a proportion of the mentally handicapped population. We have also discussed (see Chapter 2) how autistic children of normal intelligence suffer from specific neuropsychological deficits and that autism can be linked to a variety of medical conditions. It would seem reasonable to conclude, then, that there is some brain abnormality which is linked specifically to Wing's triad of impairments.

Frith (1989) argues that although the nature of this abnormality is unknown, we can assume that there is a "final common pathway" leading to that abnormality, and when this particular pathway or brain system is damaged it will always lead to autism. This possibility seems even more likely when we take into account the fact that autism is such a clearly defined syndrome involving such a strong common denominator as is implied by the triad.

It would be extremely useful then if a single cognitive deficit could be identified which might eventually be mapped onto the brain system which forms the final common pathway. We shall be examining a cognitive theory which attempts to explain the co-occurence of the triad of symptoms which are specific to autism (Baron-Cohen, Leslie and Frith, 1985, 1986; Frith, 1987; Leslie, 1987; Baron-Cohen, 1988). The theory proposes that autistic children have a specific deficit in their ability to form and use metarepresentations. In order to explain what is meant by this we need to make the distinction between primary representations and metarepresentations in normal cognitive development.

Metarepresentations

The beliefs and concepts which a child is able to form about the physical world are called "primary representations". For example, representations of categories such as bananas or telephones, with information about appearance, functions and properties are "primary representations". However, as Leslie (1987) illustrates, young children are also able to form representations of other representations, which he calls metarepresentations (also described as second-order representations by Dennett,1978, and Johnson-Laird, 1983). For example, in pretend play a young child can form the metarepresentation that <*a banana is a telephone*> which must be kept separate from the primary representation <*a banana is good to eat*>. In other words the metarepresentation is not directly related to reality. In pretend play, the cognitive system must simultaneously represent an object as real and unreal.

Leslie (1987) argues that the ability to form and use metarepresentations is normally in place by the second year of life when it is manifested in the ability to pretend. From then on more sophisticated developments take place until metarepresentational capacity will enable the child to think and reason about the content of his/her own and other people's mental states. This ability to conceive of ones own mental states and to attribute mental states (such as belief and desires) to others is achieved by using what is called a "theory of mind" (Premack and Woodruff, 1978) and requires the use of metarepresentations.

Being able to use a "theory of mind" is important for understanding the social world and for communication in general. It enables us to predict the relationship between external states of affairs and other people's mental states. We use it to make sense of the social world (eg. "He won't talk to me because he *believes* I don't like him"), to distinguish between "really meaning something" and "just pretending", to understand when somebody is joking and when s/he is are lying. It also allows us to represent someone else's false belief and to predict that s/he will behave according to that false belief. Understanding of false belief has been shown to be present in normal children at the age of four (Wimmer and Perner, 1983).

Uta Frith and her colleagues proposed that autistic children have a cognitive dysfunction in the formation and use of metarepresentations. This results in an inability to "pretend play" and also impairs the development of a "theory of mind". Before we discuss the direct evidence for this we will consider how these deficits can explain the triad impairments seen in autism.

Explaining the triad of impairments.

i) Social Impairment

The metarepresentation hypothesis makes precise predictions concerning the social impairments observed in autism. Only those social skills requiring the use of metarepresentations should be impaired whilst skills involving only "primary representations" remain intact. This would account for lack of embarrassment in autism (Baron-Cohen, 1985) since embarrassment involves conceiving of oneself as an object of others thoughts (which requires using a theory of mind). Not being able to use a theory of mind can also account for deficits in joint attention observed in autism (Mundy et al, 1986) and deficits in conceptual role-taking that we will describe later (Baron-Cohen et al, 1985,1986). Low level imitation as well as recognising people and forming emotional attachments however, may only require the use of primary representations and so remain intact. Perceptual role-taking also remains unimpaired (Hobson, 1984) as it only requires rotation of a primary representation. It is the capacity to form and maintain the sophisticated aspects of social interaction, for which the "theory of mind" is used, which is impaired in autism (Frith, 1989).

ii) Communicative Impairments

Frith (1989) presents a detailed account of how the specific communication deficits observed in autism can be accounted for by an impaired "theory of mind". The most distinctive communicative deficit in autism is in pragmatic skills (see Chapter 2) which are predicted to be impaired due to an inability to attribute mental states to others. Baron-Cohen (1989) lists a number of reasons why a speaker must be aware of a listener's mental state (italicized below) in order to communicate in a socially appropriate way:

a) The listener holds certain *beliefs* about what particular words refer to when the speaker uses them.
b) The listener is trying to *represent* the message in just the way the speaker intended it to be represented (Shatz, 1978).
c) The listener and speaker share some information but do not share other information. This involves the speaker making "psychological presuppositions".
d) The listener holds certain *beliefs* about how the speaker will act, such that the speaker will be informative, truthful, relevant, sincere, etc (Grice, 1957, 1975).

The importance of the speaker and the listener being able to take account of each other's mental states, in order for meaningful communication to take place, is a tenet of Speech Act Theory (Austin, 1962; Grice,1957,1967; Searle,1965,1979; Srawson,1964,1979). The theory notes that it is in the speaker's intention to refer to something that the meaning of an utterance resides. Therefore for the listener to understand the meaning of the speech he or she must make inferances about the speaker's intention and likewise, to make the speech meaningful the speaker must monitor whether that intention has been recognized. More recently Sperber and Wilson (1986) have extended this theory and also point out the importance of inference in meaningful communication, the object of that inference being the speaker's intention.

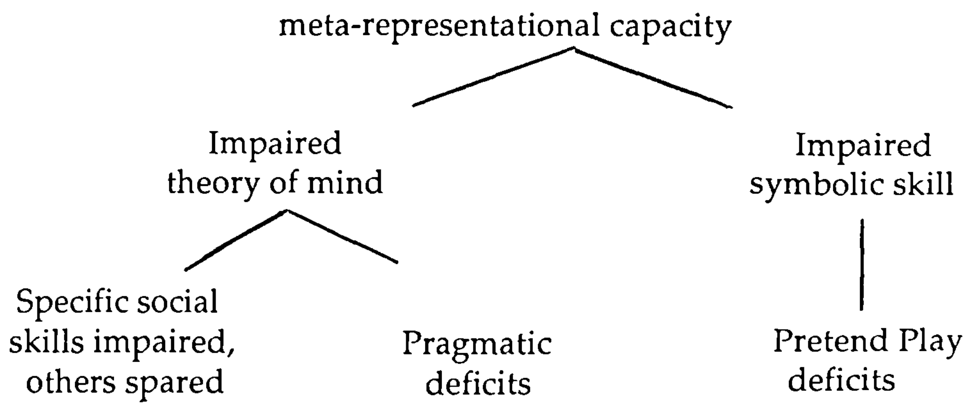
According to these theories then, using language meaningfully and communicatively depends on being able to take account of thought content. Without a theory of mind this cannot be done. The communicative impairment observed in autism may occur due to an inability to use a theory of mind, which in turn is explained by impaired metarepresentational capacity.

iii). Impairment in imaginative activity

As Leslie (1987) has shown, the ability to pretend only emerges as a result of the capacity to form and use metarepresentations. Since pretend play has been shown to be absent (Wullf, 1985; Baron-Cohen, 1987) or at least delayed (Lewis and Boucher, 1988), then it seems reasonable to suggest that this is also due to an impairment in metarepresentational capacity.

The cognitive theory was summarized diagramatically by Baron-Cohen (1989) as shown in Figure 1 below.

Table 1. Metarepresentational deficit theory



Experimental Studies

One complex ability which requires the use of a theory of mind is being able to represent someone else's false belief. Baron-Cohen, Leslie and Frith (1985) set out to demonstrate that autistic children lack the ability to understand false belief in others, while intellectually more retarded Down's syndrome children and normal four year olds do not. They used a task originally devised by Wimmer and Perner (1983), in which the child is shown a scenario involving two dolls, Sally and Anne. The first doll, Sally, hides her ball in a box and then goes outside to play. While she is away, Anne transfers Sally's ball to a basket after having played with it herself. The child is then asked,"Where will Sally look for the ball?" If the child is able to understand that Sally will believe the ball is still in the box and will act according to that belief, then the child will point to the box and not to where the ball really is. Eighty percent of the autistic children, despite being able to answer the control questions correctly, indicated the basket where the ball really was, ie. they predict Sally's behaviour in terms of the actual situation and not where Sally should think the ball is. In contrast, 85% of the Down's syndrome children and the normal children indicated the box where Sally had originally put the ball, thus taking account of her false belief. This supported Baron-Cohen et al's hypothesis.

The theory of mind was then tested using a picture sequencing task (Baron-Cohen et al, 1986). The performance of the autistic children on physical-mechanical and on social-behavioural events was far better than their performance on events which involved the protagonist's beliefs, whereas Down's syndrome and normal controls did not show this pattern. In addition the children were also asked to describe what was happening in each sequence. The autistic children used significantly fewer mental state terms than the controls.

These studies provided promising evidence that autistic children are impaired in their theory of mind and it was at this point that the work reported in this thesis was started. However, for a more complete picture we need to describe the more recent research in the area which ran concurrently with the thesis research.

Baron-Cohen (1989) went on to test the 20% of autistic children who had passed the false belief task using tests which required the use of third order representations (eg. John *thinks* that Mary *thinks* that..) and found that they failed this task where matched controls passed. This supported the hypothesis that the autistic children who have developed a theory of mind at a lower level remain "specifically delayed" in the acquisition of a more complex theory of mind.

Leslie and Frith (1988) replicated earlier findings and also used real people rather than dolls, further testing the child's understanding of false belief and also showing autistic children to be impaired in their understanding of "limited knowledge" which is another aspect of theory of mind. They also used an additional control group of children with specific language impairment.

Finally, Perner et al (1989) used a "deceptive-appearance" paradigm (which was also carried out in this thesis) to provide further evidence of difficulty understanding false belief. This was important in that it answered criticisms that results on previous false belief tasks simply reflected a difference in the common-sense assumptions about what people normally expected to happen. We shall describe this paradigm in more detail in Chapter 8.

In the next section we will attempt to deal with some of the criticisms of these studies and of the metarepresentational hypothesis itself.

Criticisms

A variety of methodological criticisms of the early studies (described above) have been made. De Gelder (1987) questioned the use of dolls in a "play" situation of the Sally-Anne task which, she argued, would be a disadvantage to the autistic children. In addition it was claimed that the test question "Where will Sally look for the ball?" would be easily misunderstood. These criticisms will be addressed in this thesis (see Chapter 5) by using a different test question, using a different medium of presentation and also testing false-belief understanding with a different task. However, recently the Sally-Anne task has been carried out using real people instead of dolls with the same result (Leslie and Frith, 1988) and also using different tests and different children (Baron-Cohen et al, 1986; Leslie and Frith, 1988; Perner et al, 1989).

Another important query is that the children in these studies were not language matched with regard to grammatical competence. Boucher (1989) points out that the grammatical competence of autistic children may develop more slowly than their vocabulary and that the vocabulary comprehension tests used for matching the children in these studies are therefore inappropriate. This issue will also be considered in the research of this thesis. However, this fails to explain why the autistic children should be able to answer grammatically complex control questions. It is also worth noting that specific language impaired children have been included as controls in some of the experiments and that these children showed the same results as the other controls, differing from the autistic children. (Leslie and Frith, 1988).

In Boucher's (1989) assessment of the theory of mind hypothesis she points out the importance of being able to show evidence that autistic children lack other abilities which are dependent on metarepresentation, the most obvious of these being pretend play. Without such evidence the hypothesis will be based on a circular argument explaining "impaired ability to attribute mental states to others in terms of specific impairment of metarepresentational capacity" whilst the only evidence for impaired metarepresentational ability would be "impaired ability to attribute mental states." She makes this point in the light of her own experiment (Lewis and Boucher, 1988) which found evidence of pretend play under eliciting conditions which clearly contradicts Baron-Cohen's (1987) findings. However, as Baron-Cohen points out, Lewis and Boucher used autistic children with much higher Mental Ages and Chronological Ages who may have developed to the point of a normal 18 month old and are able to pretend but are delayed in that ability. This would be in line with the specific developmental delay hypothesis (Baron-Cohen, 1989a).

Another interesting suggestion which Boucher makes is that the autistic children fail to use a theory of mind because they are not motivated to do so rather than because they are incapable of doing so. In other words she argues that we cannot interpret "failure to use the skill as evidence that skill is lacking." In making this claim she refers to Light's (1987) comments that to pass a conceptual perspective taking task children need to have knowledge concerning other people's states of mind but also must be able to appreciate the need to use this knowledge in different situations. Boucher claims that the discourse difficulties shown by autistic children may be such that they don't see the relevance of this task and hence don't use a theory of mind. However a theory that attempts to explain why they don't use a theory of mind in terms of motivational factors would be extremely complicated and a far simpler account for their not using a theory of mind is that they have a cognitive deficit. Also, such a theory would predict other deficits (ie in any "difficult" task) which are not observed in autism. Nevertheless it will be interesting to consider this motivational factor in the research of this thesis. An interesting proposal of Morton's (1989) is an "optimistic" view that "the necessary structures are there but have not yet been hooked up within the brain." This is also an interesting possibility.

Finally, without going into too much detail, we must mention an alternative theory which also attempts to account for the theory of mind data. Hobson (1986 a,b) and Hobson, Ouston and Lee (1988 a,b) present evidence that autistic children, relative to mental age, are impaired in their emotion recognition and argue that this is the basis of autism. Hobson argues that autistic children are impaired in the innate (preprogrammed) capacity for understanding mental states in others. In other words he assumes the philosophical stance of Butterworth (1986) that the "mind is transparent" and that the mental states of other people are naturally available. This contrasts with assumptions of the metarepresentational hypothesis which is that "mental states are not directly observable but have to be inferred" and the child must develop a theory of their existence that can be used to make sense of people's actions. Baron-Cohen presents various criticisms of Hobson's "Affective Theory". The model does not explain why there should be a link between understanding of emotions and understanding of beliefs nor does it explain unimpaired functioning in perceptual role taking, or why attachment is, to some extent, unaffected in autism (Sigman and Ungerer, 1984). The affective theory is also unclear in its explanation of pretend play, and finally Baron-Cohen (1989) also notes that impairment in emotion recognition can also be found in other mentally handicapped children who do not have autism. Hobson's findings remain interesting though and one would imagine that ultimately the role of the affective system would need to be incorporated in some way into the cognitive theory.

Clearly, then, the metarepresentational theory seems promising although surrounded by controversy. In Chapter 5 we will discuss how we have approached what would appear to be a worthwhile investigation of the theory in this thesis. Firstly though, let us look at another interesting issue concerning autism, that of computer use.

CHAPTER 4

COMPUTER USE WITH AUTISTIC CHILDREN

The introduction of computer use with special needs children has been hailed as a major step forward. However, before we can be satisfied with this new technology, we must first consider whether it is being used to optimal effect. We must think about which groups of children are most likely to benefit from computer use, how computers can be employed most effectively in education and whether the computer can be used as a research tool with special needs children.

Despite the fact that the majority of schools for autistic children now have a computer of some sort (Jordan, 1984), there have been relatively few studies concerning the use of computers with autistic children.

In this chapter we will be examining the evidence and the arguments concerning the use of computers with autistic children, looking at previous studies and also considering how the computer might capitalise on aspects of autistic cognition.

Early Studies

The first investigations of computer use with autistic children produced encouraging results. Colby (1973) reported that 13 out of 17 nonspeaking autistic children began voluntarily to use speech for social communication after playing and interacting with symbols on the computer. Each treatment session involved a single child, with an adult (sitter) present. Adult interference was kept to a minimum and the principle underlying the treatment was that the exploratory and self initiated nature of the play would promote learning. The child used a keyboard controlled audio-visual display on which he or she could produce symbols accompanied by a human voice and other sounds. It was not made clear exactly what the linguistic improvement consisted of (ie. whether it was confined to the computer sessions or extended to other situations). However, it was emphasised that the aim was simply to rekindle the child's interest in attempting speech.

Weir and Emanuel (1976) also used the computer as a catalyst to stimulate language. They worked with a seven year old autistic child, over a six-week period, using the graphics-oriented computer language LOGO. It was reported that the child's explorations in controlling the LOGO turtle had led to the development of both verbal and non-verbal language for communication. The child began to use spontaneous language, based on his descriptions of the turtle and also actively sought social interaction for the first time. It was argued that because of the nature of the computer environment the child had been given the opportunity to understand and be understood, in other words share a sense of relevance, and that the self-validating effect of this had led to increased communication. Again, the extent of the communication improvement beyond the computer sessions was not made clear.

LOGO computer language was also used by Goldenberg (1979) with a number of autistic children working individually. His anecdotal accounts were also promising. He describes the experience of one of the children as follows; "She became more active and more in control, both of herself and of the turtle, than she had been earlier. She also said several times ' I'm so happy at that turtle. That turtle listens to me. Aren't you happy at me ?'." Frost (1981) also reported that autistic children were able to control the movements and characteristics of a "screen turtle". Geoffrion and Goldenberg (1981) report further evidence of increased responsivity in autistic children after using computer-based exploratory learning systems.

These results are clearly promising, however, as Panyan (1984) points out in her review of computer technology for autistic children, the lack of experimental design and "sketchy" procedural details of these early experiments make it difficult to draw any firm conclusions.

More Recent Studies

In more recent years a number of studies have attempted a more systematic evaluation of computer use with autistic subjects. Plienis and Romanczyk (1985) compared computer instruction with other forms of instruction. Their data indicated that the use of computers has a positive effect on the attention and performance of autistic subjects.

Panyan et al (1984) used a peer tutoring approach during a computer-based instruction period to promote verbal interactions between autistic subjects. This was particularly interesting since it took the novel approach of having more than one user, in this case a pair of users, and sought to facilitate communication between the children through the use of the computer. One student provided answers in response to requests for assistance from his peer during a spelling program. Verbalizations were reported to have increased from less than 5% to around 80% during the task. It was also reported that the improved social skills were extended to other social situations.

The emphasis in most of the studies then, has been on the child learning independently, capitalising on the autonomy the computer offers and perhaps even using the computer to support something that resembles an interpersonal exchange. However, the computer can also be used in quite a different way, as with the peer tutoring approach (Panyan, 1984), if the medium is used to support joint activity. In other words, it is possible to place the emphasis more on the interactions around the computer, establishing and developing partnerships between the child and either the teacher or a peer. Both of these approaches would appear to be promising. In the next section we shall look more closely at the relationship between autism and the computer environment.

Characteristics of Autistic Cognition and the Computer

There are a number of theoretical arguments to support the idea that the computer environment is particularly well suited to autistic children. Some of these arguments have been derived from the studies described above, but the general hypothesis is that the computer may be a useful tool for education and research since it capitalises on specific characteristics of autistic cognition.

The attributes that a computer can offer and what those attributes capitalise on in terms of autistic cognition are summarised in Table 2 below.

Table 2. Computer Attributes and Autistic Cognition.

Computer Attribute Capitalised on.	Aspects of Autistic Cognition
Restricted field of vision Stimuli in close proximity Reduction of irrelevant cues	Stimulus overselectivity
Consistency Predictable cues Predictable reinforcement schedules	Ritualistic and compulsive phenomena
Nature of HCI Provides consistent communication and meaning	Impoverished communication
Provides own mini-world Involves no social dangers No Adult-Child opponent relationship Opportunity to succeed Bridge to social world	Withdrawn - Difficulty with social world

There is evidence to suggest that autistic children have difficulty attending to one aspect of a learning situation, sometimes ignoring salient cues while focusing on more subtle cues. This has been termed "stimulus overselectivity" (Lovaas et al, 1971; see chapter 2). However, Anderson and Rincover (1982) have shown that autistic children are capable of responding to more than one cue at a time if those cues are relatively close in physical proximity. They suggested that stimuli only become functional for the autistic child when they occur within a restricted field of vision. One advantage that computers may have for autistic children is that stimuli can be presented in close proximity on computer monitors. In contrast, stimulus items in non-computer instructional situations may well be spread over a large physical distance. The computer can also offer a limited and observable number of stimuli, where as adult presentation is accompanied by many idiosyncratic and often irrelevant cues which the autistic child may attend to unnecessarily.

The ritualistic and compulsive phenomena reported in autistic children (see chapter 2) may also link their behaviour with the computer. Rimland (1964) argues that the preoccupation with mechanical objects shown by many autistic children may be due to the "sameness" and the consistent effect the object has on the environment. The computer may be attractive to the autistic child then, because of its consistent effect on the environment. The computer can provide predictable cues and reinforcement schedules which may be varied gradually in an instructional situation. It would be difficult for a teacher to provide this type of consistency and control.

The impoverished nature of human-computer interaction itself seems comparable to the type of communication autistic children already display. Attwood (1984) points out that conversing with an autistic child is very like talking to a computer, "the objects of conversation are strictly limited and the same questions evoke the same responses with monotonous regularity." The routine and well-defined nature of the computer seems well suited to the routine and ritualistic aspects of autistic behaviour.

Goldenberg (1979) has presented some of the most convincing arguments in favour of computer use with autistic children. He notes the difficulty autistic children have with human communication, that they are better at initiating behaviour than copying and that they need consistent meaning assigned to their behaviour. Given these observations, Goldenberg (1979) proposes that, "..it might be a good route to communication for the autistic child to have the orderly computer world first, teaching the child that consistent communication is possible." The computer can give the children active control of their environment and establish a sense of causality as the children attach meaning to their own behaviour and to the what they teach the computer to perform.

The child can explore his or her own mini-world and be given the motivation and the opportunity to succeed. Furthermore, this mini-world is one that the child can share and communicate about.

Interacting with the computer involves none of the social dangers that interacting with other people presents. The child is not confronted with the adult-child opponent relationship that teaching situations and research entails.

One criticism of the computer is that it gives the child an opportunity to "opt out" of social interaction. In order to avoid this it is important to be positive about the role of the computer and look upon it as a bridge to communication rather than a barrier. If this is done it may prove to be an ideal common factor that we can make the most of for educational purposes and as a research tool, in order to break down the barriers.

There are also attributes of the computer that suggest its usefulness as a research tool. Reinforcers can be immediate and consistent and the computer can produce a response and provide feedback at great speed (Eisele, 1980). In addition, an accurate record of the type and frequency of response can be kept.

Conclusion

The evidence from the experimental work completed so far and the theoretical arguments presented here suggests that the prospects for computer use with autistic children are favourable. Given that the computer seems to be particularly attractive to autistic children and given that the computer generally seems to be a useful research tool, it would seem worthwhile attempting a research project with autistic children using a computer as a research device. In this thesis we have attempted to investigate a particular cognitive impairment whilst at the same time evaluating the computer in its role as a research tool and training device.

CHAPTER 5

INTRODUCTION TO EXPERIMENTAL WORK

A). OVERVIEW

It would seem from the work carried out so far concerning "theory of mind" in autism, that there is a good case for a specific cognitive deficit in this area. The rest of the thesis attempts to examine these findings with further research.

Another area of interest which seems particularly promising is the use of computers with autistic children. Further research in this area may demonstrate important practical benefits of computer use. It is possible that the computer may offer a rich new channel of communication that might be used effectively, as a training device or as an investigative tool for the research worker.

The thesis attempts to combine research in these two areas by examining false belief using tasks presented in a novel way on computer. False belief tasks are also presented with conventional apparatus so that some comparison with the results from the computer can be made. By presenting these tasks in different forms it will be possible to examine whether performance can be explained by the surface form of the tasks or by the conceptual nature of the tasks. In addition, the Vineland Adaptive Behaviour Scale is also administered using a group of autistic children and a group of Down's Syndrome children, in order to find out more about how the cognitive deficit might be linked to the child's behaviour. Finally, the computer is used in a training study using autistic, Down's Syndrome and young normal children who fail false belief tasks.

This, then, allows us to examine a number of questions concerning both the nature of the cognitive impairment in autism and the nature of the relationship between the autistic child and the computer. We can also consider whether the computer mode of presentation produces any results that differ from the conventional mode of presentation. If there are any differences, then we can look at whether this tells us anything more about the child's understanding of false belief, or about the qualities of computer presentation that yield different results.

Outline of Experiments.

There are two main aims for the first experiment:-

1. The first aim is to examine false belief in autistic children, Down's Syndrome children and normal children, using a revised version of the Sally-Anne task (Wimmer and Perner, 1983). Alterations are made to the text of the story and to the test questions in an attempt to eliminate some of the ambiguities of the Sally-Anne task used by Baron-Cohen et al (1985). Also, computer versions of the Sally-Anne task are presented. This will provide us with further information about the child's understanding of false belief and, by using the same task via a very different medium, we will be able to test whether it is the conceptual nature of the task that matters rather than its surface form.

2. A secondary aim is to gather information about the child's handling of the computer interface during the training program and the computer tasks. We will be able to analyze time spent on each screen (logged by the computer), as well as considering our own informal observations.

In this experiment, then, we shall be interested in the hypothesis that failure on the false belief task can be predicted by clinical type. According to Baron-Cohen et al (1985), autistic children fail the false belief task whilst Down's Syndrome children and young normal children pass. We will also be able to consider alternative hypotheses as to why failure on the Sally-Anne test might occur (Baron-Cohen, 1985), for example:-

a). It may be due to a deficit in the child's understanding of false belief (Baron-Cohen et al, 1985).
b). The child may have difficulty with some other aspect of the task, not involving "theory of mind". For example, memory for the events that have taken place. It would be the job of the control questions to identify what this might be.
c). It may be due to the mode of presentation of the task.
d). It may be due to other factors, such as IQ or Chronological Age.

We will be able to differentiate between these possibilities more clearly by using a variety of computer tasks.

The second experiment will involve retesting the children approximately six months later. Here we will be interested in the Test-Retest reliability of the tasks, in other words whether the results are stable over time. One hypothesis might be that training (ie. previous experience of the program) improves initial performance.

In the third experiment, understanding of false belief will be examined using a different task, called the "Smarties" task which was used by Perner et al (1987) with normal young children. Again, this task will be presented using conventional materials and also on computer. This will allow comparisons to be made between modes of presentation and also across different types of tasks, since the same subjects are used in all three experiments. If the Sally-Anne task and the Smarties task are both testing false belief, then we would expect there to be a strong correlation between performance on the two different tasks. If children fail to understand false belief on one task but not on another, then we might conclude that it is the task itself, rather than the understanding of false belief, that has lead to the failure. Although, of course, success on both types of task is not a guarantee that it is false belief that is being tested. In addition, the assessment of performance on a second computer-based task will allow us to draw more general and confident conclusions about autistic children's communication with computers.

By looking across a range of tasks and presentation modes, we hope to demonstrate the robust and conceptual nature of the "false-belief" phenomenon in autistic children

In the fourth study we will examine the "ecological validity" of the theory of mind hypothesis by considering whether the cognitive deficit is linked to deficits in real behaviour. The Vineland Adaptive Behaviour Scale will be administered using autistic children and Down's Syndrome children, with each diagnostic group divided into a subgroup of children who pass false belief tasks and a subgroup who fail false belief tasks. Information will be collected for each of the following domains:-

a). Communication
b). Daily Living Skills
c). Socialization

If the hypothesis is correct that a cognitive deficit in the theory of mind as reflected in poor understanding of false belief, is causally linked to autistic behaviour (Leslie, 1987; Baron-Cohen et al, 1985, 1986), then we would expect to find a correlation between performance on the false belief tasks and scores on the Vineland Adaptive Behaviour Scale. We will be able to look at how false belief is situated within the overall pattern of behaviour and consider whether false belief is a specific deficit.

In the fifth experiment a specially designed computer training program will be used to train children to understand false belief. Autistic, Down's Syndrome and young normal children who initially fail a series of false belief tasks will be tested before and after training, and information will be gathered on the training task performance, pre-test and post-test transfer task performance and follow-up results. We will then be able to consider whether the computer can be used effectively as a training device, whether the diagnostic groups differ in terms of performance and learning and whether factors such as Chronological Age and Mental Age are predictors of performance. We will also be interested in whether subjects learn the concept of false belief or an algorithm for the false belief task used in training. These results may allow us further insight regarding the cognition of the three diagnostic groups used.

B). SUBJECTS

Since approximately two thirds of autistic children score in the mentally retarded range for IQ, it is necessary to establish whether test performance on the experimental tasks is a reflection of IQ or of clinical type. This is done by using a comparison group of subjects of similar Chronological Age and IQ who are not autistic. For this thesis Down's Syndrome children were chosen as a comparison group. A specific diagnostic category is used to ensure that the comparison group is homogeneous. We also need to consider the possibility that performance may simply be normal for the child's stage of development (ie Mental Age).

This thesis, then, also uses a comparison group of young normal children whose Mental Ages are equal to or below those of the autistic children.

i). Autistic Children

a). Diagnosis

A total of 40 children who had been diagnosed as autistic were used in the thesis experiments. These children attended either Storm House School, West Yorkshire, Thornhill Park School, Tyne and Wear, Radlett School, Heartfordshire or Brondyffryn School, North Wales. The children are referred to the schools by their local Education Authority after having been independently diagnosed as autistic by a School Medical Officer and Educational Psychologist. All the children used in the study had been at the Autistic School for at least three years. Diagnosis was made on the basis of the established criteria set out by Rutter, Bartak and Newman (1971), which are:-

1. Delay in speech and language development
2. Failure to develop inter-personal relationships
3. Ritualistic and compulsive phenomena
4. Onset before 30 months.

b). The Schools

All four of the autistic schools are run by the National Autistic Society. The schools have a philosophy of providing a structured environment and education for the children concentrating on the teaching of specific skills to each child. There is a high teacher:pupil ratio of approximately seven children to one teacher, with four assistant care staff. Storm House School, Radlett School and Brondyffryn School all have residential facilities and approximately half the children used in the study stayed overnight at the school during the week. Thornhill Park School is full-time residential.

A visit to each school was made prior to experimentation, in an effort to get to know the children and help them feel more relaxed in the company of the experimenter.

ii). Down's Syndrome Children

a). Diagnosis

A total of 45 Down's Syndrome children, all with trisomy 21, were used in the thesis. Diagnosis is made by a doctor in cases of Down's Syndrome on the basis of standard criteria. Prevalence is high for a specific syndrome associated with mental handicap, occurring in approximately 14 children per 10,000 (Smith and Berg, 1976).

b). Schools

The Down's Syndrome children used in the study attended either Galtres School or Lidgett Grove School in the York area, or Foxfield School or Dee Bank School in the Chester area. These schools are for children with mental handicap and learning difficulties and so do not cater, exclusively, for Down's Syndrome children. Unlike the schools for autistic children, these schools are not residential. However, teacher:pupil ratios were similar to those of the autistic schools, as was the philosophy of providing a structured environment and education for the children.

iii). Normal Children

There were 33 normal children used in the thesis. They attended Hobmore Primary School, York, and or Boughton Nursery School in Chester. All were in the normal educational stream.

C). IQ STUDIES

All of the children were tested for Verbal IQ and Non-Verbal IQ. As we described earlier in this chapter, we are interested in a specific cognitive deficit which occurs independently of general retardation. It is necessary, then, is to establish the IQ's and hence the Mental Ages of the three groups.

The British Picture Vocabulary Test was used to test Verbal IQ. This is a well established IQ test, widely used to test mentally handicapped and normal children. This test was also used by Baron-Cohen et al (1985,1986) in their series of experiments examining false belief. The Leiter International Performance Scale was used to measure Non-Verbal IQ. This is also a well established IQ test which can be used for mentally handicapped children and young normal children and was used by Baron-Cohen et al (1985,1986).

CHAPTER 6.

DESIGN AND DEVELOPMENT OF COMPUTER TASKS

a) Materials

The programs used in this study were written using an authoring system called PED (for Picture Editor) on a computer assisted learning (CAL) system developed in the Department of Psychology at York (Hammond and Allinson, 1988). The system is an example of a hypermedia system (Conklin, 1987) consisting of a network of screens of information (incorporating text, graphics, bit-mapped images and sounds) traversed by a computer mouse to point and click on active areas in the currently viewed screen.

The user interface is entirely mouse-driven with each display frame containing a variable number of mouse-selectable links (active areas). The active areas provide hypertext links from the displayed frame to a related frame. When the mouse cursor is moved over the active area it will change colour, highlighting its significance, at which point clicking the mouse will change the screen to the related screen.

b) Composing the Programs

Using the authoring system PED it was possible to compose each screen and define the links to related screens. The facilities used in creating the screen are shown in Table 5 below.

As the authoring and user systems are separate, only the screen information and the relatively small program to allow full interactive "playback" are required in order to use the system. This meant that the generated sequences used in the study could be stored on a single floppy disc and a single machine could be taken to the various testing locations.

Table 3. PED Facilities

1) Colour and texture selection

2) Text input, editing and positioning
(four sizes and orientation of text available)

3) Object-oriented paint package
(graphics elements used included lines, boxes, circles, ellipses, arcs, fills and deletions)

4) Animated sequence production
(selected objects or areas of the screen can be moved at specified rates, with or without leaving a trail)

5) Bit-mapped pictures run-length encoded
(obtained via a video frame grabbing system)

6) Monotonic sound sequences
(Music was created by selecting intensity, pitch, attack and decay times for each note)

7) Conditional branching depending on user actions

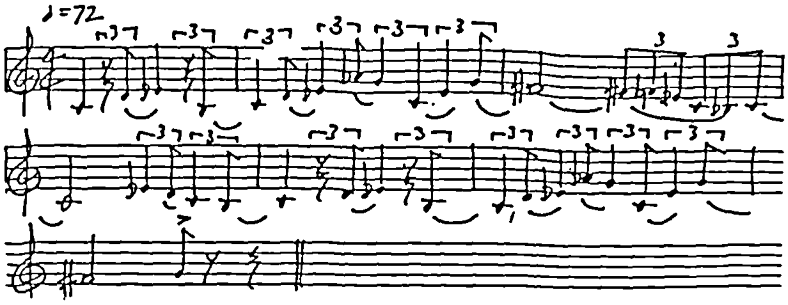
8) Bottom line facilities
(restart and end session)

The software was used to construct a number of games. The children saw a screen display, sometimes with objects moving on the display. Clicking a mouse over an active area caused the next screen to be chosen, often with accompanying music.

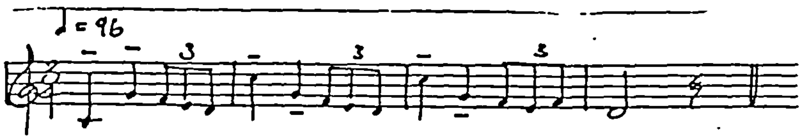
Table 4 below shows the music written for the computer. A tune is played with each screen. Table 4 also shows a key (code) to each of these tunes which will be used later to show which tune goes with which screen.

Table 4. Music used

Tune	Key
Pink Panther Theme	P



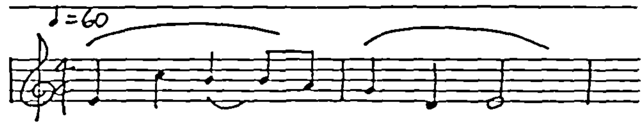
Tune	Key
Star Wars Theme	S



Tune	Key
Bod Theme	B

Tune	Key
Girls and boys go out to play	G

Tune	Key
Sad Tune	ST



Tune	Key
Wrong Tune	WT

Another feature of the interface that was altered was that the mouse was surrounded by a red cardboard arrow to match a red arrow cursor used on the screens. It was thought that this would help the children make the relation between the mouse and the cursor and understand that moving their red arrow (the mouse) caused the red arrow on the screen to move. A white button was built on to the mouse so that clicking was easy to perform.

c) Design Principles

We needed to design computer tasks that would be attractive and motivating for the autistic children and which would also be easy to use. We needed to consider general principles that would apply to the autistic group as a whole (ideally, these principles might be adapted to suit the individual needs of each autistic child).

The following factors were taken into account for the design:-

1. Attentional Processes
2. Communication Skills
3. Responsivity to Sensory Stimuli
4. Coping with Change
5. Learning History
6. Difficulty Level

1. Attentional Processes

In Chapter 2 we discussed the phenomenon of overselectivity (Lovaas et al, 1976). Autistic children cannot attend well to simultaneously presented information and therefore tend to select a narrow aspect of information, often fixating on minor features of the environment whilst ignoring important features. Although this was found not to be specific to autism, these attentional problems have important implications for the design of the computer tasks.

Given the deficit in attentional processes we hypothesized that it would be most appropriate to focus on a minimalist design, keeping the program as simple as possible, cutting down on irrelevant features. The tasks are therefore designed using simple, easily distinguishable shapes and colours.

2. Communication Skills

Considering the same principles of overselectivity and given the difficulties autistic children have with language (see Chapter 2), it was necessary to design programs that make the minimum of linguistic demands. Programs were therefore made as self-explanatory as possible (particularly the training program which required no linguistic skills). Clearly, certain text was necessary for the false belief tasks (for example the test question), however we tried to design the tasks so that the scenarios could be followed with a minimum use of language.

3. Responsivity to Sensory Stimuli

Evidence suggests that autistic children are attracted to and motivated by music (Blackstock, 1978; Nelson et al, 1984). For this reason, using music as a motivating aspect is an important feature of the programs. Again, a minimalist design prevails, using single tone synthesized music with simple, easily recognisable tunes.

We also needed to consider the effects of visual stimuli. The literature suggests that this will present no problems for the subjects, however, we decided not to use any subjects with a history of epilepsy as a precautionary measure to the flicker affects of the computer screen.

4. Coping with Change.

Although the novelty value of the computer might be one of its advantages, for autistic children this change in their environment might be disturbing. Previous work (see Chapter 4), however, suggests that this should not be a problem for autistic children. In terms of the programs themselves, the predictability and repetitive nature of the tasks need not be problematic, and indeed may be a motivating factor for the autistic children.

5. Learning History

The individual learning history and previous experience with the computer could be taken into consideration in designing programs for specific children. However, for these experiments we are designing tasks suitable for a number of children, most of whom have no prior experience of using computers, and all of whom have never used a mouse before. We need to consider the difficulty level accordingly.

6. Difficulty Level

Designing the task to the correct difficulty level is particularly important for the training program. One of the functions of the training program is to ensure that all the subjects are capable of performing with ease on the later programs. If the subjects can master the training program, then they should have no difficulty with the false belief task games.

The early screens of the training program were designed to accept input that the child could make easily, producing an engaging and easily perceivable response or output. In other words, a large effect could be obtained with a very small effort. As the child becomes more interested in the output, then the program is designed so that input becomes more and more difficult to make, by reducing the size of the active areas. The child can then no longer rely on random movements, but instead is required to make more deliberate movements, requiring skill and mastery of the mouse.

d) Program descriptions

A selection of colour photographs of the screens used in the training program and the various false-belief games are shown at the end of this chapter. These are intended to illustrate the various features of the interface.

Figure 6.1 shows the first screen of the training program. A white arrow indicates where the active area is. This is a convention used throughout the programs. In this case the active area is the large red square. When the cursor (the red arrow) is moved over the red square (see fig 6.2.), the square changes colour to green. Clicking the mouse then changes the screen to that shown in figure 6.3 with the accompanying music. Simple, easily distinguishable colours have been used (Red, Green, Blue, Purple, White) throughout the programs.

Figures 6.4 to 6.7 show another sequence of screens from later in the training program. A character appears in figure 6.4. Clicking the cursor over the character (see figure 6.5) results in a new screen with an animated sequence (see figure 6.6) where the character moves across the screen with accompanying music, ending up on the opposite side of the screen and becoming a new active area (see figure 6.7). The double image in fig 6.6, and later figures, is due to movement of the characters during camera exposure.

Figures 6.8 to 6.13 show the sequence of screens that make up Game type B (see Chapter 7.) in the false-belief program. The other false-belief program games have the same features as those displayed in this sequence of photographs. Figure 6.8 shows the two characters "Sally" and "Anne". These two characters are more easily distinguishable on the actual screen, although it is clear from this photograph. The character "Sally" wears white with a large "S" on her clothing and "Anne" wears purple with a large "A". Before testing the experimenter checks that the child can tell these two characters apart. This screen also includes text, a ball in "Anne's" hand and two containers (red and blue). When the cursor is moved over "Anne" and clicked the new screen appears in which the character moves with the ball to the red container with accompanying music (see figure 6.9). "Anne" then puts the ball into the container (see figure 6.10) and at the end of the screen a door appears in the top right-hand corner of the screen (see figure 6.11). The door opens by the child putting the cursor over it and clicking the mouse and "Anne" moves out through the door which closes behind her (see figure 6.12).

At the end of this sequence the text "Where does Sally think the ball is?" appears (see figure 6.13). The experimenter asks the child this question and the child can then click the cursor over one of the large white arrows above the containers. The containers themselves are not used as active areas since they would change colour when the cursor is moved over them. Although this is a drawback the children soon learn that the arrow is associated with the container below it and, since the arrow changes colour, that it is an active area. If the child clicks over the correct container (in this case the red container) "Sally" goes to the container and retrieves the ball and the text "YES, WELL DONE" flashes on the screen. If the child chooses incorrectly the text "NO I WON'T" and then "TRY AGAIN" appears on the screen. It is not assumed that the child can read this text, so the experimenter repeats it out load. However if the child repeats the text aloud himself or herself then the experimenter keeps quiet.

Figure 6.1

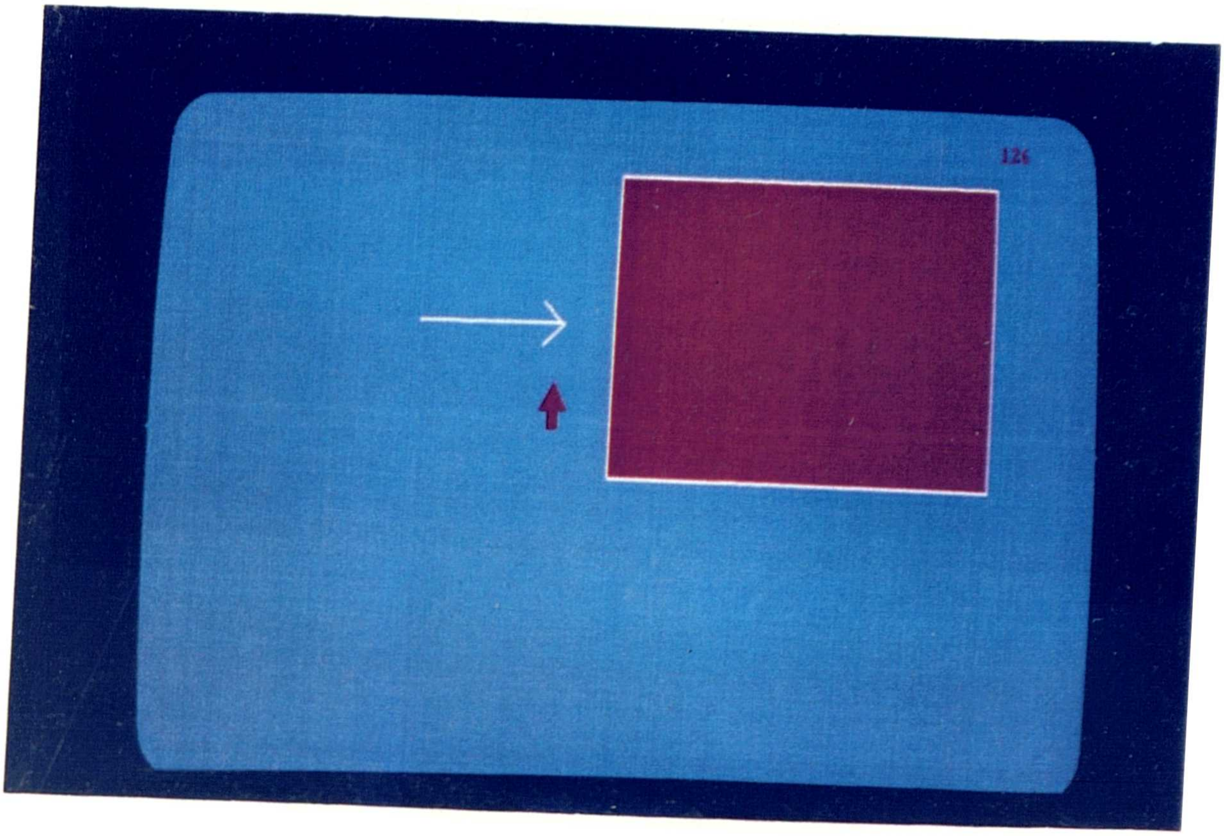


Figure 6.2

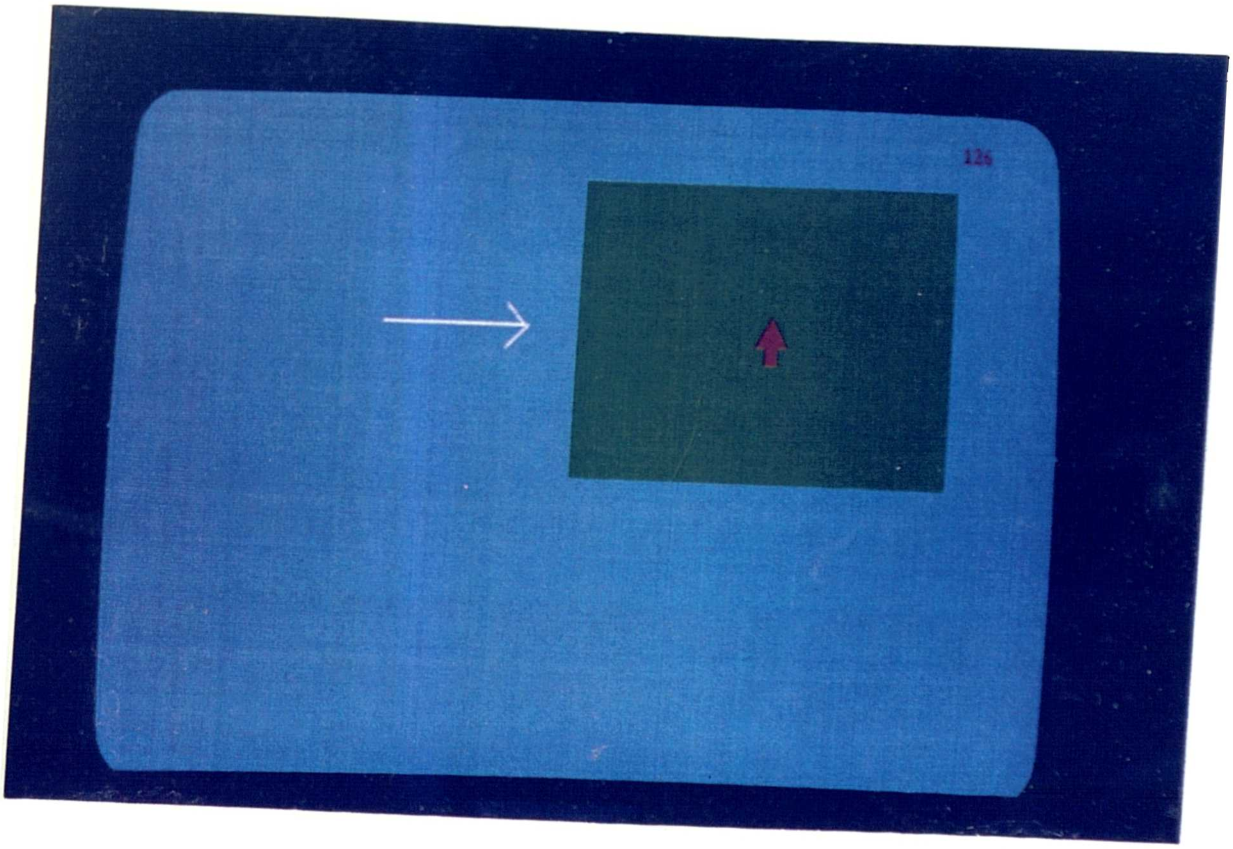


Figure 6.3

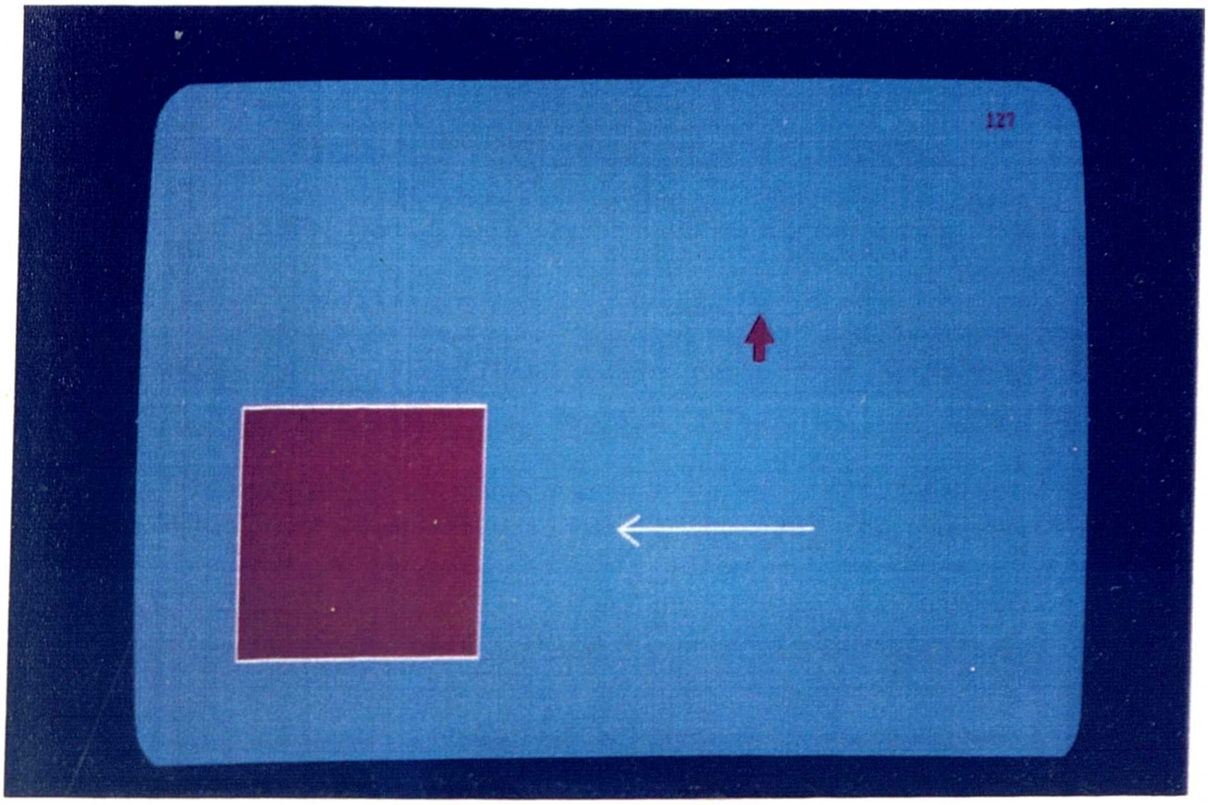


Figure 6.4

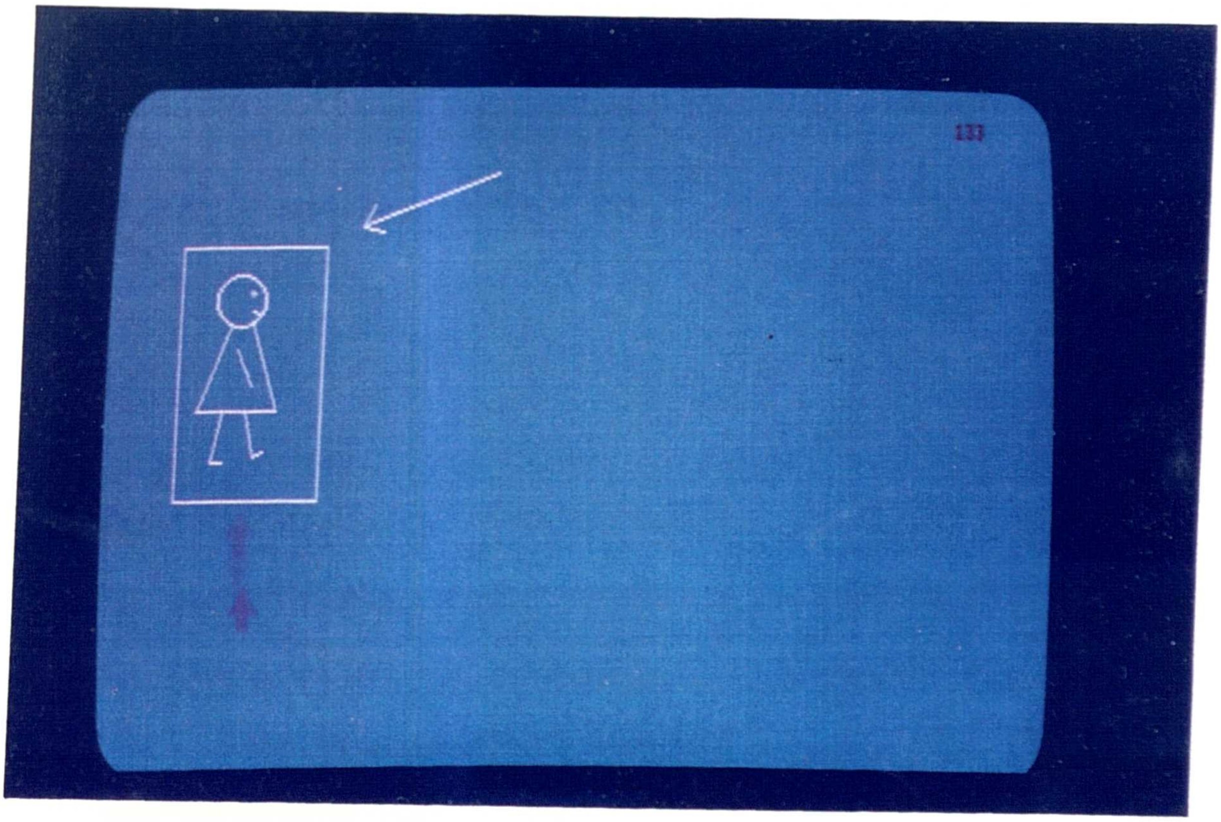


Figure 6.5

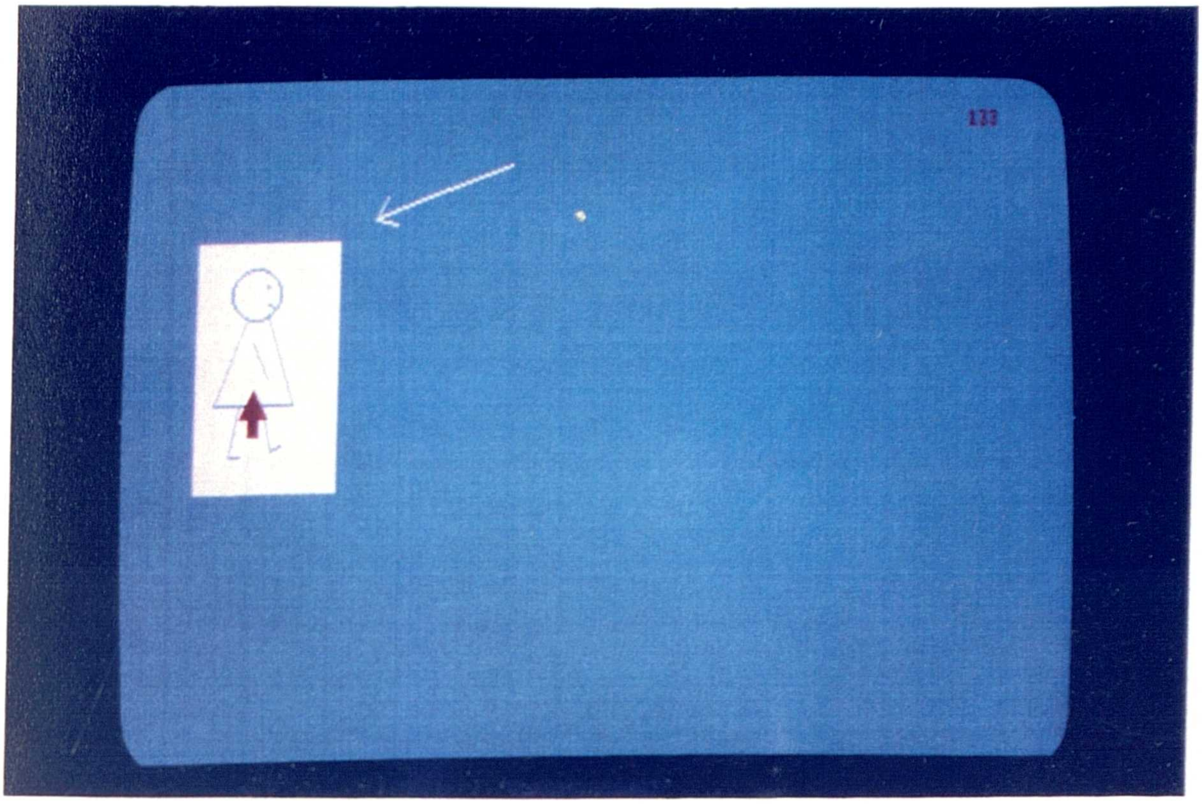


Figure 6.6 Music - S

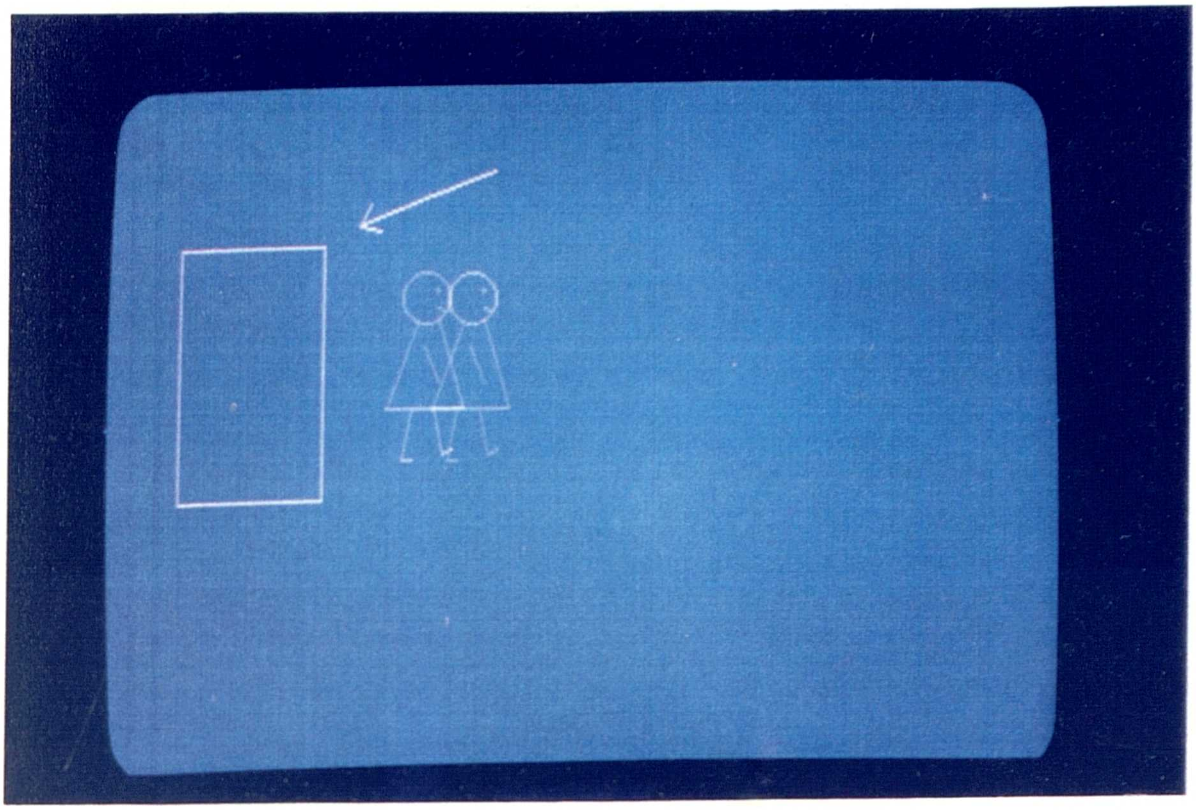


Figure 6.7

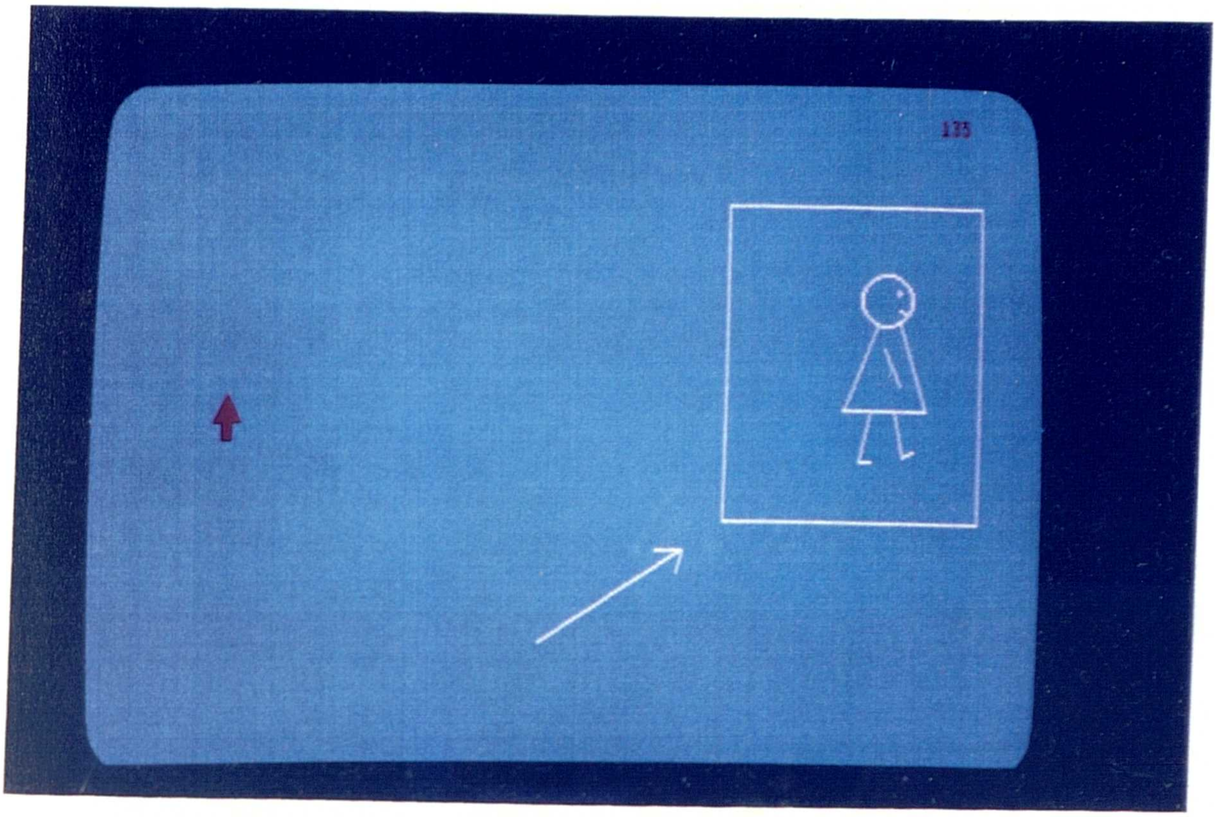


Figure 6.8

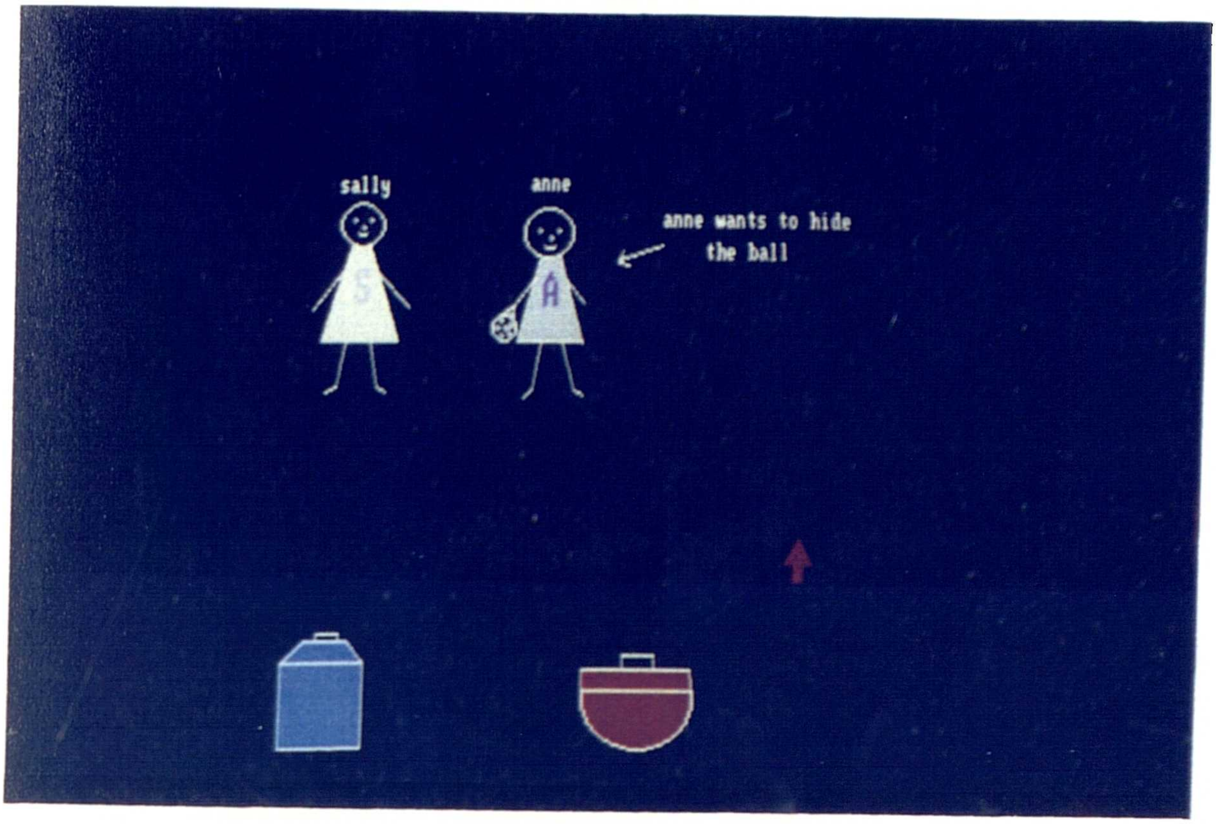


Figure 6.9

Music - P

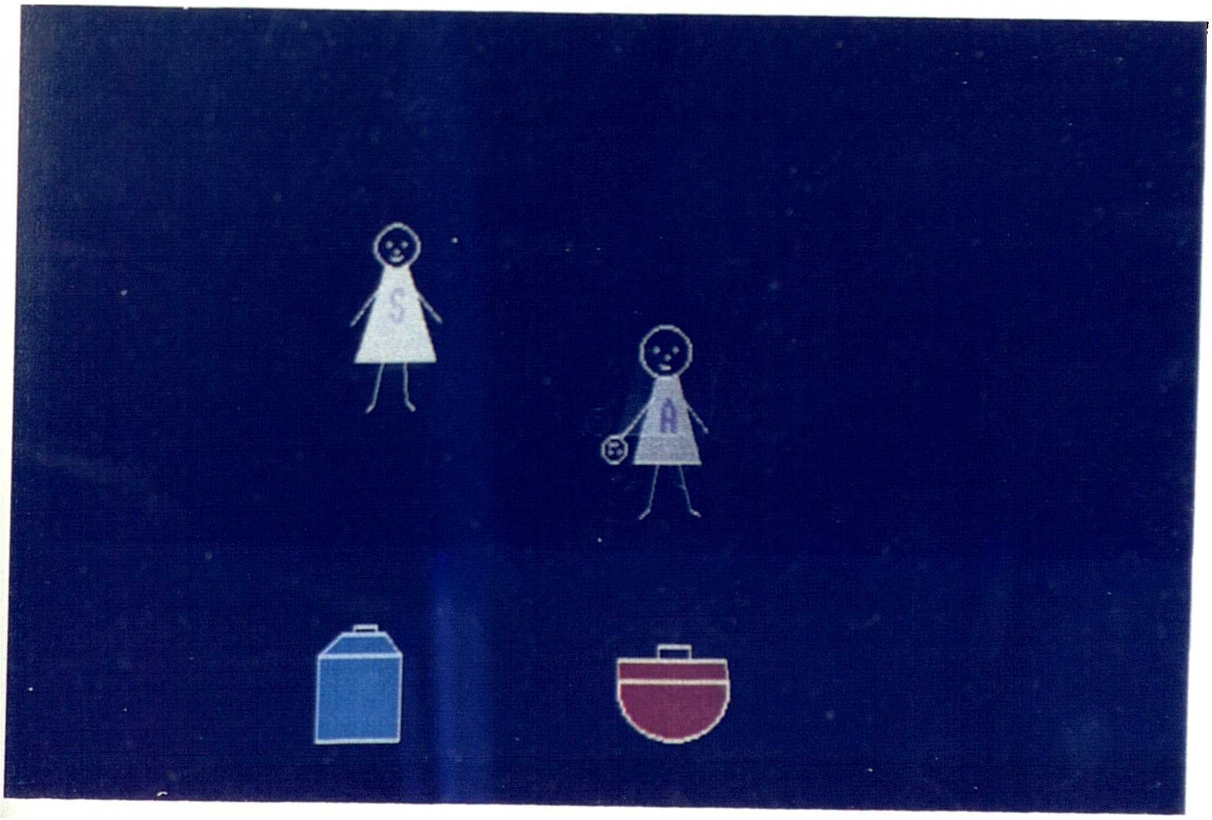


Figure 6.10

Figure 6.11

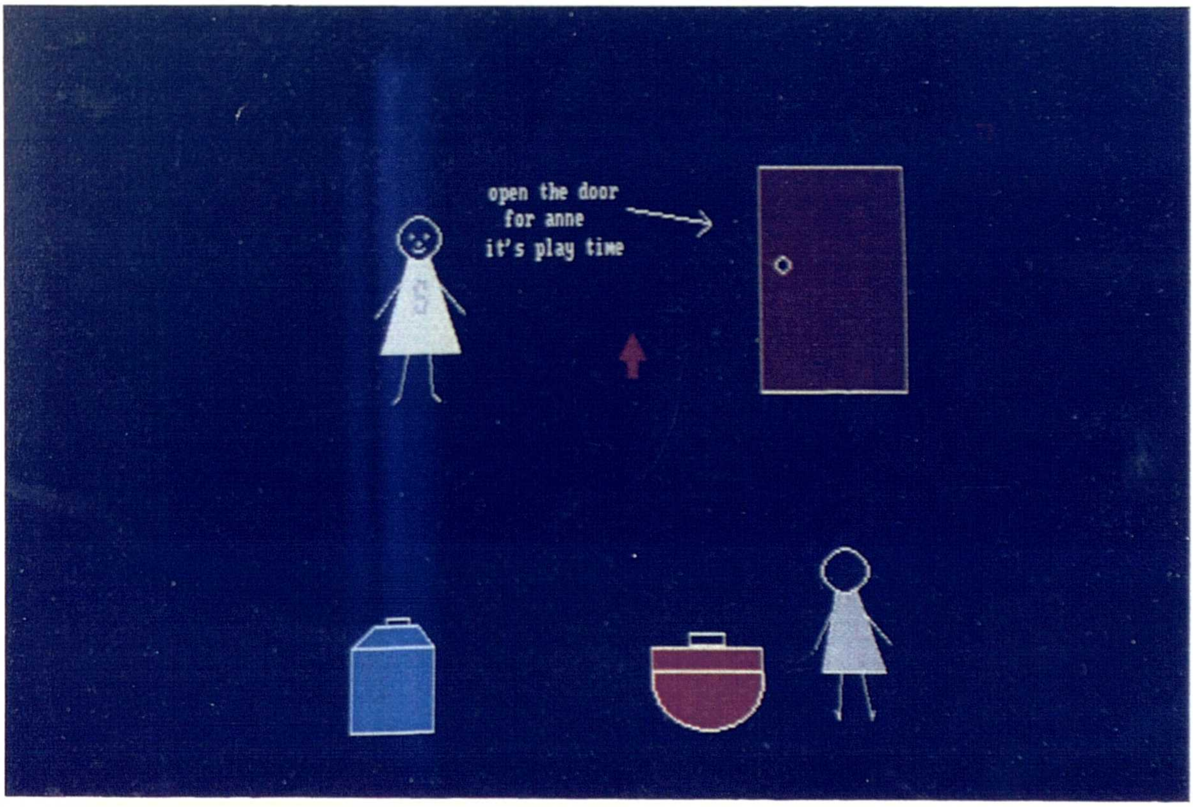


Figure 6.12

Music - G

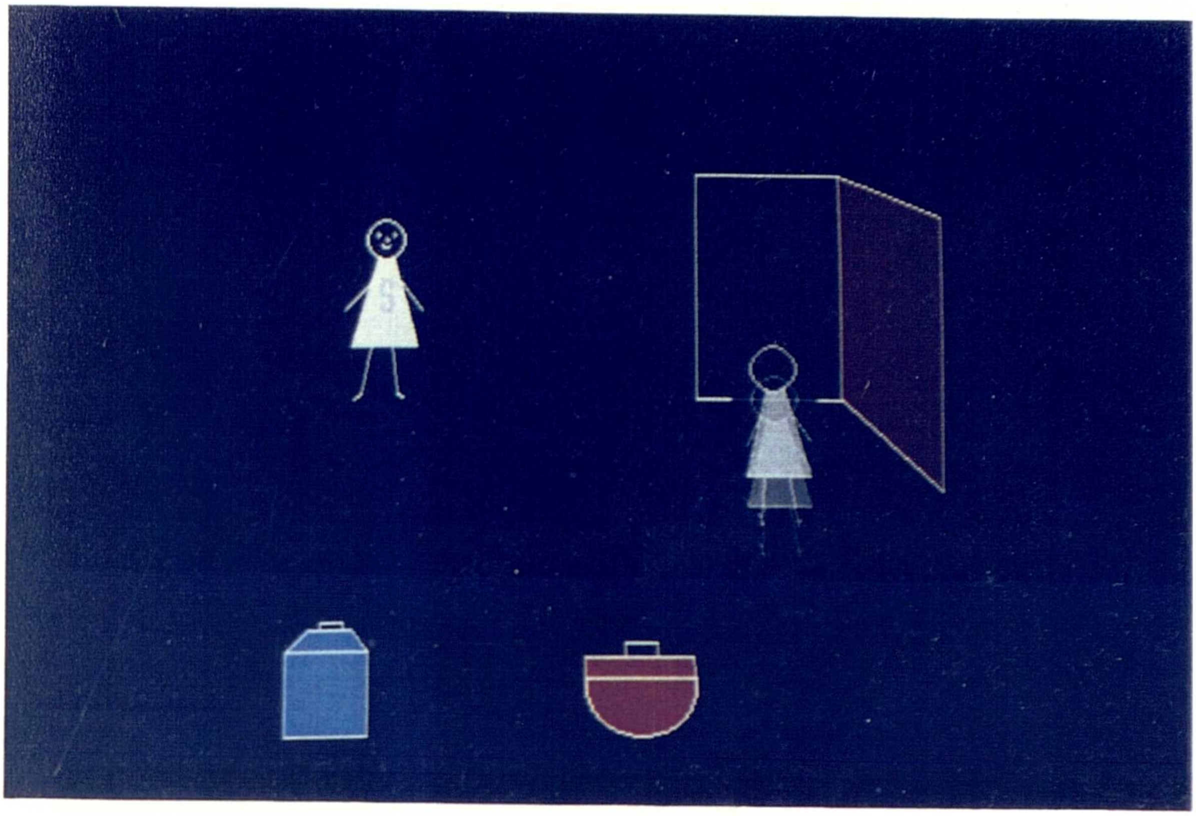
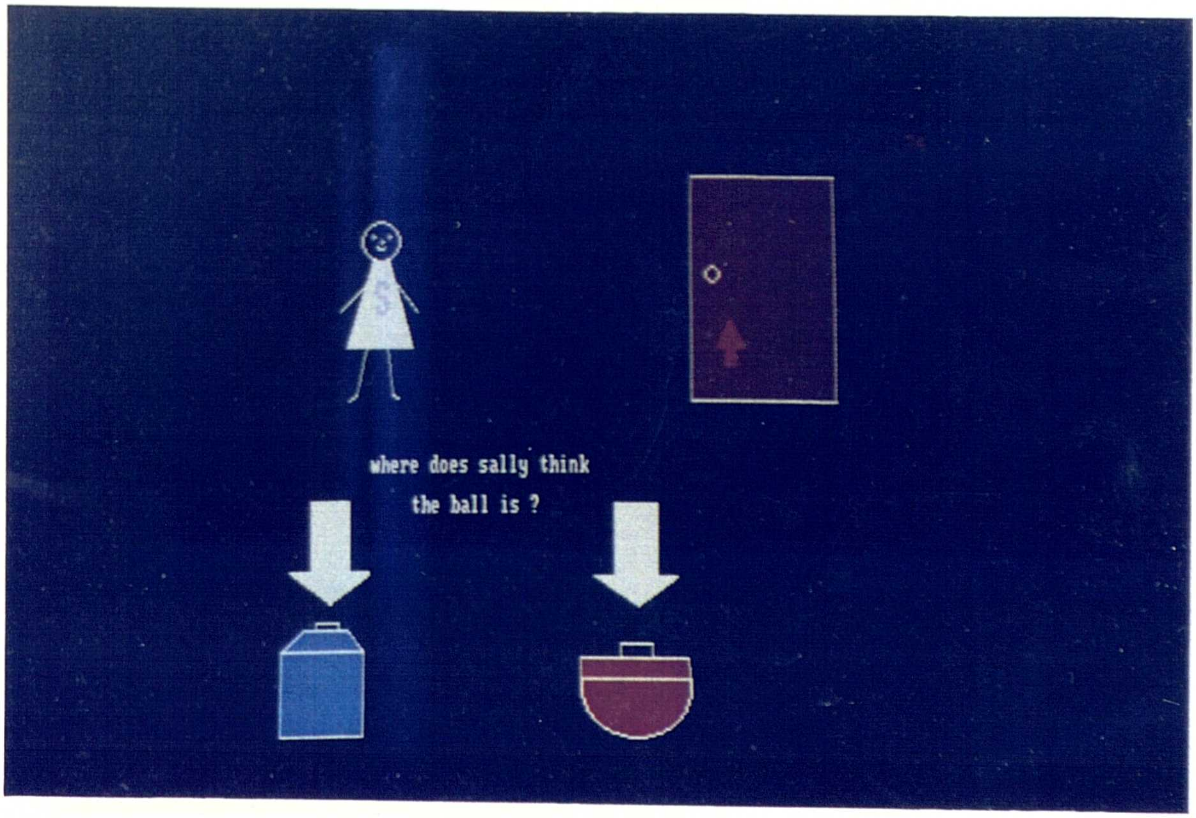


Figure 6.13



The key to the music used throughout this program is shown alongside the photographs. There is some consistency to the choice of music used which holds throughout the false-belief games. "Sally's" movements are accompanied by the "Bod theme", "Anne's" movements by the "Pink Panther theme" and the music to "Girls and boys go out to play" accompanies a character leaving.

This small selection of photographs illustrates the colour and movement that it has been possible to include in the computer games. They also show how simple, easily distinguishable shapes and characters have been used for the games. The main emphasis in writing the programs was to create an interface that was easy to understand and also easy to use.

In order to display as many of these screens as possible when describing the computer games we will illustrate using small black and white photocopies of the screens for the remainder of the thesis.

CHAPTER 7

EXPERIMENT 1.

INTRODUCTION

In Chapter 5 we described the aims of the first experiment. Briefly, these can be listed as follows:-

a) To examine understanding of false-belief in autistic, Down's Syndrome and normal children using a revised version of the false-belief task, with alterations made to the task used by Baron-Cohen et al (1985).
b) To examine false belief in the same groups of children using computer versions of the task.
c) To gather information about the child's handling of the computer interface during the training program and the computer tasks.

We are interested in the hypothesis that failure on the false-belief task can be predicted by clinical type. Baron-Cohen et al (1985) found that autistic children failed the false-belief task whilst Down's Syndrome children and young normal children passed. We will be able to consider alternative hypotheses as to why failure on the false-belief task (Baron-Cohen, 1985) might occur, for example:-

a) It may be due to a deficit in the child's understanding of false-belief (Baron-Cohen et al, 1985).
b) The child may have difficulty with some other aspect of the task, not involving "theory of mind". For example, memory for the events that have taken place. It would be the job of the control questions may identify this.
c) It may be due to the mode of presentation of the task, (ie. the surface form rather than the conceptual nature of the task).
d) It may be due to other factors, such as IQ or Chronological Age.

Using a variety of computer tasks we will be able to differentiate between these possibilities more clearly.

We shall also test the hypothesis that autistic children are well suited to the computer environment (Goldenberg, 1979) and will not experience difficulties with the technology.

Let us consider how the doll presentation of the false-belief task might be revised from its original form (Wimmer and Perner, 1983; Baron-Cohen et al, 1985). Table 5 shows the text for the presentation of the dolls used in this experiment. The alterations made to the text used by Baron-Cohen et al (1985) are underlined.

<u>Table 5. False-belief task - Text</u>

Julie is playing with her ball
Julie decides she wants to go out to play
So she puts her ball away under the basket <u>and she carefully remembers where she puts it , as she might want it later.</u>
<u>(PROMPT)-Where did Julie put the ball?</u>
Julie goes out through the door and out to the playground.
While she is away, Bruce takes the ball from the basket and plays with it.
<u>But, Bruce forgets to put the ball back in the basket and puts it in the box instead.</u>
Then Julie comes back to collect her ball.

<u>Test Question</u>
<u>"Where does Julie think the ball is?"</u>

<u>Control Questions</u>

Reality -	"Where is the ball really?"
Memory 1-	"Where did Julie put the ball in the beginning?"
Memory 2-	<u>"Where did Bruce put the ball?"</u>
Memory 3-	<u>"Where was Julie when Bruce put it there?"</u>
Memory 4-	<u>"So did Julie see Bruce put it there?"</u>

The false-belief procedure used by Baron-Cohen et al (1985) was originally designed by Wimmer and Perner (1983). The alterations that have been made to that task in this experiment are based on changes made by Perner, Leekam and Wimmer (1987), which were used in testing young normal children. These changes focus on three main criticisms of the original design; that failure on the false-belief task could be due to:-

a) Failure to retain essential facts.
b) Failure to understand normal expectations that give rise to false-belief.
c) Pragmatic misinterpretation of the test question.

Let us consider how the "new" text attempts to deal with these factors.

a) Failure to retain essential facts

In order to predict correctly that Julie would mistakenly look in the original location, children must have understood and remembered the relevant facts in the story. In order to examine this, additional memory questions, underlined in the text above, were included as control questions. Memory 2 examines whether the child remembers where Bruce put the ball. Memory 3 examines whether the child remembers that Julie was not present when Bruce moved the ball. Finally, memory 4 examines whether the child realises that since Julie was not present she will not have seen Bruce move the ball to a different location. In other words, this final question assesses the child's "visual perspective taking" ability and hence the child's understanding of the fact that Julie did not see the object being transferred.

If any of these facts are not understood then Julie's false belief cannot be correctly inferred and failure on the test question could be due to memory failure for relevant story facts. We need to ensure that none of these factors leads to failure on the test question before we can claim that a failure was due to a deficit in the child's understanding of false belief.

b) Understanding normal expectations that give rise to false-belief

In order to make the correct belief attribution the child must appreciate the fact that Julie expected the object to stay in its original location. This expectation was made clear in the text with the line "..she carefully remembers where she puts it as she might want it later." The commonsense assumption that once an object has been placed in a particular location it can be expected to remain there, is also made explicit in the text. This is done by explaining that the other character (Bruce) transferred the ball to the new location by mistake ("Bruce forgets to put the ball back in the basket and puts it in the box by mistake"). Finally, it is made explicit, in the text, that the protagonist (Julie) did not witness the transfer of the ball ("Julie is still in the playground and couldn't see where Bruce put the ball.").

We would expect that if the autistic children in the previous experiments (Baron-Cohen et al 1985) failed belief attribution because they did not make the correct assumption about the protagonist's common sense expectation, then an explicit description of this expectation should elicit more correct attributions from the autistic children in this experiment.

c) Pragmatic misinterpretation of the test question.

The test question from the original design of this task (Wimmer and Perner, 1983) used by Baron-Cohen et al (1985) was "Where will Sally look for her marble?". This question may be open to pragmatic misinterpretation. The question may have been taken as a request to help the protagonist to find the object, so the actual question may have been glossed over as meaning "Where should she look....?". It is possible then that the child may see it as his/her role to help the protagonist find the ball. This would lead them to answer the test question incorrectly. In the text used in this experiment, however, the test question has been changed from "Where will Julie look for the ball?" to "Where does Julie think the ball is?" in an attempt to limit the possibilities of misinterpretation.

In comparison to the doll presentation the computer presentation does not have such direct control questions. Instead, the child plays control "games". Each type of game involves different actions for the characters Sally and Anne and requires varying levels of understanding of the component rules of false-belief. A description of the screen components of each game and the rules required to understand each scenario is shown in Table 6.

There are five types of game, but only game E involves an understanding of all the component rules of false-belief; games A, B, C and D act as "control" games. If the child fails on game E we can only say that this is due to a deficit in their understanding of false-belief if he or she has been able to pass similar games, which did not involve false-belief but did involve some of the component rules. In other words, if the child fails false-belief game E for any reason other than a deficit in false-belief understanding, then he or she should also fail one or more of the control games.

Table 6. False-belief program Games - Screen components and rules.

Screen Components	Rules
Games 1 and 2 (Type A)	
Sally hides the ball. Sally leaves then returns. Sally looks for ball	Person is exposed to a situation S1-where person=actor Person will contract belief B1, will remember this and will act upon it.
Games 3 and 4 (Type B)	
Anne hides the ball, Sally watches. Anne leaves. Sally looks for the ball.	Person observes situation S1 where person=actor and contracts belief B1. Person will act on this belief.
Games 5 and 6 (Type C)	
Anne hides the ball, Sally watches. Sally leaves. Sally returns. Sally looks for ball.	Person observes situation S1 where person=actor and contracts belief B1 Person remembers S1, and,returning, will act on belief B1.
Games 7 and 8 (Type D)	
Sally hides the ball, Anne watches. Anne moves the ball, Sally watches. Sally looks for the ball.	Person observes situation S1 where person=actor and contracts belief B1 Person then observes situation S2 and contracts belief B2 and acts on this belief.
Games 9 and 10 (Type E)	
Sally hides the ball, Anne watches. Sally leaves. Anne moves the ball, Sally not present, Sally returns. Sally looks for the ball. will act on this.	Person observes situation S1 where person=actor and contracts belief B1. Situation S2 occurs. Person does not observe S2 and so does not contract belief B2, but retains belief B1 and

In addition to their function as control games, games A to D can also tell us about the child's understanding of the component rules of false belief. It would be interesting, for example, if the children consistently failed one of those games.

METHOD

Subjects

Subjects were 23 autistic children, 17 Down's Syndrome children and 25 clinically normal children.

i). Autistic Subjects

The autistic subjects were attending Storm House School or Thornhill Park School (see Chapter 5 for details). The groups consisted of 16 males and 7 females. This reflects the male:female ratios found in epidemiological studies (Rutter and Schopler, 1987). The Chronological Ages of the autistic children ranged from six years and three months to sixteen years and nine months. All these children had a primary diagnosis of autism according to DSM-III criteria.

ii). Down's Syndrome Subjects

A total of 17 Down's Syndrome children were used in the study, 10 males and 8 females. These subjects were attending either Galtres School or Lidgett Grove School (see Chapter 5 for details). The Chronological Ages of the Down's Syndrome subjects ranged from nine years and four months to eighteen years and three months.

iii). Normal Subjects

There were 25 normal children used in the study, all of whom attended Hobmore Primary School. Chronological Ages ranged from fours years and one month to four years and ten months.

IQ Testing Procedure.

Each child was tested individually in a quite room in the school. Verbal IQ was tested using the British Picture Vocabulary Test and Non-Verbal IQ was tested using the Leiter International Performance Scale (see Chapter 5 for details). Each IQ test took between 30 and 40 minutes to complete , so that two sessions with each child were required.

General Procedure

Each child was tested in one session which lasted for approximately 45 minutes. In that session the child was tested on the false-belief task using two different forms of presentation:-

1. Using dolls in a similar procedure to that used by Baron-Cohen et al (1985), but with added control questions and a more explicit story.
2. Using computer versions of the task.

The order of presentation was counterbalanced, so that, by random selection, half of the children worked with the computer first and then with the dolls and vice-versa.

In addition, computer presentation of the false-belief task was preceded by an introduction to the computer using the training program.

i). Presentation with the dolls

a). Materials

The two dolls used in this presentation were both approximately 15 cm high and had distinctive appearances (eg. different clothing and hair) so that the children had no difficulty distinguishing between them. The basket (brown, measuring 20 cm in diameter and 7 cm in height) and the box (white, length 30 cm, width 16 cm and height 9 cm) were also easily distinguishable. The ball measured 2 cm in diameter and was multi-coloured. Finally, a white partition (length 70 cm and height 45 cm) was used to separate what was referred to in the story as "outside" or "playground" from the area "inside" where the movement of the ball takes place.

b). Procedure.

The experimenter sat next to the child and introduced the two dolls, Julie and Bruce. Before continuing the task, the experimenter checked that the child knew which doll was which and could also distinguish between the basket and the box. The experimenter also explained that beyond the partition Julie would be outside on the playground and could not see inside where the basket and box were. The experimenter then told a set story (see Table 5 for the text), moving the dolls and the ball appropriately. At a crucial point in the story a prompt question was given to ensure that the child was following the events. If the child's response was incorrect at this point then a clue was given and the story retold until the correct answer to the prompt question was given.

At the end of the story when Julie returns to look for her ball, the child is asked a series of questions; the test question followed by five control questions. The experimenter then marked down whether the child's response was correct or incorrect. The responses may be verbal or, in the case of the first three questions, the response may be given by simply pointing to the correct location.

The standard scenario was performed three times, using a different location for the ball on each occasion (the basket, the box and a third location which was the experimenter's pocket). This was done to ensure that the correct responses at the end of each trial were a different location.

ii). Presentation with the computer

Introduction to Procedure

The computer presentation began with a training program which served as an introduction to the interface, teaching the child how to use the mouse and how to work through "games" similar to those used in the false-belief program. None of the children in the study had used a mouse before. This was followed by the group of "games" which formed the main false-belief program.

a) Training program.

Procedure

The child sat next to the experimenter at a table and was told that there were several games to play on the computer. The computer was situated directly opposite the child at the back of the table. Immediately in front of the child was the mouse, surrounded by a red cardboard arrow (see Materials), which could be moved around the table in front of the computer.

The experimenter first moved the arrow and pointed out to the child that there was a similar red arrow on the screen which moved in the same way. The child was then asked to place his or her hand on the arrow and move it around on the table. The movements of the arrow on the screen were pointed out again. The child is then asked to move the arrow over the coloured shapes. From this point onward the child moves the arrow without the aid of the experimenter. As we described in Chapter 6 the training program is designed to be easy to begin with, gradually becoming harder as the child works through the screens, until eventually the child has mastered all the skills necessary to use the main false belief programs.

A flow diagram of the training program screens is shown in figure 7.1 at the end of this section. The photocopies used do not show the colours. However, the photographs used earlier (see Chapter 6) give an indication of the colours used. Figures 6.1 to 6.3 are photographs of screens 1 and 2 and figures 6.4 to 6.7 are photographs of screen 8 and 9. The first four screens of the training program are coloured squares. A character is introduced on screen five. On screen eight clicking the cursor over the character produces an animated sequence where the character moves across the screen. There are several photographs of this animation as we move from screen 8 to screen 9. Only one mouse click is required at the start of the sequence and this is represented in the flow diagram by the arrows between the photocopies. The music which plays following the mouse click is also represented in the flow diagram. Clicking on screen ten produces another animated sequence to screen eleven.

Once the child reaches screen 11 the experimenter asks whether he or she would like to continue this game or play another game. If the child elects to play another game then the cursor is clicked over the square with "restart" written in it and the child will have completed 10 screen clicks in all. However, if the child elects to continue then he or she can work through to screen 13 where again there is an opportunity to stop, or continues further to screen 14 which, as can be seen from the flow diagram "loops" back to screen 10 again. This loop continues until the child indicates that he or she would like to play another game. In this way it was emphasised that the children were free to play what they wanted and stop whenever they wished. It was considered important to stress to the child that this was not an adult-guided activity and, although the experimenter was there to help (or join in the games) if required, the child was in control.

By the end of the training program it was hoped that the child had sufficient understanding of the interface to enable him or her to use the false-belief program, which required mouse control and contained similar components of music and animation of characters. The screens visited and the time spent on each screen were also logged by the computer during the training program. These data should give us an indication of the child's ability to handle the interface.

b) False-belief program

Procedure

In the main program there were five different types of game. Each had a counterpart which differed only in that the ball was originally hidden in the other container, making ten games in all. Each type of game involved different actions for the characters Sally and Anne, and required varying levels of understanding of the component rules of false-belief. A description of the screen components of each game, and the rules required to understand each scenario, is shown in Table 6 (see introduction).

The games were worked through in the following order:-

1. Type E
2. Type A
3. Type B
4. Type C
5. Type D
6. Type E

Flow diagrams of these games are shown in figures 7.2 to 7.6 at the end of this section. Figure 7.2 shows a flow diagram of game type A. The standard text on the screens may be read out by the child or by the experimenter. These text serve as both instructions and indications of what is going on. As with the training program, a white arrow indicates where the active area is. For screen 1 "clicking" the mouse over the character "Sally" causes the character to move across the screen and put the ball into the blue container (see animated sequences). Screen 2 invites the child to "open the door for Sally." and explains that "..it's play time". The child opens the door by "clicking" the mouse over the door, causing the door to open and the character to leave the screen through the door. After a pause of four seconds there is an audible knock on the door and the child is told "Sally wants to come in, open the door for her" (see screen 3). The child "clicks" the mouse over the door and Sally returns to the screen. On the next screen the child is then asked the test question "Where does Sally think the ball is ?" The child must then choose to move the mouse and "click" over the blue container (on the left) or over the red container (on the right). In this case the blue container is the correct choice and Sally will move to the container and retrieve the ball, after which the text "YES, WELL DONE" flashes on the screen. If, however, an incorrect choice was made and the child moved the mouse over the red container (on the left) and clicked, the screen flashes the text "No I won't" and "Try again" and the animated sequence returns to screen 4 and the test question once more.

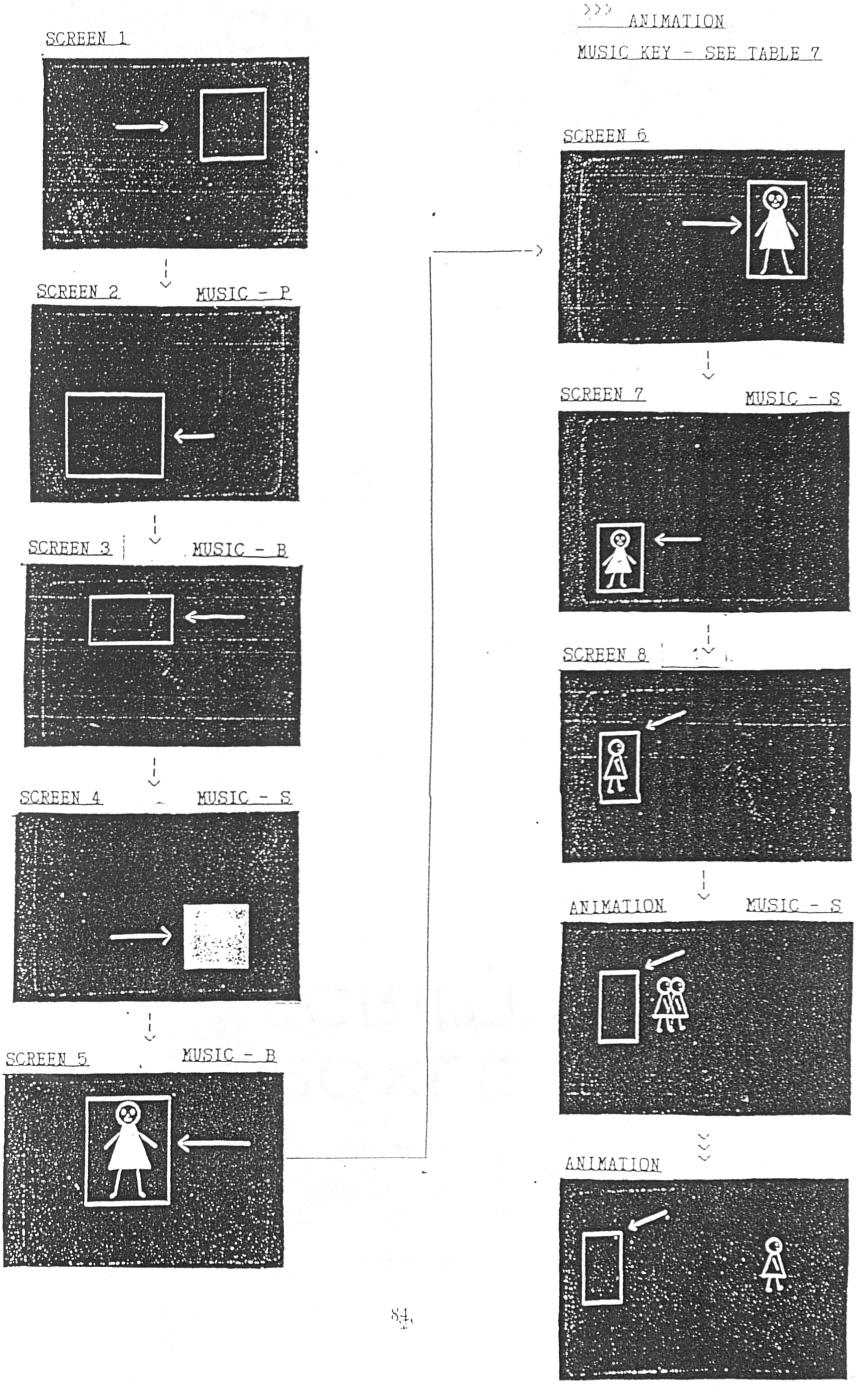
The flow diagram of game type B is shown in figure 7.3. A new character "Anne" is introduced (see figure 6.8). The experimenter first checks that the child can distinguish between these two characters before the child proceeds with the game. Game type C is shown in figure 7.4 and game type D in figure 7.5. The components of these screens are described in table 6. For these figures the flow diagram continues as far as the test question "Where does Sally think the ball is?" As with game type A the correct choice for these games will lead to Sally retrieving the ball with the accompanying music and the text "YES WELL DONE", where as an incorrect choice prompts the child to try again and loops back to the test question screen.

Games Type E (see figure 7.6) requires a full understanding of false-belief in order to answer the final question correctly. In other words, this is the computer equivalent of the false-belief task carried out with the dolls. Once again an incorrect choice here prompts the text "No I won't" and "Try again" and loops back to the test question (not shown in figure 7.6). However, with this game answering the test question correctly does not lead Sally to the ball; instead Sally approaches the container and finds no ball there which is accompanied by the text "The ball is not there anymore", the character Sally stamps her feet and the text "YES WELL DONE" flashes on the screen.

The child was allowed to continue playing the games for as long as he or she wanted and an attempt was made to keep to the order shown above. The only real constraint was that a game could not be repeated immediately. In exceptional cases this "freedom of choice" may have led to some gaps in the data collection, however, this only occurred on a couple of cases, as we shall see from the data later, and almost all the children completed the games in the order shown above with no omissions. Data collected under forced circumstances was considered worthless and disruptive for further experiments. The computer was the child's personal "toy" and not an experimental device that he or she had been "plugged" into.

The computer logged which screens had been selected and also the time spent on each screen. These data could be printed out for analysis.

Figure 7.1 TRAINING PROGRAM



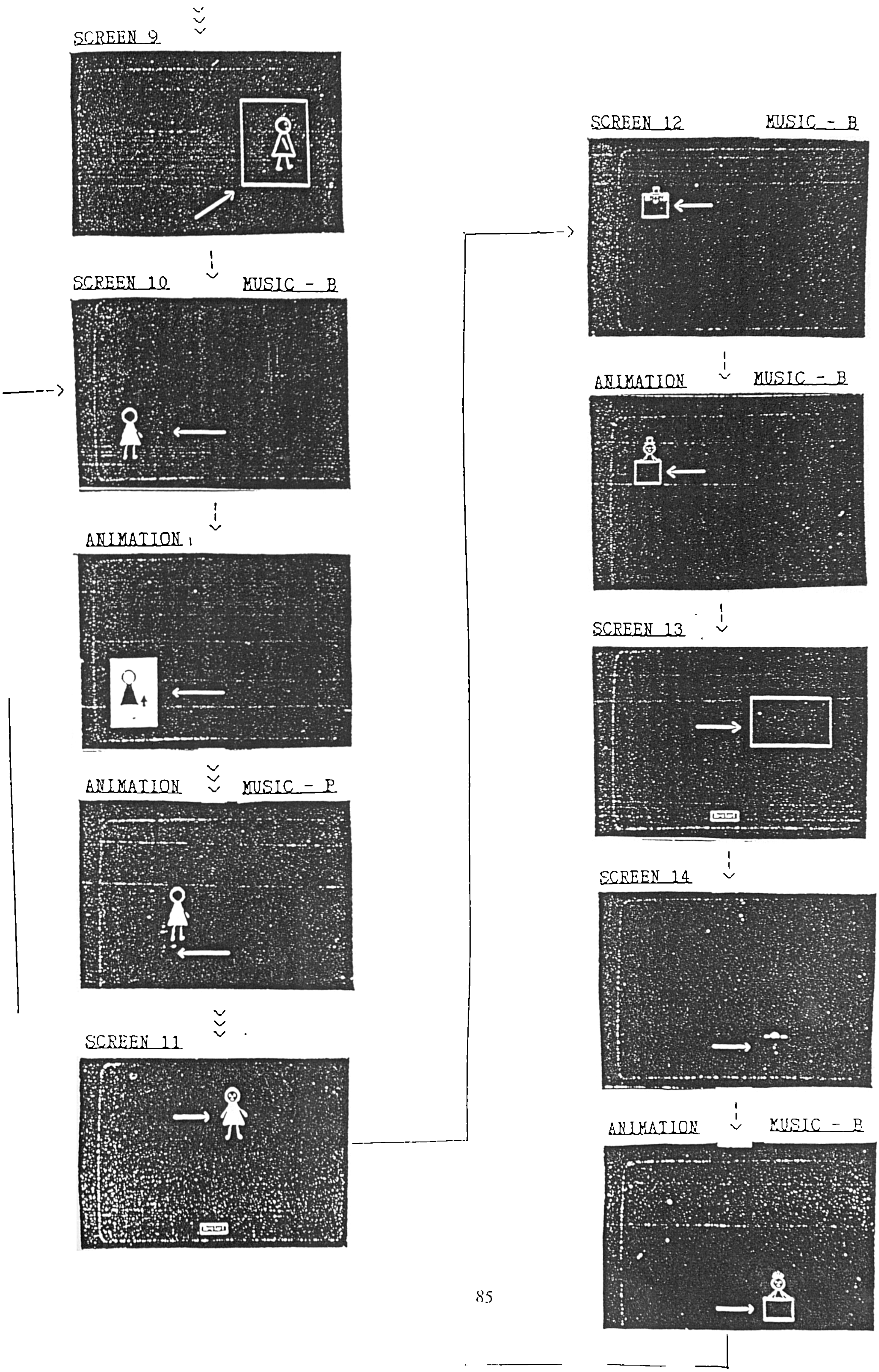

SCREEN 9
SCREEN 10
MUSIC - B
ANIMATION
ANIMATION
MUSIC - P
SCREEN 11
SCREEN 12
MUSIC - B
ANIMATION
MUSIC - B
SCREEN 13
SCREEN 14
ANIMATION
MUSIC - B

Figure 7.2 GAME TYPE A

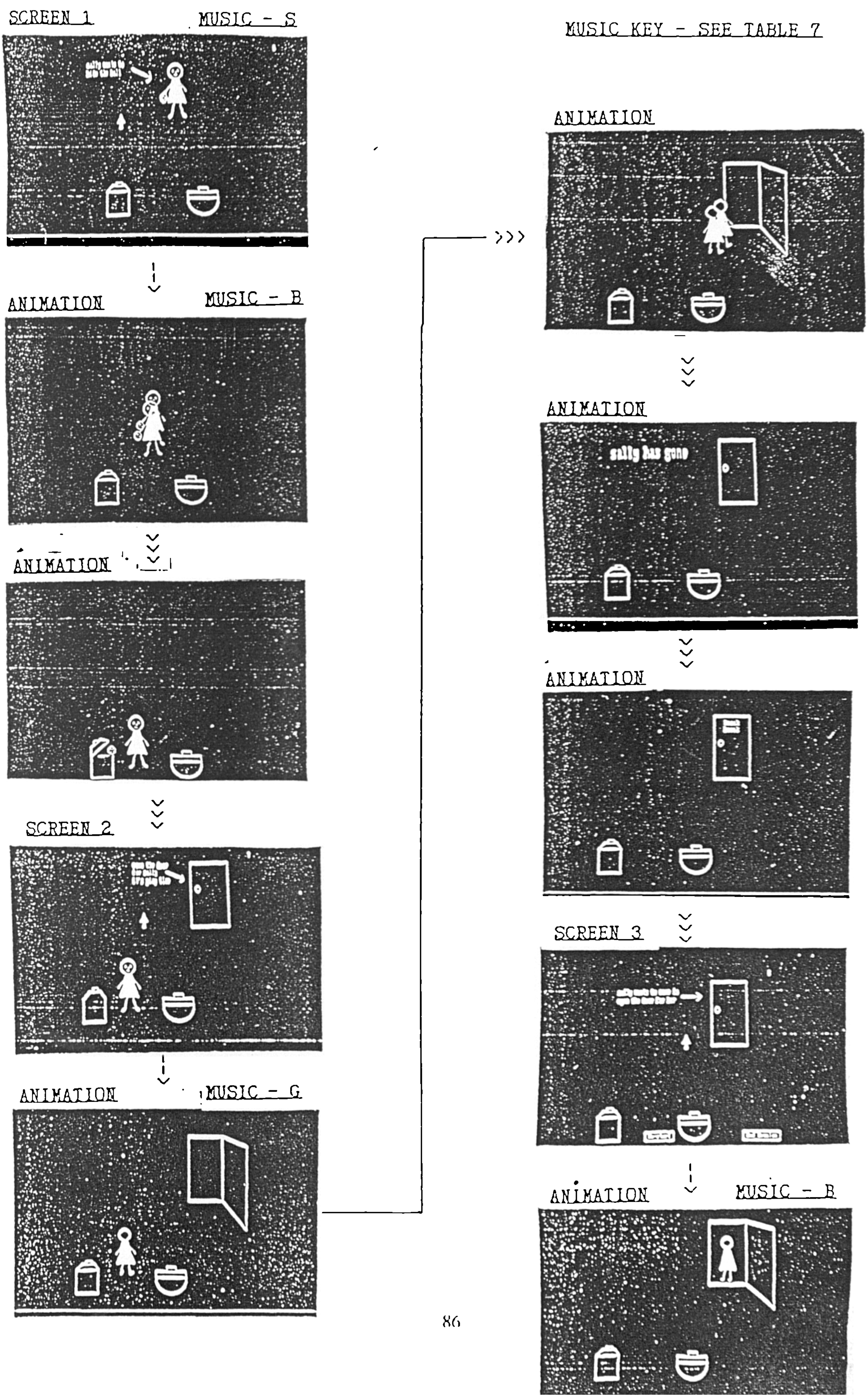
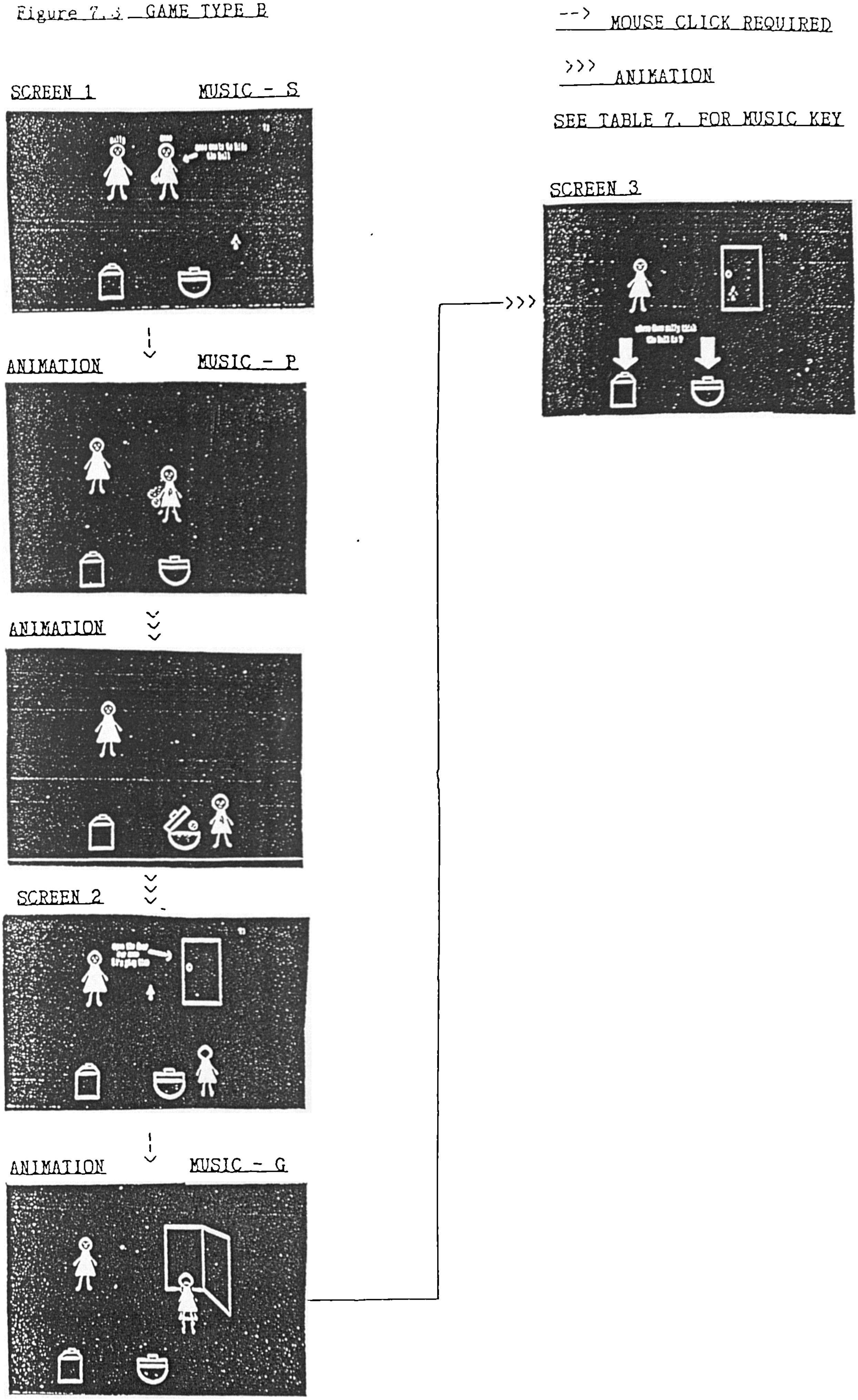


Figure 7.3 GAME TYPE B



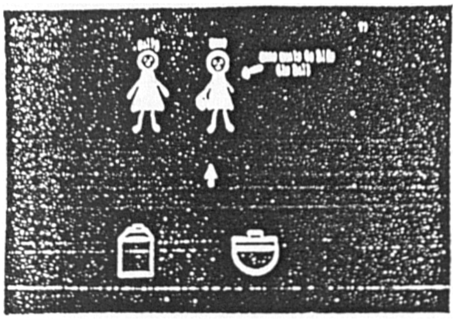
[illegible] GAME TYPE C

- > MOUSE CLICK REQUIRED

>>> ANIMATION

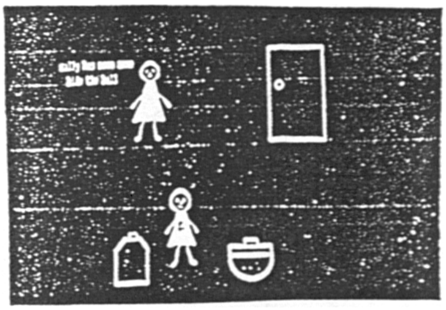
MUSIC KEY - SEE TABLE 7

SCREEN 1 MUSIC - S

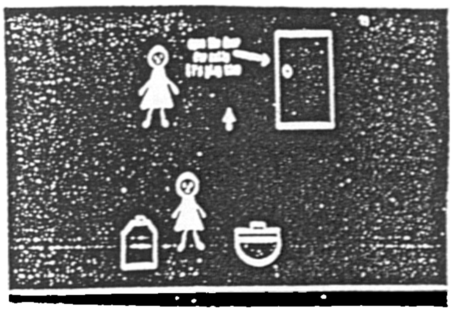


ANIMATION MUSIC - P

ANIMATION

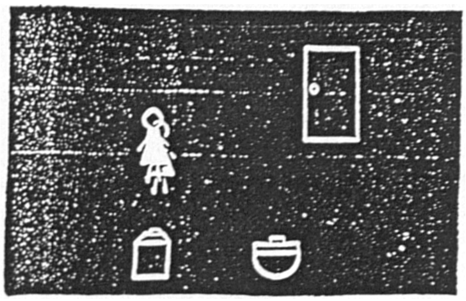


SCREEN 2

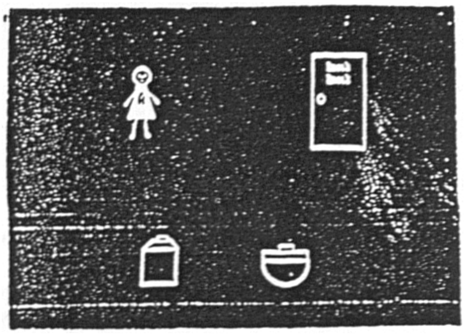


ANIMATION MUSIC - G

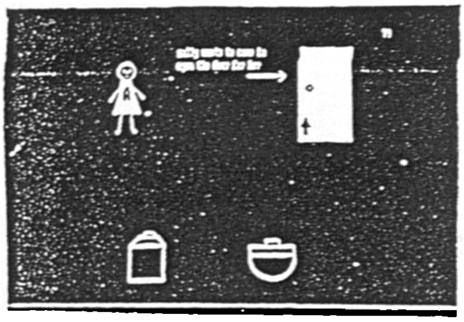
ANIMATION MUSIC - P



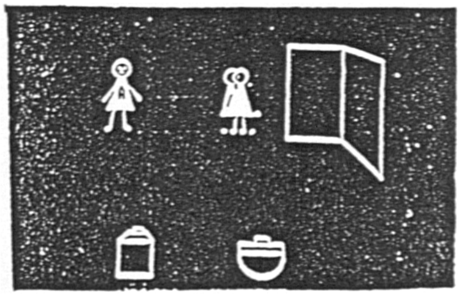
ANIMATION



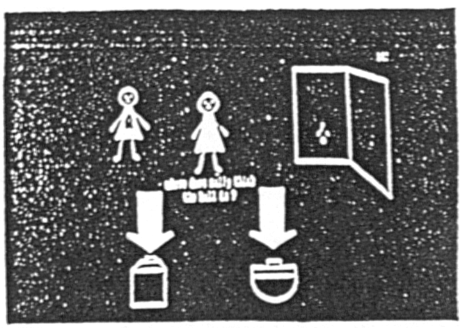
SCREEN 3



ANIMATION MUSIC - B



ANIMATION



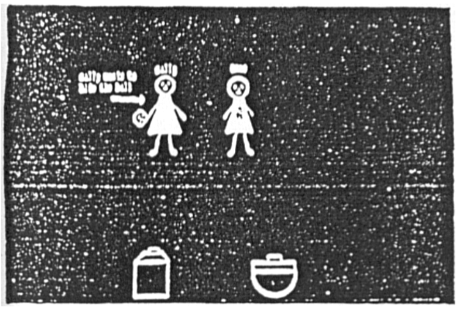
GAME TYPE D

--> MOUSE CLICK REQUIRED

>>> ANIMATION

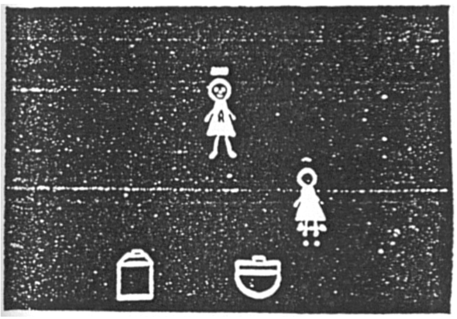
MUSIC KEY - SEE TABLE 7

SCREEN 1 MUSIC - S

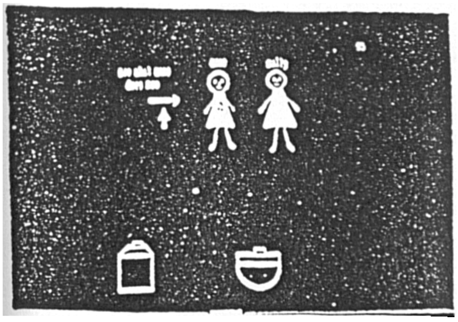


ANIMATION MUSIC - B

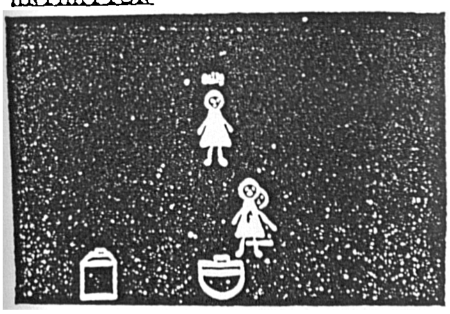
ANIMATION



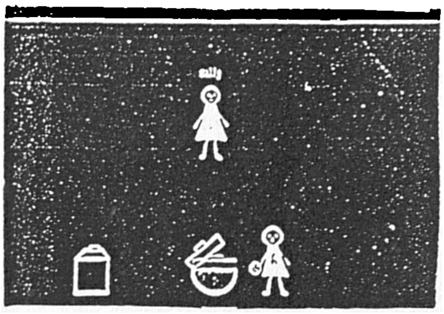
SCREEN 2



ANIMATION MUSIC - P

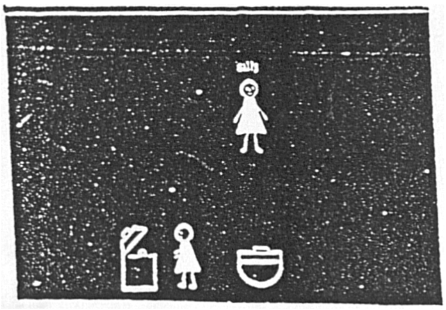


ANIMATION MUSIC - P

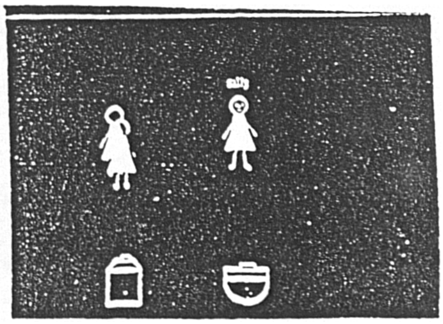


ANIMATION

ANIMATION



ANIMATION



SCREEN 3

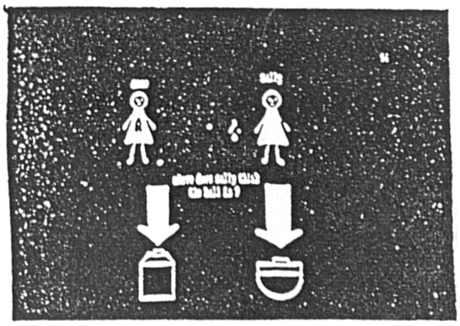
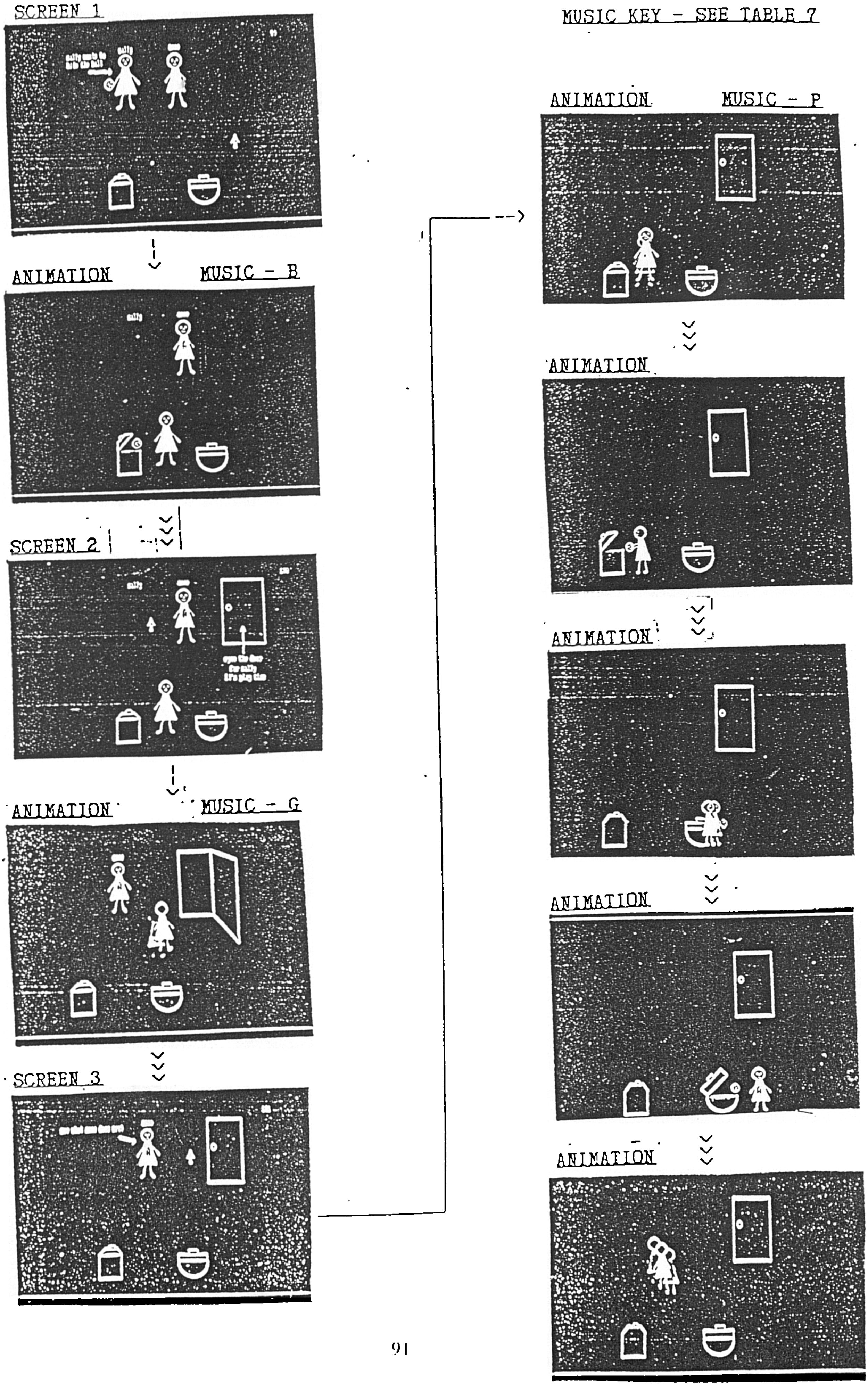


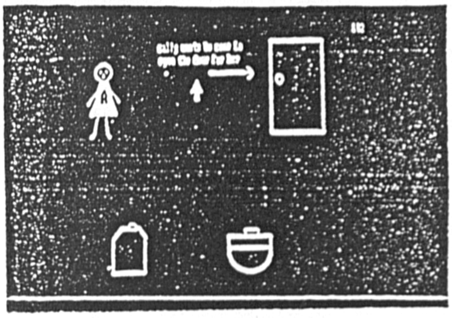
Figure 7.6 GAME TYPE E

>>> ANIMATION

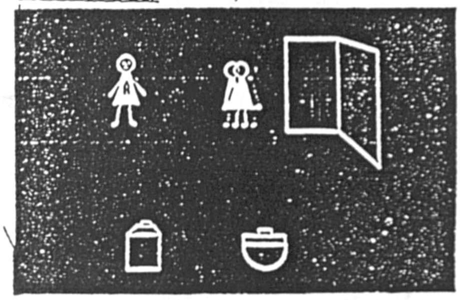
MUSIC KEY - SEE TABLE 7



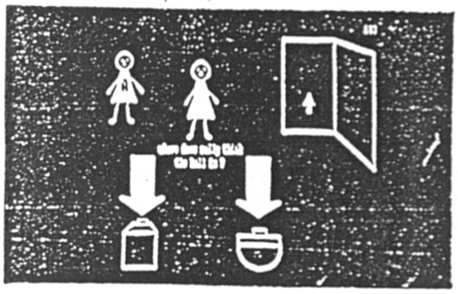
SCREEN 4



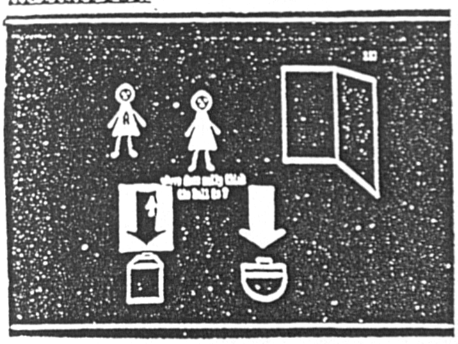
ANIMATION MUSIC - B



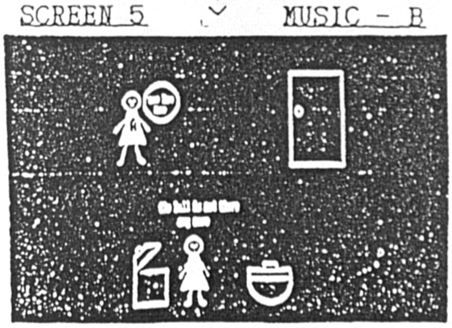
ANIMATION



ANIMATION



SCREEN 5 MUSIC - B



ANIMATION MUSIC - ST

RESULTS

Tables 7 to 11 show the results of experiment 1 for all three groups of subjects. For each group the results of the non-computer presentation are shown in the table headed "Dolls Data" and the results of the computer presentation are shown in the table headed "Computer Data".

For the "Dolls Data" tables the column headings refer to the following:-

Subj Subject (code number).

Response to the task Questions

TQ Test Question-"Where does Julie think the ball is?"

RQ Reality Question-"Where is the ball really?"

M1 Memory Question 1-"Where did Julie put the ball in the beginning?"

M2 Memory Question 2-"Where did Bruce put the ball?"

M3 Memory Question 3-"Where was Julie when Bruce put it there?"

M4 Memory Question 4-"So did Julie see Bruce put it there?"

Chronological Age and Mental Age.

CA-Chronological Age in years and months.

VMA-Verbal Mental Age in years and months.

NVMA-Non-Verbal Mental Age in years and months.

For the "Computer Data" tables the column headings refer to the following:-

Subj Subject (code number)

Computer Games

TQ Response to the Test Question- "Where does Sally think the ball is?" for game type E (requiring understanding of false-belief).

A to D Response to the Test Question- "Where does Sally think the ball is?" for game type A,B,C or D.

Training games

t(s) Total time spent on the training game in seconds.

n.sc. Number of screens visited.

t/d(s) Time per decision on the training game in seconds.

Analysis Strategy

The data will be presented and dealt with in the following way:-

1. Presentation of raw data (tables 9 to 13)
2. Summary data (means for each group etc.)
3. Analyses (Chi squared, t-test, Fisher Exact etc.)

For both the "Dolls Data" and the "Computer Data" tables, responses are represented as follows :-

/ = Correct Response,

0 = Incorrect Response.

In table 7 below, there are three trials with a response to each question for each trial. So, for example, subject A1 made the response ooo for the test question (Test Q); which means that this subject responded incorrectly to that question on the first, second and third trial.

Table 7. Results of Experiment 1. - Autistic Children

Dolls Data

	Task Questions						Age and Mental Age		
Subj	TQ	RQ	M1	M2	M3	M4	CA	VMA	NVMA
A1	000	///	///	///	///	///	13:6	7:2	6:7
A2	000	///	///	///	///	///	13:8	7:11	6:5
A3	///	///	///	///	///	///	13:0	8:7	14:6
A4	000	///	000	000	///	000	14:6	6:5	4:3
A5	000	///	00/	///	0//	000	16:0	7:4	6:3
A6	///	///	///	///	///	///	9:8	10:4	7:8
A7	000	///	///	///	///	///	6:3	3:7	5:10
A8	000	///	///	///	///	///	10:4	5:5	8:6
A9	000	///	0//	///	///	000	10:0	5:6	7:8
A10	///	///	///	///	///	///	16:0	15:4	12:10
A11	///	///	///	///	///	///	16:2	16:7	16:10
A12	000	///	000	000	///	000	12:5	5:6	5:7
A13	000	///	///	///	///	///	13:1	7:9	6:10
A14	000	///	000	000	000	000	8:3	5:0	5:3
A15	0/0	///	000	///	///	000	9:6	4:10	5:6
A16	000	///	///	///	///	///	16:9	10:1	16:11
A17	000	///	///	///	///	///	16:1	7:7	10:9
A18	000	000	000	000	000	000	16:4	7:0	9:2
A19	000	000	000	000	000	000	14:4	6:2	7:4
A20	000	///	///	///	///	///	14:1	8:5	10:5
A21	000	///	///	///	///	///	14:7	7:4	10:6
A22	///	///	///	///	///	///	14:8	8:6	9:3
A23	000	///	///	///	///	///	16:1	11:5	9:4

Table 8. Results of Experiment 1. Autistic Children

Computer data

Subj	TQ	A	B	C	D	t(m/s)	n.sc.	t/d(s)
A1	000	/	/	0	0	264	10	26.4
A2	00/	/	/	/	0	273	10	27.3
A3	//	/	/	/	/	180	12	15.0
A4	000	0	/	/	0	359	10	35.9
A5	/0	0	0	0	0	140	10	14.0
A6	//	/	/	/	/	150	12	12.5
A7	00	/	/	/	/	155	10	15.5
A8	000	/	/	/	/	261	10	26.1
A9	00	/	/	/	/	225	10	22.5
A10	/	/	/	/	/	190	10	19.0
A11	/	/	/	/	/	196	10	19.6
A12	0	/	0	/	/	237	10	23.7
A13	000	/	/	/	/	160	10	16.0
A14	000	/	/	/	/	451	10	45.1
A15	0/0	/	/	/	/	422	10	42.2
A16	/0	/	/	/	/	228	10	22.8
A17	000	/	/	/	/	291	10	29.1
A18	000	/	/	/	/	257	10	25.7
A19	000	/	/	/	/	185	10	18.5
A20	000	/	/	/	/	226	10	22.6
A21	00	/	/	/	/	789	22	35.9
A22	/	/	/	/	/	237	10	23.7
A23	000	/	/	/	/	322	12	26.8

Table 9. Results of Experiment 1. - Down's Syndrome Children

Dolls Data

	Task Questions						Age and Mental Age		
Subj	TQ	RQ	M1	M2	M3	M4	CA	VMA	NVMA
D1	///	///	///	///	///	///	16:9	10:3	5:2
D2	///	///	///	///	///	///	16:5	8:6	6:3
D3	///	///	///	///	///	///	14:1	7:7	4:11
D4	000	///	///	///	/00	/00	14:9	6:6	6:2
D5	///	///	///	///	///	///	14:10	6:10	4:9
D6	000	///	///	///	0/0	00/	18:3	9:6	4:0
D7	///	///	///	///	///	///	17:2	9:7	4:4
D8	///	///	///	///	///	///	16:9	7:9	5:0
D9	000	///	///	000	000	000	11:3	5:2	3:3
D10	000	///	///	///	///	///	15:0	7:6	4:10
D11	///	///	///	///	///	///	11:4	5:11	4:6
D12	///	///	///	///	///	///	11:2	6:0	4:2
D13	000	///	///	000	000	000	10:9	4:4	4:1
D14	000	///	///	///	///	///	15:2	8:1	5:2
D15	///	///	///	///	///	///	15:8	8:0	5:2
D16	///	///	///	///	///	///	13:2	6:4	4:6
D17	///	///	///	///	///	///	9:4	5:6	3:9

Computer Data

Subj	TQ	A	B	C	D	t(m/s)	n.sc.	t/d(s)
D1	//	/	/	/	/	236	10	23.6
D2	///	/	/	/	/	220	10	22.0
D3	//	/	/	/	/	259	10	25.9
D4	000	/	/	/	/	230	10	23.0
D5	//	/	/	/	/	279	10	27.9
D6	/0	/	/	/	/	285	10	28.5
D7	//	/	/	/	0	325	10	32.5
D8	//	/	/	/	/	165	10	16.5
D9	00	/	/	/	0	189	10	18.9
D10	00	0	/	/	/	221	10	22.1
D11	//	/	/	/	/	165	10	16.5
D12	//	/	/	/	0	221	10	22.1
D13	00	0	/	/	/	316	10	31.6
D14	//	/	/	/	/	205	10	20.5
D15	//	/	/	/	/	185	10	18.5
D16	//	/	/	/	/	296	14	29.6
D17	//	/	/	/	/	239	10	23.9

Table 10. Results of Experiment 1. - Clinically Normal Children

Dolls Data

	Task Questions						Age and Mental Age		
Subj	TQ	RQ	M1	M2	M3	M4	CA	VMA	NVMA
N1	///	///	///	///	///	///	4:1	5:1	5:1
N2	///	///	///	///	///	///	4:9	6:7	5:10
N3	///	///	///	///	///	///	4:9	5:5	5:5
N4	///	///	///	///	///	///	4:10	5:10	5:11
N5	///	///	///	///	///	///	4:7	5:8	5:6
N6	000	///	///	///	///	///	4:9	4:7	4:11
N7	///	///	///	///	///	///	4:10	4:10	4:6
N8	///	///	///	///	///	///	4:9	5:0	5:0
N9	///	///	///	///	///	///	4:7	5:7	5:9
N10	///	///	///	///	///	///	4:7	5:7	5:8
N11	///	///	///	///	///	///	4:7	5:6	5:1
N12	///	///	///	///	///	///	4:10	5:3	5:10
N13	///	///	///	///	///	///	4:10	5:3	5:10
N14	///	///	///	///	///	///	4:9	6:1	6:1
N15	///	///	///	///	///	///	4:7	4:9	5:1
N16	00/	///	///	///	///	///	4:8	5:1	5:1
N17	///	///	///	///	///	///	4:10	5:5	6:2
N18	///	///	///	///	///	///	4:3	5:11	5:11
N19	///	///	///	///	///	///	4:10	5:11	5:11
N20	000	///	///	///	///	///	4:7	4:4	5:1
N21	///	///	///	///	///	///	4:7	4:7	5:11
N22	///	///	///	///	///	///	4:8	5:3	5:3
N23	///	///	///	///	///	///	4:7	5:4	4:5
N24	///	///	///	///	///	///	4:7	5:4	5:9
N25	///	///	///	///	///	///	4:8	4:5	4:4

Table 11. Results of Experiment 1. Clinically Normal Children

Computer data

Subj	TQ	A	B	C	D	t(m/s)	n.sc.	t/d(s)
N1	/	/	/	/	/	265	10	26.5
N2	/	/	/	/	/	212	10	21.2
N3	/	/	0	/	/	174	10	17.4
N4	/	/	/	/	/	183	10	18.3
N5	/	/	/	/	/	134	10	13.4
N6	/	/	/	/	/	206	10	20.6
N7	/	/	/	/	/	237	10	23.7
N8	/	/	/	/	/	157	10	15.7
N9	/	/	/	/	/	180	10	18.0
N10	/	0	/	/	/	203	10	20.3
N11	/	/	/	/	/	257	10	25.7
N12	/	/	/	/	/	237	10	23.7
N13	/	/	/	/	/	244	10	24.4
N14	/	/	/	/	/	193	10	19.3
N15	/	/	/	/	/	184	10	18.4
N16	0	/	/	0	0	197	10	19.7
N17	/	/	/	/	/	219	10	21.9
N18	/	/	/	0	/	164	10	16.4
N19	/	/	/	/	/	190	10	19.0
N20	0	0	/	0	/	212	10	21.2
N21	/	/	/	/	/	181	10	18.1
N22	/	/	/	/	/	236	10	23.6
N23	/		/		0	220	10	22.0
N24	/	/	/	/	/	200	10	20.0
N25	/	/	/	/	/	201	10	20.1

Details of the mean IQ scores and Chronological Ages of the three groups are shown below in Table 12.

Table 12. IQ scores and Chronological Ages of the three groups

Gp	n		CA (y:m)	Verbal IQ (BPVS)	Non-Verbal IQ (Leiter)
A	23	Mean	13:3	60	67.4
		SD	2:11	18.2	21.5
		Range	6:3-16:9	43-107	29-112
D	17	Mean	14:3	50.8	33.2
		SD	2:8	5.4	4.9
		Range	9:4-18:3	40-61	22-40
N	25	Mean	4:8	113.6	116.3
		SD	0:2	12.0	11.8
		Range	4:1-4:10	95-139	93-139

Key for Table 12. (and Table 13. below)
A - Autistic
D - Down's
N - Normal
Gp - Group
CA - Chronological Age
y:m - years:months

Pairwise comparisons were carried out on these data using analysis of variance, further analysis was then carried out using Tukey's HSD test.

Chronological Age Comparisons

Pairwise comparison of Chronological Ages for the three groups, using analysis of variance, revealed a significant effect ($F(2,62)=130.15$, $p<.001$). Further analysis of this effect using Tukey's HSD showed that the autistic children and the Down's Syndrome children were significantly older than the normal children, and that the difference in Chronological Age between the Down's Syndrome children and the autistic children did not reach significance (HSD=19.6).

Verbal IQ Comparisons

Pairwise comparisons of the Verbal IQ's for the three groups, using analysis of variance, showed a significant effect ($F(2,62)=144.88$, $p<.001$). Further analysis of this effect using Tukey's HSD showed that the normal children had a significantly higher mean Verbal IQ than the autistic children and the Down's Syndrome children. The Verbal IQ of the autistic children was slightly higher than that of the Down's Syndrome children, but this difference was not found to be significant (HSD=9.9).

Non-Verbal IQ Comparison

Pairwise comparisons of the Non-Verbal IQ's for the three groups, using analysis of variance showed a significant effect ($F(2,62)=163.78$, $p<.001$). Further analysis using Tukey's HSD revealed that the mean Non-Verbal IQ was significantly higher for the normal children than for the autistic and Down's Syndrome children, and that the autistic children had a significantly higher mean Non-Verbal IQ than the Down's Syndrome children (HSD=11.1).

Details of the mean Verbal Mental Ages and the mean Non-Verbal Mental Ages of the three groups are shown in Table 13.

Table 13. Mean Mental Ages (MA)

Gp	n		Verbal MA (y:m)	Non-Verbal MA (y:m)
A	23	Mean	8:0	8:11
		SD	3:2	3:7
		Range	3:7-16:8	4:3-16:11
D	17	Mean	7:2	5:6
		SD	1:9	1:5
		Range	4:4-10:3	3:3-8:1
N	25	Mean	5:4	5:5
		SD	0:7	0:6
		Range	4:4-6:7	4:4-6:2

Verbal Mental Age Comparisons

Pairwise comparisons of the Verbal Mental Ages of the three groups, using analysis of variance, showed a significant effect ($F(2,62)=10.38$, $p<.001$). Further analysis using Tukey's HSD showed that the normal children had a significantly lower mean Verbal Mental Age than both the autistic children and the Down's Syndrome children (HSD=18.6).

Non-Verbal Mental Age Comparisons

Pairwise comparisons of the Non-Verbal Mental Ages of the three groups, using analysis of variance, showed a significant effect ($F(2,62)=17.65$, $p<.001$). Further analysis using Tukey's HSD showed that the autistic children had a significantly higher mean Non-Verbal Mental Age (NVMA) than both the Down's Syndrome children and the normal children. There was no significant in NVMA between the Down's Syndrome and the normal children (HSD=23.5).

Discussion of IQ results.

The Down's Syndrome group was slightly older than the autistic group, although this difference did not reach statistical significance. This matching of Chronological Ages was what we set out to achieve from the comparison group.

The autistic group had a higher mean Non-Verbal IQ and Non-Verbal Mental Age, than the Down's Syndrome group. However, this difference was only statistically significant for the Non-Verbal measures.

The higher IQ and Mental Age means for the Down's comparison group was not considered to be problematic since in fact it adds to the power of the comparison group. If the performance of the Down's Syndrome children is better on the experimental tasks than the autistic children then we can rule out IQ as an explanation, since performance was superior despite a lower mean IQ.

Comparing the autistic group with the normal children (comparison group), it was found that the autistic group had a significantly higher mean

Verbal Mental Age and Non-Verbal Mental Age. Again, this difference is not a problem since it is the autistic group with the higher mean Mental Age scores which increases the power of the comparison group.

Finally, since the individual Mental Ages of each of the subjects has been obtained, this will enable us to make within-group comparisons between Mental Age and performance on the tasks.

A number of comparisons can be made from the results concerning the training program and the understanding of false-belief as measured by conventional procedure and by computer games. The remainder of this section then will be divided into a number of parts addressing these issues.

i). Computer Training Program

Table 14 shows the total time spent on the training program and the time per decision (ie average time spent on each screen), for the three groups of subjects.

Table 14. Time spent on the Training program

Group	n		Total time (seconds)	Time per dec. (seconds)
Autistic	23	Mean	265	24.6
		SD	141	8.6
		Range	140-789	14.0-45.1
Down's	17	Mean	237	23.7
		SD	50	5.0
		Range	185-325	16.5-32.5
Normal	25	Mean	203	20.3
		SD	32	3.1
		Range	134-265	13.4-26.5

Pairwise comparisons were carried out using analysis of variance, comparing the total training times for each of the three groups and also comparing the time per decision on the training program for each group.

Total training time comparisons

Pairwise comparisons using analysis of variance revealed no significant differences between the three groups in total time spent on the training program ($F(2,62)=2.84$, $p<.05$)

Time per decision

There was also no significant difference between the three groups in the time per decision (time spent on each screen) on the training program ($F(2,62)=3.28$, $p<.05$)

Discussion

The Autistic and the Down's groups tended to spend longer on the training program and make slower decisions than the normal controls. However, analysis of variance revealed that this difference was not significant.

Although the autistic children as a group were calculated to have a much greater mean total training time than the other two groups, this could be explained by one particular subject (A21) who had spent considerably more time on the training program than any of the other subjects. Without this subject, the mean total time for the autistic group is 245 seconds.

We can conclude from these results then, that the autistic children, although they may have been slightly slower on the training program than the normals, did not have any special difficulty handling the computer interface. Any differences between the autistic group and the other two groups in their performance on the computer tasks could not be attributed to an inability to use the computer.

It is sufficient at this point, to be satisfied that none of the children failed to be able to use the mouse and, as a preliminary observation, the mechanics of the computer environment seem to present no problems for any of the subjects.

ii) Performance on the False-Belief Tasks

Doll Presentation

Table 15 below shows the number of children from each group who either passed or failed the test question of the false belief task given that they had passed all the control questions.

Those children who failed any one of the control questions are not considered in this analysis; therefore when we refer to "failing the false-belief task" we mean that the subject has failed the test question despite passing all the control questions.

Table 15. Performance on the False-Belief task (using Dolls)

Group	Number who passed	Number who failed
Autistic	5	10
Down's	11	2
Normal	21	3

Chi squared or Fisher Exact analyses were carried out on these data, making comparisons between the groups in terms of the numbers of children who passed or failed on the false-belief task.

a) Autistic vs Down's Syndrome group
Significantly more autistic children failed the false-belief task than Down's Syndrome children (Chi squared=5.53, $p<0.01$)

b) Autistic vs Normal group
Significantly more autistic children failed the false-belief task than normal children (Chi squared=9.87, $p<0.01$)

c) Down's Syndrome vs Normal group
There was no significant difference in the proportions of children who passed or failed the false-belief task when comparing the Down's Syndrome group with the Normal group (Fisher Exact, $p=0.78$)

Computer Presentation

Table 16. shows the number of children from each group who either passed or failed on game type E of the false-belief program (False-belief scenario test question), given that they passed the test questions on all the other "control" games (A to D).

Those children who failed any one of the "control" games are not considered in this analysis. Two interesting cases (A15 and A16) showed a combination of passing and failing the test game E whilst passing all the control games. These subject were not included in the analysis but we will consider them later.

Table 16. Performance on False-Belief task (using computer)

Group	Number who passed	Number who failed
Autistic	5	11
Down's	9	1
Normal	17	0

Chi squared or Fisher Exact analyses were carried out on these data making comparisons in terms of the numbers who passed from each group.

a) Autistic vs Down's Syndrome group

Significantly more autistic children failed the false belief game E than Down's Syndrome children (Fisher Exact, $p=0.005$)

b) Autistic vs Normal group

Significantly more autistic children failed the false-belief game E than Normal children (Chi squared=14.57, $p<0.001$)

c) Down's Syndrome vs Normal group

There was no significant difference in the proportion of children who passed or failed on the false-belief game E between the Down's Syndrome group and the Normal group (Fisher Exact, $p=0.37$)

Discussion

Dolls data

Analyses were carried out using only those children who passed all the control questions. Of these children, a greater proportion of the autistic group failed the false-belief task than passed, whereas for the Down's Syndrome group and the group of young normal children a greater proportion passed the task than failed. In other words the performance of the autistic group was significantly different from the performance of either of the other two groups in that the autistic group failed the test question "Where does Sally think the ball is?"

Despite the added control questions of the revised false-belief task, then, the pattern of these results were similar to those found by Baron-Cohen et al (1985).

It is interesting that five of the autistic children did pass the false-belief task. Later we will consider what it might be about these subjects which enabled them the pass the test question.

It is also worth noting that 18 out of the 23 autistic children failed the test question, although of course 8 of these subjects also failed the control questions. It may be the case that these children do not understand false-belief but we cannot deduce this from our task since their failure on the test question may be explained by their failure on a control question.

We need further analysis before we can be satisfied that failure on the task was purely due to a deficit in understanding of false-belief. Failure may be due to some abstract feature of the task rather than the conceptual nature of the task. Therefore we need to consider whether a completely different mode of presentation makes any difference.

Computer data

The computer data revealed similar patterns of results to the dolls data. Using only those children who passed all the control games it was found that a greater proportion of the autistic children failed on game E (false-belief scenario) than passed, whilst the Down's syndrome children and the normal children tended to pass on this game. This result testifies to the consistency of the results found with the dolls experiment and suggests that the computer has been used effectively as a tool for investigating false-belief in the children.

Although the overall pattern of results from the two forms of presentation are similar, we need to look in more detail for any differences in performance on the computer presentation compared to the dolls presentation.

iii) Comparison of results - Dolls vs Computer presentation

The five autistic children who passed the false-belief task with dolls (A3,A6,A10,A11,A22) were also the only five to pass the computer presentation.

There are however, four interesting cases of autistic children who showed a combination of passing and failing on different trials of the test question or test game. Although this is too few subjects to be of any major significance, as individual cases they are still worth reporting.

Subjects A2 and A5 both passed game E on one trial but failed on other trials. Unfortunately neither of these subjects passed all the control games successfully. A2 failed game D and A5 failed all the control games. One explanation for the inconsistency of their performance then, is that they are simply making random selections. It is interesting though that using the dolls presentation subject A2 failed the test question consistently whilst making no errors on the control questions. Subject A5 also failed the test question consistently using the dolls presentation. It will be interesting to follow these subjects up by retesting them later.

It is also worth observing the performances of subject A15 and A16. Using the dolls presentation subject A15 passed the test question on one occasion but failed control questions and subject A16 failed the test question on all three trials but passed all the control questions. For the computer presentation though, both of these subjects showed a combination of passing and failing game E whilst passing all the control questions. If the explanation for their success on the computer presentation was that they were simply making random selections then why were they so consistently correct in their performance on the control games?

Obviously all four of these subjects have difficulty with their understanding of the false-belief question, but they are interesting cases since their performance is inconsistent. It may be that they are on the verge of understanding false-belief, or that they are somehow learning how to answer this question correctly. It is particularly interesting to observe that in all four cases performance was improved on the computer presentation and that the order of presentation was dolls first followed by computer. Retesting these subjects will be particularly valuable.

It is also worth observing some discrepancies in the performances of the Down's Syndrome children. Subjects D6 and D14 are of particular interest. D6 consistently failed the test question and also failed control questions on the doll presentation. However, on the computer presentation this subject showed a combination of pass and fail on game E (the test game) whilst passing all the control games. Also D14 failed on the test question on the doll presentation but passed all the control questions, whilst on the computer presentation this subject passed the test question on both trials and passed all the control games.

The raw data show no pattern of particular control questions or games being failed. However, it may be that the computer control games are easier to pass than the doll control questions, perhaps because they require less memorised information. We will speculate as to the differences between computer and doll presentation later in the general discussion.

It is interesting then, that whenever there is a discrepancy in performance it always occurs in the same "direction", failing on the dolls presentation and passing on the computer presentation. This result was also found for the normal subjects as N6 failed on the dolls task but passed on the computer task.

iv). The relation of performance to Chronological Age and Mental Age

In tables 17 to 22 below the autistic subjects are divided into two groups, those who passed the test question (Pass group) and those who failed the test question (Fail group), given that they passed all the control questions. We can then compare the Chronological Age (CA), Verbal Mental Age (VMA) and Non-Verbal Mental Age (NVMA) of the two groups, to see if passing or failing on the test question is related to any of these factors.

Mann-Whitney U tests were carried out to compare the two groups since the numbers in each group were small.

a) Doll Presentation

Table 17. Performance vs Chronological Age (Dolls Presentation)

	n	median (y:m)	mean (y:m)	Std.Dev (y:m)	Mean Rank
Pass Group	5	14:8	13:11	2:8	8.2
Fail Group	10	13:11	13:5	3:2	7.9

Table 17 shows the median, mean and standard deviation (Std.Dev) Chronological Age in years and months (y:m) for the Pass group and the Fail group for the dolls presentation. The median CA of the Pass group is higher than that of the Fail group. CA's were transformed into ranks in order to perform the Mann-Whitney U test. The mean ranks differed in the same direction as the median CA's. However, although the Pass group was found to be older the effect was not significant at the .05 level (p=0.9511).

Table 18. Performance vs Verbal Mental Age (Dolls Presentation)

	n	median (y:m)	mean (y:m)	Std.Dev (y:m)	Mean Rank
Pass Group	5	10:4	11:10	3:10	12
Fail Group	10	7:6	7:8	2:2	6

The median Verbal Mental Age of the Pass group is higher than that of the Fail group and the mean ranks differ in the same direction as the medians. A Mann-Whitney U test shows the difference in Verbal Mental Age to be significant at the .05 level (p=0.0169).

Table 19. Performance vs Non-Verbal Mental Age (Dolls Presentation)

	n	median (y:m)	mean (y:m)	Std.Dev (y:m)	Mean Rank
Pass Group	5	12:10	12:3	3:9	10.2
Fail Group	10	8:11	9:3	3:3	6.9

The median NVMA of the Pass group is higher than that of the Fail group and the mean ranks differ in the same direction as the medians. However the Mann-Whitney U test shows that this difference is not significant at the .05 level (p=0.1984)

b) Computer Presentation

The same analyses were carried out for the Pass and Fail group of the computer presentation, comparing performance with CA, VMA and NVMA.

Table 20. Performance vs CA (Computer Presentation)

	n	median (y:m)	mean (y:m)	Std.Dev (y:m)	Mean Rank
Pass Group	5	14:8	13:11	2:8	9.4
Fail Group	11	14:1	12:8	3:5	8.1

The median CA of the Pass group is higher than that of the Fail group and the mean ranks also differ in the same direction. However the Mann-Whitney U test shows that this difference is not significant at the .05 level (p=0.6504).

Table 21. Performance vs VMA (Computer Presentation)

	n	median (y:m)	mean (y:m)	Std.Dev (y:m)	Mean Rank
Pass Group	5	10:4	11:10	3:9	13.4
Fail Group	11	8:6	8:4	1:11	6.3

The median VMA of the Pass group was higher than that of the Fail group and the mean ranks differed in the same direction. The Mann-Whitney U test revealed this difference to be significant at the .05 level (p=0.0065)

Table 22. Performance vs NVMA (Computer Presentation)

	n	median (y:m)	mean (y:m)	Std.Dev (y:m)	Mean Rank
Pass	5	12:10	12:3	3:9	11.9
Fail	11	7:0	6:10	2:1	7

The median NVMA of the Pass group was higher than that of the Fail group and the mean ranks differed in the same direction. However, the Mann-Whitney U test revealed that this difference was not significant at the .05 level (p=0.0616).

Discussion

The autistic children who passed the false belief task were slightly older than those who failed (although this difference did not reach significance). Also, those who passed had significantly higher Verbal Mental Ages and higher Non-Verbal Mental Ages (although this did not quite reach significance) than those who failed. Can this explain why most of the autistic group failed?

If we compare the autistic group with the control groups it is clear that Chronological Age (CA) and Mental Age (MA) alone cannot account for failure to pass the false belief questions. The Down's Syndrome control group had the same CA and a lower MA than the autistic group (see chapter 5) and yet were able to pass the false belief questions. The normal controls had a lower CA and MA than the autistic group (see chapter 5) and were also able to pass the test question. In other words, failure to pass the false belief task is not related to general developmental delay.

So, what is the significance of the CA and MA of the "Pass" group? In order to find an explanation for the results we need to look at the "specific developmental delay hypothesis" proposed by Baron-Cohen (1989). This theory states that there is a specific delay in the development of the mechanism for meta-representational capacity (thought to underlie theory of mind), and that some autistic children may eventually develop a theory of mind at the lowest level some years after it would develop normally. Baron-Cohen (1989) found that the four autistic children who passed the Sally-Anne task in an earlier experiment (Baron-Cohen et al, 1985) and a further six who passed from another large sample, were amongst the oldest children (none was younger than 11 years) and also had a higher Verbal Mental Age. However, these children were unable to attribute beliefs at a more advanced level (eg. Mary thinks that John thinks the icecream van is in the park), whereas matched non-autistic controls (normal 7 year olds and Down's children) could. In other words, those autistic children who passed the false belief task at the simplest level (used in our study) are specifically delayed in the acquisition of more complex theory of mind.

The autistic children who passed the false belief task in our experiment were similar to those who passed the original version of the false belief task in the experiments of Baron-Cohen et al (1985) and Baron-Cohen (1989). They had a higher Verbal Mental Age than those who failed and (apart from one subject who was 9:8 years) were well above 11 years of age. Mental Age clearly has some role to play in being able to pass the false belief task, but it must also be noted that there were some children who failed the task who had similar levels of ability. Therefore we can conclude, as Baron-Cohen (1989) did, that "High Verbal MA is a necessary but not sufficient condition for developing a theory of mind."

These data then, are in line with those found in previous studies (Baron-Cohen et al, 1985, 1986; Leslie and Frith, 1988; Baron-Cohen, 1989). The autistic children who passed were all in a high age range with high Mental Ages. However, we would expect these children to fail on higher levels of belief attribution. Also, it must be noted that this was true of both media of presentation (Dolls and Computer), suggesting further that there is something about the conceptual nature of the task (ie. understanding of false belief) which causes the autistic children to fail.

v). Informal Observations.

Finally, Our informal observations suggested that all three groups of subjects were attracted to and motivated by the experience of working with the computer. In particular, we were interested in the reactions and behaviour of the autistic children.

a)Initial Reactions

All of the autistic children reacted positively to the prospect of working on the computer, despite the fact that the majority of these children had little or no previous experience of computer work. The exception to this was subject A3 who was described by his teachers as having an "obsession" for the computer, which he had worked with at a previous school. The difficulty with this subject then was in ending the computer sessions without the child becoming upset. This was achieved fairly easily by promising the child that he would be able to indulge another obsession (setting out the plates at lunch time) if he behaved well at the end of the computer session.

b). Behaviour

The initial signs are that the autistic children were able to concentrate extremely well when working with the computer, compared to the more conventional forms of work. Certainly for a number of children specific behavioural problems were vastly reduced during the computer session.

Subject A4 who normally pulled the hair of any one near her (a behavioural problem which was normally solved by holding her hands while talking to her), was able to work with the computer, using the mouse with what was effectively a free hand, whilst the experimenter held the other hand. This was considered to be somewhat of a breakthrough for this subject.

Subjects A2 and A9 were normally obsessive questioners, a behavioural problem which made the dolls presentation of the false belief task very difficult to carry out. However, working with the computer held their attention more effectively and limited their questioning to a more acceptable level.

c). Motivation

The autistic children appeared to be highly motivated by the rewards the computer offered. They reacted particularly well to the computer music, often humming along to the well known tunes. They appeared to appreciate the opportunity to control and initiate the work they were doing without the prospect of failing.

Clearly it is dangerous to place too much emphasis on informal observations such as these, however they do serve the function of giving a general positive picture of the autistic child's experience with the computer.

GENERAL DISCUSSION

In this first experiment it was found that all three groups of children were able to handle the computer interface successfully. Given the various arguments in Chapter 4 as to why autistic children might be particularly well suited to the computer environment, it is promising to find that this group of children had no problems using the mouse and navigating the screens. Furthermore, since the pattern of results found using the computer presentation was similar to the results found using the doll presentation it would seem that the computer has been used successfully here as a novel investigative tool in a cognitive psychology experiment.

The results of the false-belief task, for both presentations, showed that the autistic children failed to understand false-belief whereas the Down's Syndrome children, with lower Verbal and Non-Verbal MA's passed and the normal children, also with lower Mental Ages than the autistic children, also passed. These results are similar to those found by Baron-Cohen et al (1985), and was found using a revised version of the Sally-Anne task and using a novel form of presentation of the task, suggesting further that there is something about the conceptual nature of the task which causes autistic children to fail.

This experiment then, lends further support to the hypothesis that autistic children are specifically impaired in their "theory of mind".

The few autistic children who pass the test tend to have higher Mental Ages. However, Down's Syndrome children with lower MA's passed the test. It is possible that autistic children have a "specific developmental delay" in the cognitive mechanism employed in attributing beliefs.

A closer comparison between the computer data and the dolls data revealed that those children who passed consistently on one presentation always passed on the other presentation. However, the few inconsistent results that appeared in the data are interesting. Of those children who showed a combination of passing and failing the test question or game, any inconsistency between performance on the two presentations showed failure on the dolls presentation and passing on the computer presentation. Also, in all these cases the computer came second in the order of presentation.

There were too few children who showed these inconsistent results to make any major claims about, however we might consider a number of questions on the basis of this finding. Firstly, are these children somehow on the borderline between understanding and not understanding false-belief? Secondly, is the computer functioning as some sort of training device and if so, in what way? Thirdly, is there something about the computer that enables the child to pass?

There are a number of differences between the computer presentation and the dolls presentation which may be relevant. One possibility is that the external representation of the computer presentation may be easier to deal with as a primary representation than the dolls presentation. In general, it would seem likely that the doll presentation involves far more cues, generated by the interpersonal interaction, than the computer presentation. Another factor may be the differing linguistic demands of the two versions, the dolls version involving more spoken language and in particular the dolls control questions consisting of a long list of questions requiring reference to memorized information. The computer version, on the other hand, involves far more recognition than recall. It is also possible that the presentation by computer has a novelty value which motivates the child during the task.

If the child is somehow learning to understand false-belief this may be being done in two different ways. If the autistic child lacks an innate ability that cannot be learned, then they may be passing the task by "hacking out" a solution to a subset of problematic situations, in other words the child has learned an algorithm that has enabled him or her to predict what was happening next without having understood the basic concept. However, as Morton (1989) points, one explanation is that the necessary structures are there but have not yet been "hooked up" within the brain. If this is true, then these children who are learning to pass the false-belief task may be "linking together" deficient cognitive structures and genuinely learning to understand false-belief. This latter explanation is the most optimistic of the two and the most desirable from a therapist's point of view. It would be useful if the computer proves to be a good training device as well as an investigative tool.

It will be interesting to retest these children in the next experiment to examine how stable the results are over time and if there is any improvement on initial performance. In particular it will be interesting to follow the performance of those children who showed inconsistent results.

CHAPTER 8.

EXPERIMENT 2.

INTRODUCTION

In the second experiment we retested a number of autistic children and Down's Syndrome children approximately six months after the completion of experiment one. The main objective was to look at how stable the results would be when the experiment was repeated.

We will be testing the hypothesis that the tasks are reliably testing the understanding of false belief and, assuming that this cognitive skill will not change in the six months between experiments, that the results will remain the same upon retesting.

In particular, we will be interested in retesting those children who failed the false belief task, or showed inconsistent results in the first experiment. If the results are stable, then the children who failed originally will fail again. However, if retesting yields different results and these children pass, we will have to consider a number of different explanations.

One possibility is that the children may develop an understanding of false belief over the months between testing and retesting. Leslie and Frith (1988) and Baron-Cohen (1989) have suggested that the theory of mind at the lowest level may develop late (beyond the normally expected mental age) in older autistic children (this is the "specific developmental delay" hypothesis referred to in Chapter 7). However, it seems unlikely that developmental change in just a few months would produce a sharp change in results, but it will be interesting to observe the borderline subjects who showed inconsistent results in experiment one.

Another possibility is that the children may learn to answer the false belief test by using a compensatory strategy and that repeated testing has a "training" effect. Learning may have taken place as a result of the feedback given in the computer version of the task; a correct choice leads to Sally retrieving the ball with accompanying music and the text "YES WELL

DONE", whereas an incorrect choice prompts the child to "TRY AGAIN" and loops back to the test question screen. Feedback was also given in the Dolls version as the child is told "Well done" for the correct choice. Another possibility is that a combination of developmental change and "training" may explain a change in results.

Finally, an explanation for different results on retesting may simply be that the tasks are unreliable, in which case some of the subjects who passed in experiment 1 might fail in experiment 2.

METHOD

Subjects

Twelve autistic children and seven Down's Syndrome children, who were all used in experiment 1, were retested in this experiment. Details of the subjects are presented in Chapter 5, with individual details of IQ score and Chronological Age given in Chapter 6. It was not possible to retest all the subjects we would have liked (for example some had left the school and some were ill).

Procedure

The subjects were retested approximately six months after their participation in experiment 1. For each subject, the two types of task (dolls and computer) were presented in a different order to experiment 1. Also, there was no training program preceding the tasks. Otherwise, the procedure was identical to experiment 1.

RESULTS

Tables 23 and 24 show the results of experiment 2, retesting autistic and Down's Syndrome children (see Chapter 6 for the key to column headings). In addition, the final two columns show summarised results from experiment 1:-

TestQ - responses to test question from experiment 1.

Controls - / refers to passing all the control questions in expt 1.
0 refers to failing one or more of the control questions in expt 1.

Table 23. Retesting Autisic Children

Dolls Data

	Task Questions						Expt.1. Results	
Subj	TQ	RQ	M1	M2	M3	M4	TestQ	Controls
A1	000	///	///	///	///	///	000	/
A2	0/	///	///	///	///	///	000	/
A3	///	///	///	///	///	///	///	/
A6	///	///	///	///	///	///	///	/
A8	000	///	///	///	///	///	000	/
A9	000	///	///	///	///	///	000	/
A12	000	///	000	000	///	000	000	0
A13	000	///	///	///	///	///	000	/
A15	000	///	///	///	///	000	0/0	0
A16	000	///	///	///	///	///	000	/
A20	000	///	///	///	///	///	000	/
A21	000	///	///	///	///	///	000	/

Computer Data

	Task Questions					Expt.1. Results	
Subj	TQ	A	B	C	D	TestQ	Controls
A1	000	/	/		/	000	0
A2	//	/	/	/	/	00/	0
A3	//	/	/	/	/	///	/
A6	///	/	/	/	/	///	/
A8	00	/	/	/	/	000	/
A9	///	/	/	/	/	00	/
A12	/0	/	0	/		0	0
A13	00	/	/	/	/	000	/
A15	0/	/	/	/	/	0/0	/
A16	0/	/	/	/	/	/0	/
A20	00	/	/	/	/	000	/
A21	00	/	/	/	/	00	/

Table 24. Retesting Down's Syndrome Children

Dolls Data

	Task Questions						Expt.1. Results	
Subj	TQ	RQ	M1	M2	M3	M4	TestQ	Controls
D3	///	///	///	///	///	///	///	/
D4	000	///	///	///	000	000	000	0
D6	000	///	///	///	000	000	000	0
D9	000	///	///	///	///	000	000	0
D10	000	///	///	///	///	///	000	/
D13	000	///	///	000	000	000	000	0
D14	000	///	///	///	///	///	000	/

Computer Data

	Task Questions					Expt.1. Results	
Subj	TQ	A	B	C	D	TestQ	Controls
D3	/	/	/	/	/	//	/
D4	0	/	0	/		000	/
D6	0	/	/	/	/	/0	/
D9	0	/	0	/	/	0	0
D10	00	/	0	/	/	00	0
D13	00	/	0	0	/	00	0
D14	0/	/	0	0	/	//	/

These tables allow for quick comparisons between retesting results and the results of the original experiment. However for a more detailed comparison refer to the full results of the original experiment in tables 9, 10 and 11.

In the tables below we have attempted to summarize performances on the first and second experiment. What are the possible responses to the control questions and to the test questions?

For experiment 1 a subject may:-
1. Pass all the controls or fail at least one.
2. Pass all the test questions or fail at least one.

When that subject is retested on experiment 2, the same possible responses are available:-
1. Pass all the controls or fail at least one.
2. Pass all the test questions or fail at least one.

The summary tables consider each possible combination of responses over the two experiments (16 altogether) and shows the number of children who performed that combination. For example, in table 25, two subjects passed all the control questions and passed the test questions on experiment 1 whilst also passing all the control questions and passing the test questions on experiment 2. Directly below the number 2 in this table is a zero. This shows that no children passed all the control questions and passed the test questions in experiment 1 whilst passing all the control questions and failing at least one test question in experiment 2.

Given the geometry of these tables then, entries along the diagonal (top left to bottom right) represent the numbers of children who show the same result in experiment 1 and experiment 2.

Table 25. Summary of Test Retest responses. Autistics (Doll Pres'n)

<table>
<tr><td colspan="4" rowspan="3"></td><td colspan="4">Expt 1.
Control Qns</td></tr>
<tr><td colspan="2">Pass
Test Qn</td><td colspan="2">Fail
Test Qn</td></tr>
<tr><td>Pass</td><td>Fail</td><td>Pass</td><td>Fail</td></tr>
<tr><td rowspan="4">Expt 2
RETEST
Control Qns</td><td rowspan="2">Pass</td><td rowspan="2">Test Q</td><td>Pass</td><td>2</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fail</td><td>0</td><td>7</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Fail</td><td rowspan="2">Test Q</td><td>Pass</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fail</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
</table>

In tables 25 to 28 "Pass" refers to passing all the questions and "Fail" refers to failing at least one of the questions.

In table 25 all the numbers fall on the diagonal which means that the twelve autistic children retested using the dolls presentation showed the same results in experiment 1 as in experiment 2. Analysis of those children who passed the control questions in both experiments (the top left four cells) confirms that the consistency is unlikely to be due to chance (Fisher Exact, $p=0.03$).

Table 26. Summary of Test Retest responses. Autistics (Computer Pres'n)

Expt 1.

				Control Qns			
				Pass		Fail	
				Test Qn		Test Qn	
				Pass	Fail	Pass	Fail
Expt 2 RETEST	Control Qns	Pass	Test Q Pass	2	1	0	1
			Test Q Fail	0	6	0	0
		Fail	Test Q Pass	0	0	0	0
			Test Q Fail	0	0	0	2

Table 26 considers the data from the two computer presentation experiments. Ten of the subjects showed the same performance on both experiments (numbers on the diagonal). However one subject (A9), who passed the controls but failed the test questions on experiment 1, passed both control and test questions on retesting. Another subject (A2) who failed both controls and test questions in the original experiment, passed the controls and test question on retesting. Considering only the children who passed the control questions in both experiments, analysis shows that these subjects are more likely to show the same performance (Fisher Exact, $p=0.08$) on the two experiments.

Table 27. Summary of Test Retest responses. Down's (Doll Pres'n)

				Expt 1. Control Qns: Pass, Test Qn: Pass	Control Qns: Pass, Test Qn: Fail	Control Qns: Fail, Test Qn: Pass	Control Qns: Fail, Test Qn: Fail
Expt 2 RETEST	Control Qns Pass	Test Q	Pass	1	0	0	0
			Fail	0	2	0	0
	Control Qns Fail	Test Q	Pass	0	0	0	0
			Fail	0	0	0	4

There were seven Down's Syndrome children retested. Table 27 shows the data for the dolls presentation. All of the numbers fall on the diagonal which means that these children showed the same performance on retesting as they did in the first experiment. The frequencies are too small to allow statistical analysis.

Table 28. Summary of Test Retest responses. Down's (Computer Pres'n)

			Expt 1. Control Qns: Pass		Expt 1. Control Qns: Fail	
			Test Qn		Test Qn	
			Pass	Fail	Pass	Fail
Expt 2 RETEST: Control Qns	Pass	Test Q Pass	1	0	0	0
		Fail	0	1	0	0
	Fail	Test Q Pass	0	0	0	0
		Fail	1	1	0	3

For the computer presentation five of the seven Down's Syndrome children showed the same performance on both experiments. However, two of the subjects performed differently on the two experiments. D14 passed controls and test question on the first experiment but failed both controls and test questions on retesting. D4 passed the control questions and failed the test questions on experiment 1 but failed both controls and test question on experiment 2.

DISCUSSION

In experiment two we retested 12 autistic children and 7 Down's Syndrome children. In general, it was found that the results from the first experiment remained the same on retesting. We can conclude from this that the tasks are reliable and that the results are stable. These results confirm our earlier finding that autistic children are impaired in their understanding of false belief, and that the two forms of presentation, dolls and computer, essentially measure the same aspects of understanding.

There were, however, some exceptions to this result, which we also need to consider. Two of the autistic children are of particular interest. For the dolls presentation A2 failed the test question on each trial of experiment one, but on retesting, passed the test question on the second trial. The performance of this subject is also interesting on the computer presentation. On experiment one A2 failed a control game, failed the first two trials of the test question game and passed the third trial. On retesting however, A2 passed all the control games and both trials of the computer game. It would appear from these results then, that the performance of A2 is improving and that that improvement is shown particularly on the computer presentation.

Another interesting case is A9. This subject showed no improvement in performance on the doll presentation retesting, however he improved on the computer presentation and was able to pass all the control games and all three trials of the test question games.

Only one of the Down's Syndrome children showed a different performance on the test question. D14 who had originally passed control games and the test question games on computer presentation, failed both test question and control on retesting.

Finally, it is also worth observing that subjects A15 and A16 who showed inconsistent results on the computer test question in the first experiment responded similarly on retesting, both failing on the first trial and passing on the second.

How can we explain the improvement in performance of the two autistic children A2 and A9? It seems unlikely that the discrepancy in performance is due to the tasks being unreliable since the majority of subjects perform so consistently. Therefore improvement in performance may be due to late development of the understanding of false belief (Baron-Cohen, 1989) or to the child learning to pass the test question by using an algorithm or compensatory strategy. Although we cannot say for certain which of these two processes are taking place, there are some indications of the subjects learning to pass the tasks.

Firstly, it is interesting that improvement was shown on computer presentation for both subjects, although the order of presentation was different for each subject and would not therefore seem to be relevant. Learning may take place more easily on computer. Failing on the first trial and passing on subsequent trials within a session may be an indication of learning; this was true of A2, A15 and A16. Finally, passing the Sally-Anne task on retesting having failed previously, then going on to fail a different test of false belief (Smarties test of experiment 3) may be an indication that the subject has learned how to perform correctly on the Sally-Anne task without really understanding the concept of false belief. Our third experiment, then, may give us some indication of whether this has taken place with subjects A2 and A9, A15 and A19.

CHAPTER 9.

EXPERIMENT 3.

INTRODUCTION

The third experiment examines understanding of false belief in the same group of autistic children but using the "Smarties" task, originally devised by Perner et al (1987). This task will be presented using conventional materials and also using computer. This will enable us to make comparisons across different types of tasks and between different modes of presentation.

The aim of this experiment is to replicate the autistic children's problems in understanding false belief using a different paradigm. If the Sally-Anne task (experiment 1) and the "Smarties" task are both testing false belief then we should expect to find a strong correlation between performance on the two different tasks. In addition, a second computer-based task will provide us with further information about the extent to which the conceptual or the abstract nature of the task leads to failure, rather than the presentation medium.

The "Smarties" task involves testing false belief using a "deceptive-appearance" paradigm. In this task the child is shown a well-known tube of chocolates (Smarties) and asked what is in the tube. The child answers "Smarties". However, when the tube is then opened s/he is surprised to find a pencil inside. Understanding of false belief is then tested by asking the child what another child would say about the contents of the box when s/he sees it for the first time.

The advantage of this paradigm is that the children are first misled by the deceptive appearance of the box, which allows them to experience false belief in themselves before having to attribute false belief to somebody else.

METHOD

Subjects

Nineteen of the original 23 autistic children used in experiment 1 were tested in experiment 3. Testing began approximately twelve months after the first experiment. Details of the subjects are presented in Chapter 5, with individual details of Mental Age and Chronological Age given in Chapter 7.

General Procedure

Each child was tested in one session which lasted for approximately 10 minutes. In that session the child was tested on the "Smarties" task using two different forms of presentation:-

1. Using conventional presentation similar to the procedure used by Perner et al (1987).
2. Using a computer version of the task.

The order of presentation was counterbalanced.

i) Conventional Presentation

a) Materials

The Smarties tube used in this task is a well known confectionary box which normally contains chocolate pastilles. It is a tubular container with a picture of the sweets on the outside and measures 13 cm long and 2.5 cm in diameter. The only other material used was a red pencil, short enough to fit inside the box.

b) Procedure

The experimenter produced a packet of smarties from his bag and asked the subject "What do you think is in the packet?" After the children had answered "Smarties" or "sweets", the experimenter then opened the packet and showed the child that in fact, there was just a pencil inside, saying to the child "No, it's a pencil." The experimenter then put the pencil back in the box and closed it again. The subject was then asked a prompt question, "Now what do you think is in the packet?" The final control question checks that the child is still aware of his/her first judgement concerning the contents of the packet by asking, "When I first asked you, what did you think was in the packet?" After the subject had answered these questions, the experimenter explained that the next subject to follow had not seen what was in the packet:-"[name of next subject] has not seen what is in the packet. When he/she comes in I'll show him/her this packet and ask: [name] what do you think is in the packet?" The subject was then asked the test question "What will [name] think is in the packet?".

The subject will then have given responses to four key questions:-

1. First Response control: "What do you think is in the packet?"
2. Reality control: "Now what do you think is in the packet?"
3. Own-Response control: "When I first asked you, what did you think was in the packet?"
4. False-belief test: "What will [name] think is in the packet?"

ii). Presentation with the computer

a) Materials

The computer assisted learning system with mouse control described in Chapter 6 was used for this presentation.

b) Procedure

The experimenter sat next to the child and checked that he or she knew what the four objects on the screen were (see figure 9.1. which shows a pencil, smarties, a flower and a smarties packet). The child was then asked the first response control question, "What do you think is in the packet?". This appears as text in figure 9.1 and if the child does not read it out the experimenter does. Each screen is accompanied by music (the tune used for each screen is shown above the figures, and the key to the music can be found in chapter 6, table 4.)

The child then has to choose between the pencil, the smarties or the flower to answer the question. In most cases the child simply says "smarties" to which the experimenter replies "move the arrow over the smarties" (see figure 9.2). Whatever the child's response, the next screen will show a pencil emerging from the smarties packet and then re-entering (figures 9.3 to 9.5).

The child is then asked the reality control question, "Now what do you think is in the packet?" (see figure 9.6). Once again the child has to choose between the pencil, smarties and the flower. In this case the correct choice is the pencil (see figure 9.7). If the child were to choose incorrectly then the program loops back to figure 9.3 and the sequence repeats. However, if the child chooses correctly then the screen that follows flashes up "YES, WELL DONE" in different colours (see figures 9.8 to 9.10). The final control question, the own-response control, is then asked, "What did you first think was in the packet?" (see figure 9.11). In this case the correct choice is the smarties (see fig 9.12). An incorrect choice takes the program back to figure 9.3. If the correct choice is made the message "YES, WELL DONE" will appear again (see figures 9.8 to 9.10).

After a time delay of five seconds an animated character moves onto the screen (see figure 9.13; note that the double image shows the movement of the character). The following texts then appear explaining who the character is, which are read out by the child or the experimenter. These are, "This is Fred" (figure 9.14), "Fred has been outside" (figure 9.15), "Fred has not seen what is in the packet" (figure 9.16), and finally the test question "What does Fred think is in the packet?" (figure 9.17).

Once again the child has three choices. The correct choice is, of course, the smarties (see figure 9.18); if this is chosen then the pencil appears (fig. 9.19) and Fred is disappointed (figures 9.20 and 9.21). If the child chooses incorrectly the screen merely shows the pencil appearing.

Because the program is set up to follow a different route of screens depending on the choices made by the child, the log of screens visited shows how the child has answered the four questions:-

1. First Response control - "What do you think is in the packet?"
2. Reality control- "Now what do you think is in the packet?"
3. Own-Response control - "What did you first think was in the packet?"
4. False-belief test - "What will Fred think is in the packet?"

Figure 9.1

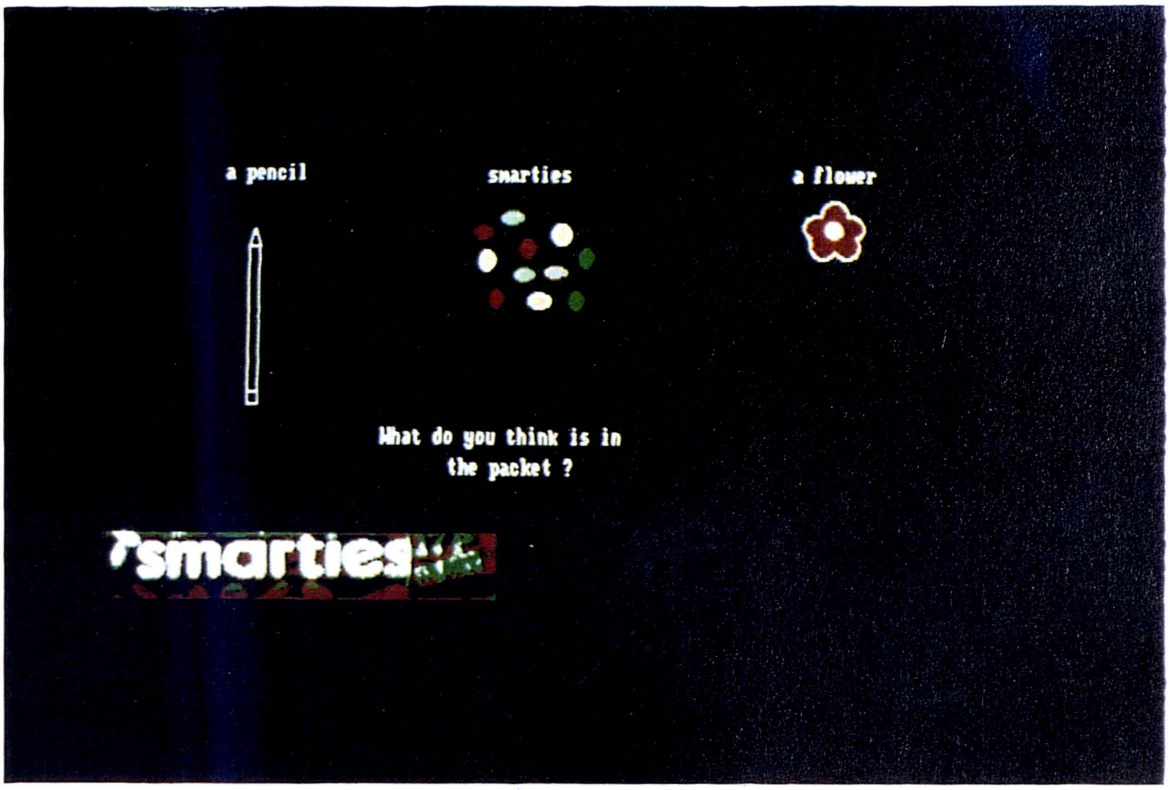


Figure 9.2

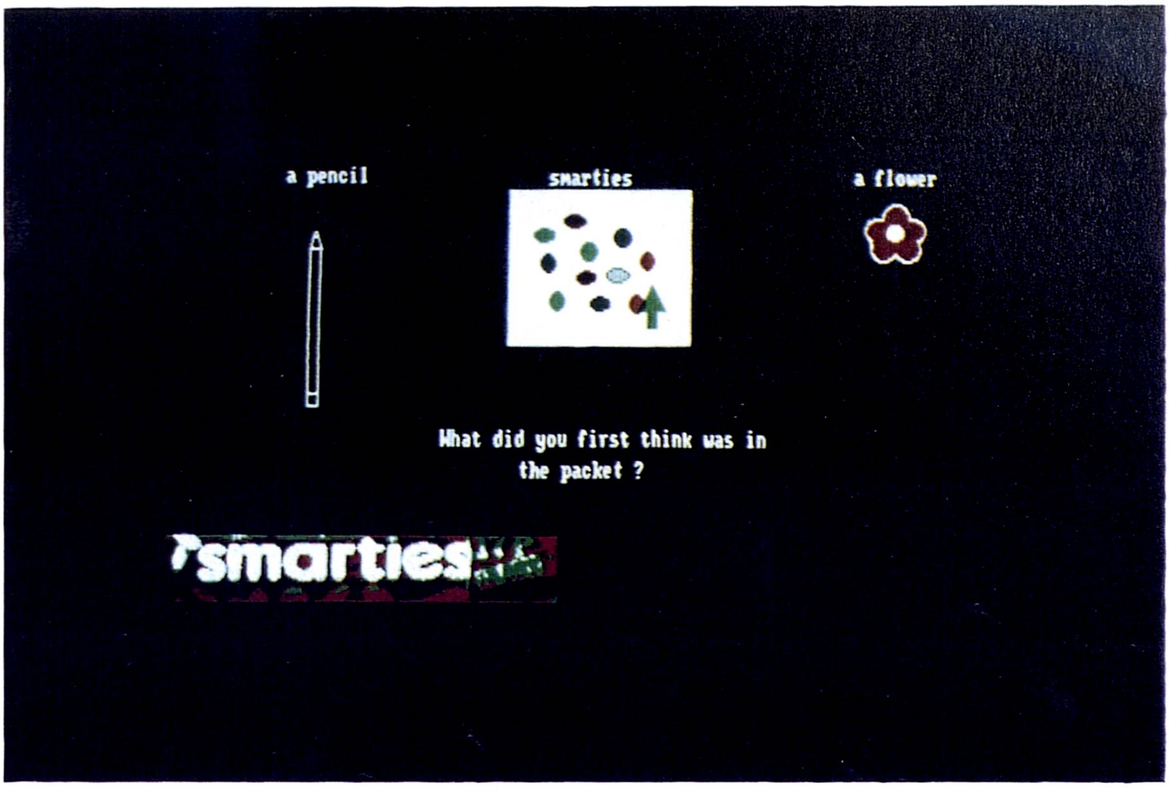


Figure 9.3

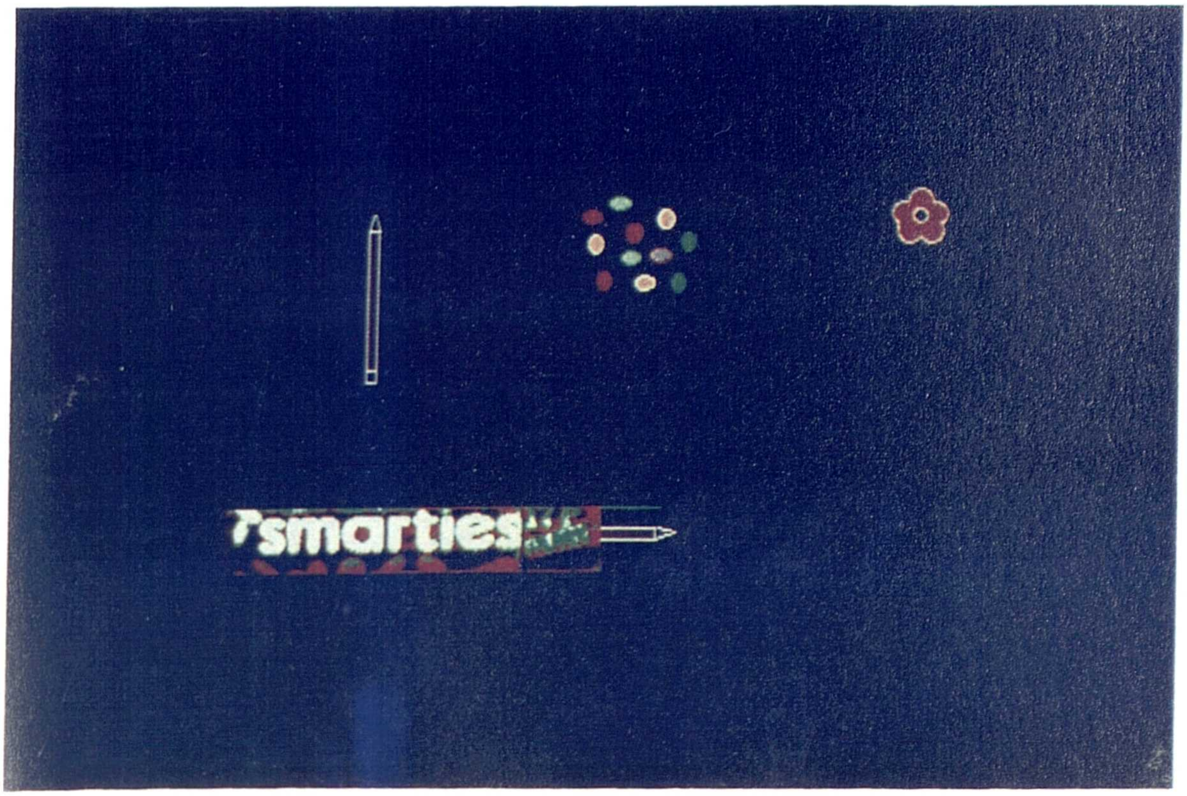


Figure 9.4

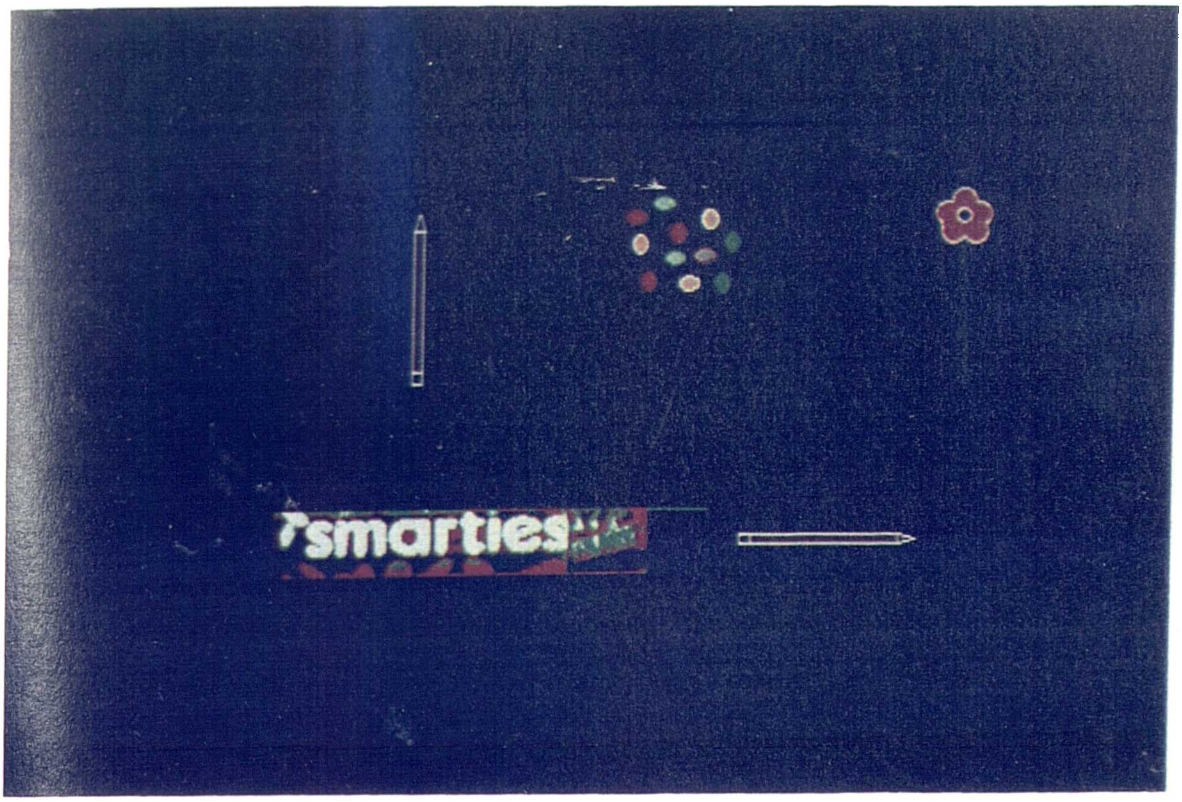


Figure 9.5

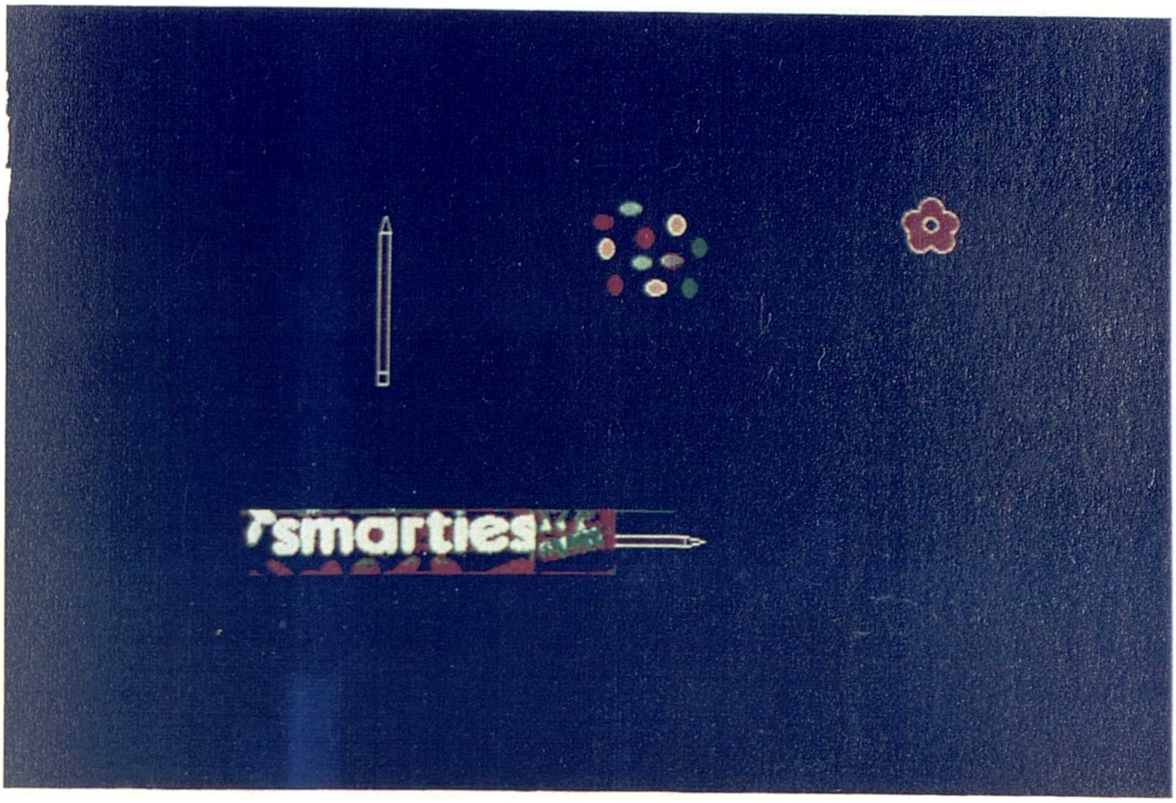


Figure 9.6

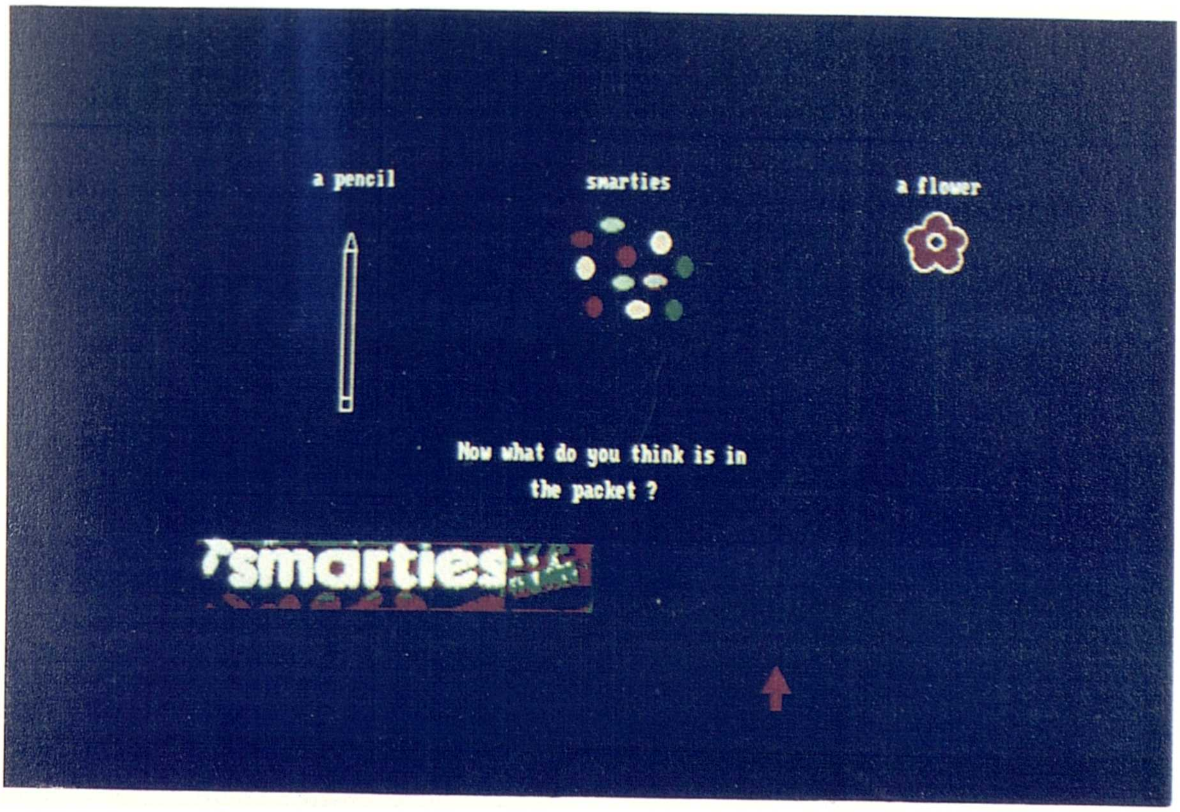


Figure 9.7

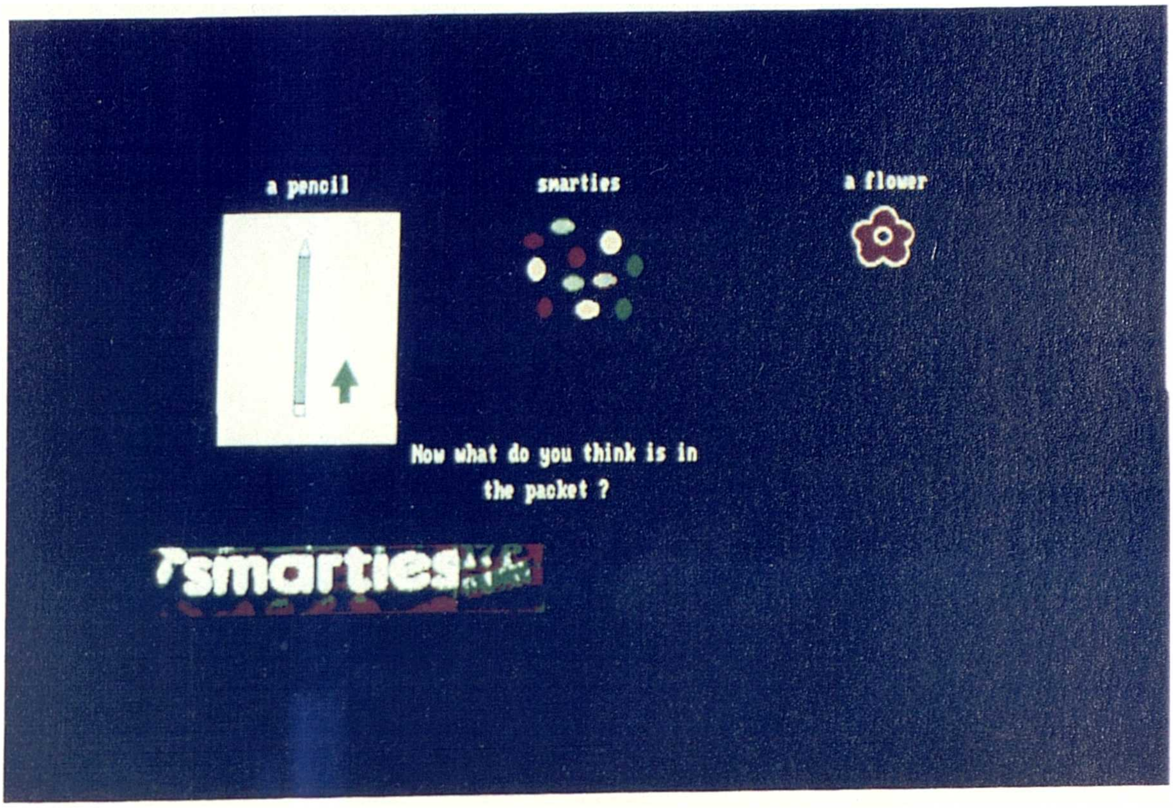


Figure 9.8 Music - S

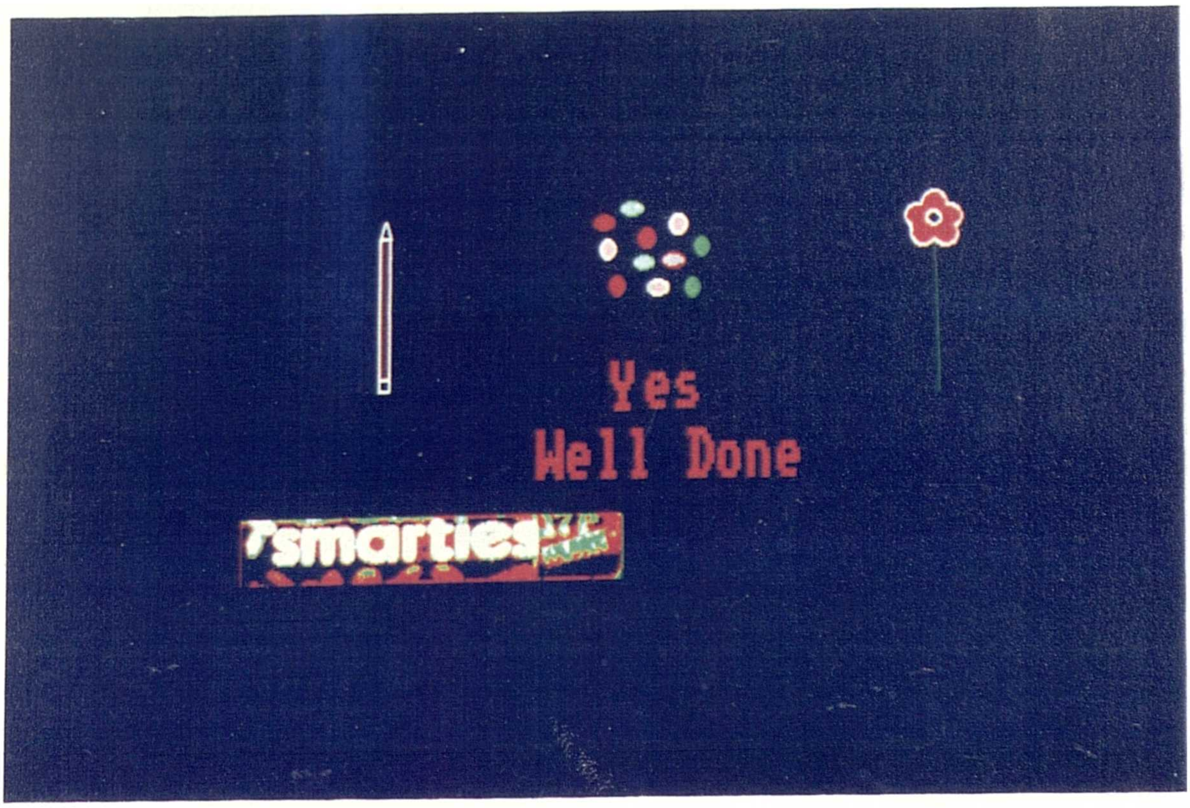


Figure 9.9

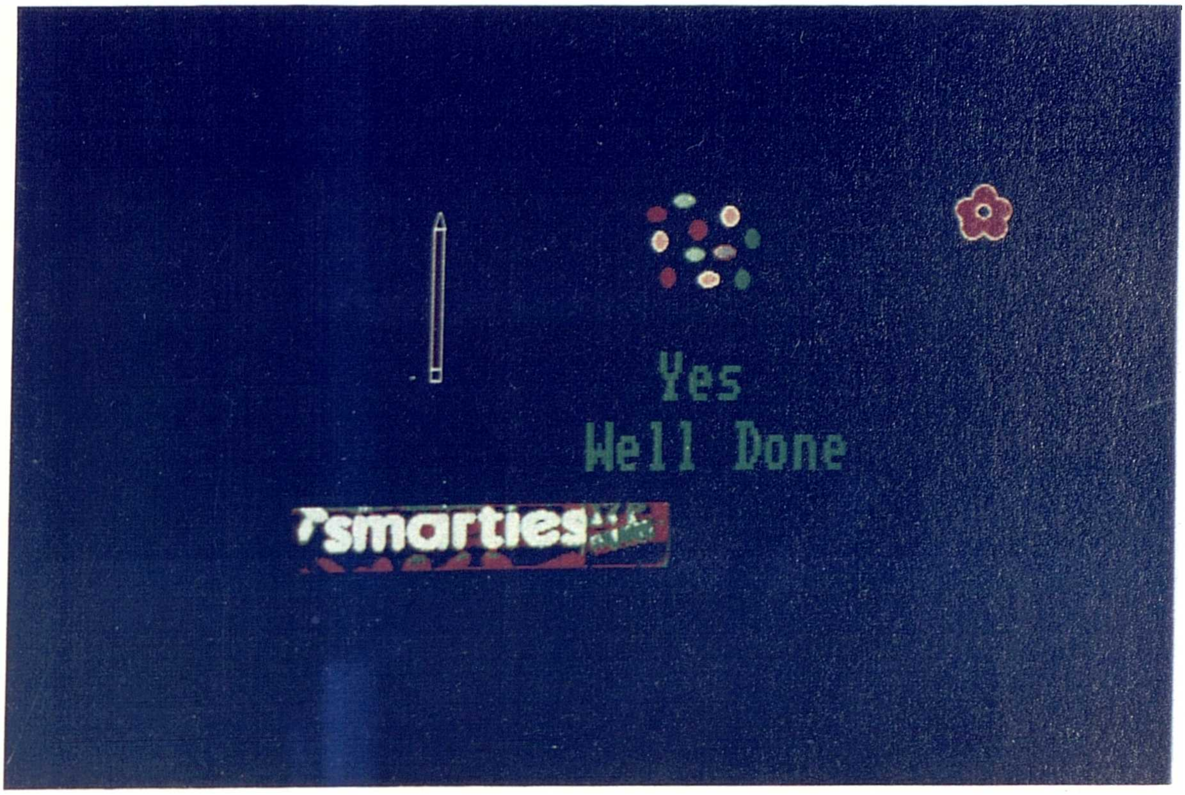


Figure 9.10

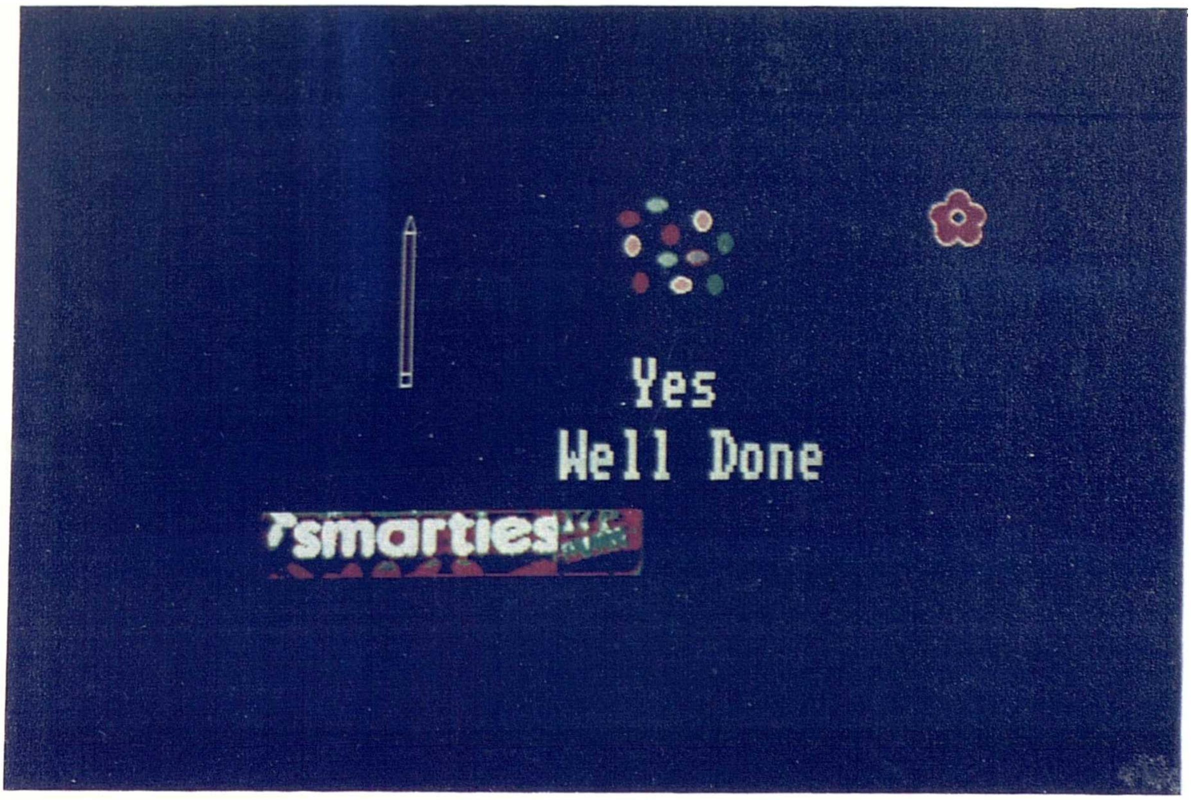


Figure 9.11

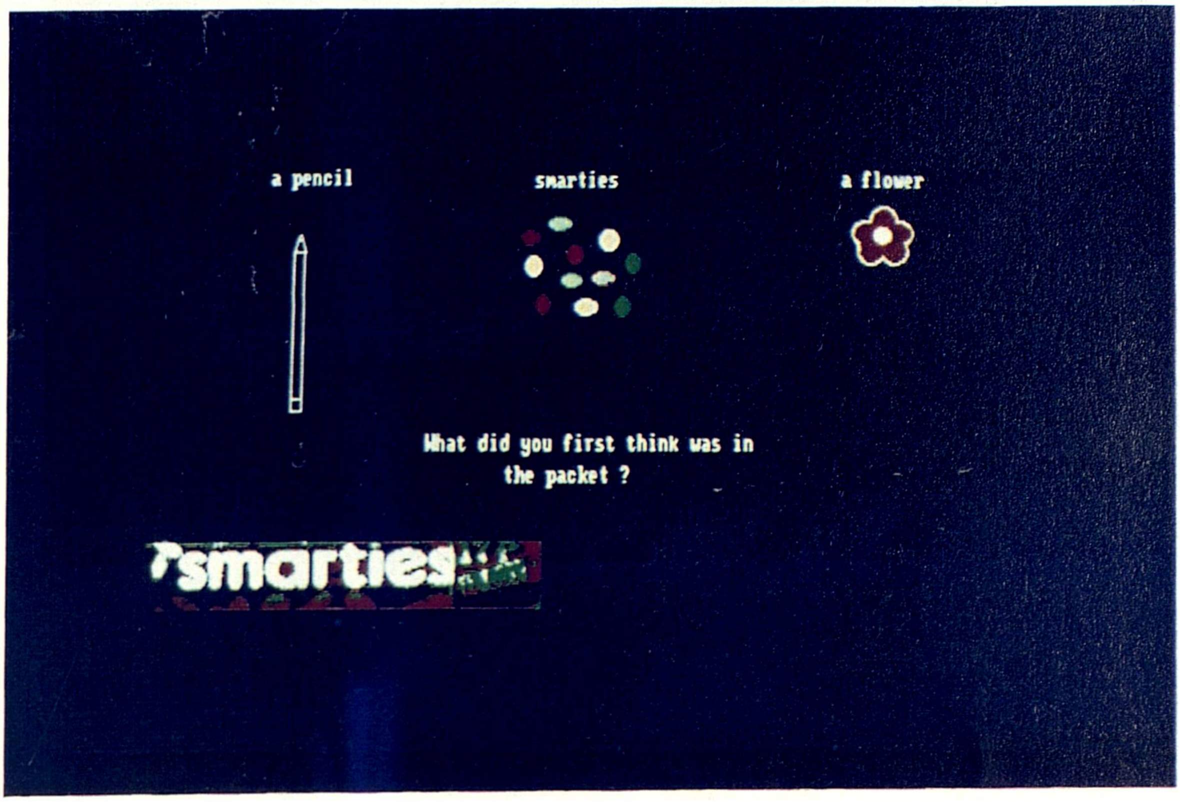


Figure 9.12

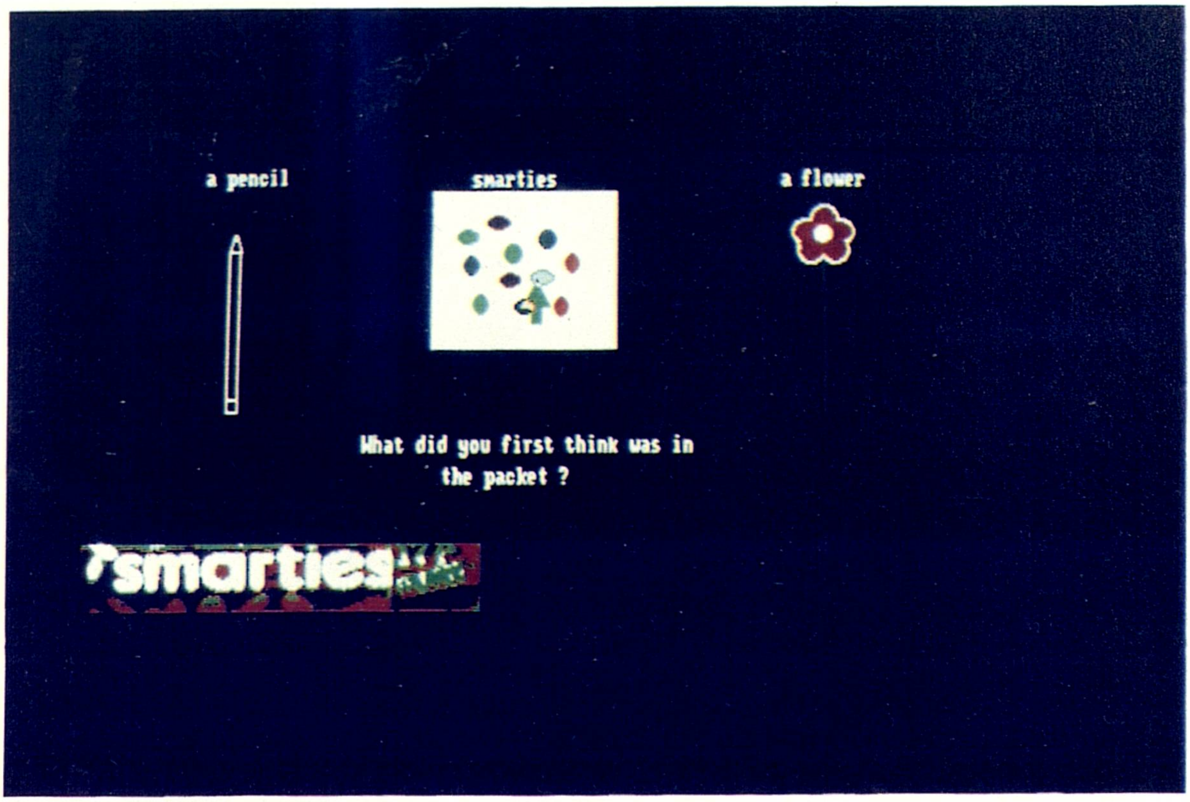


Figure 9.13

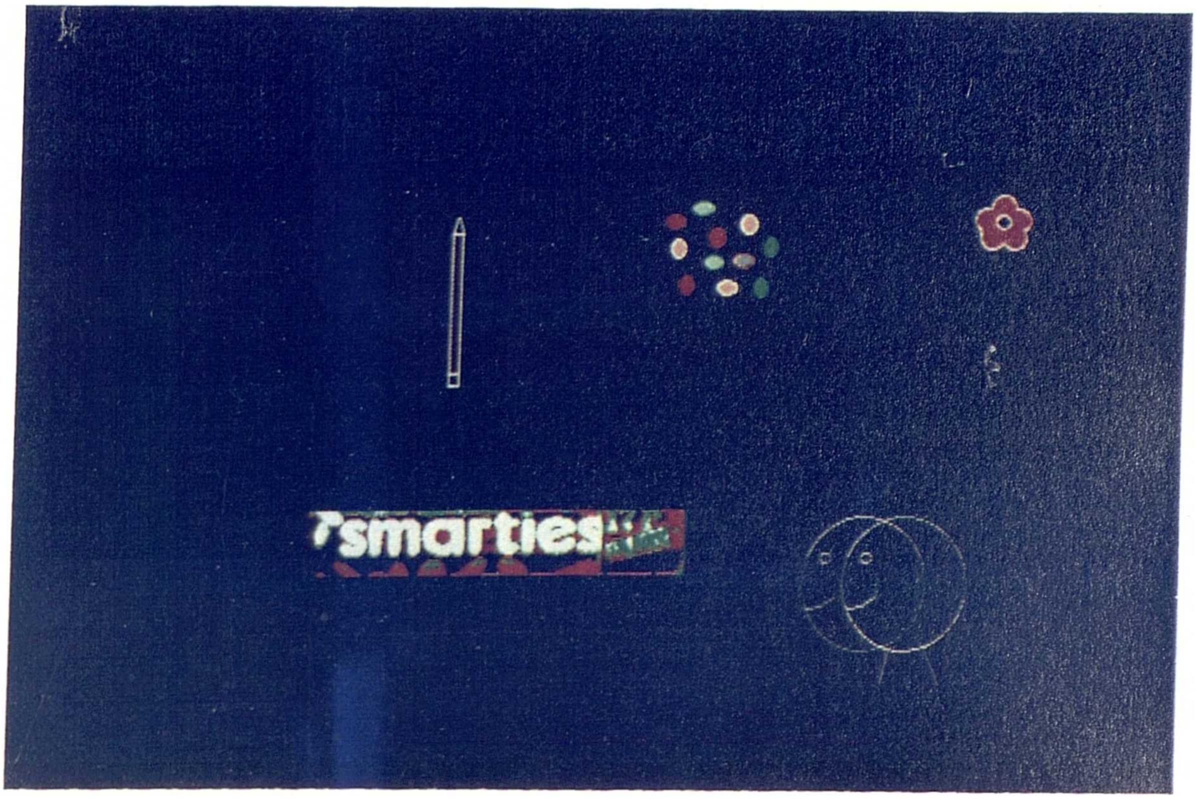


Figure 9.14

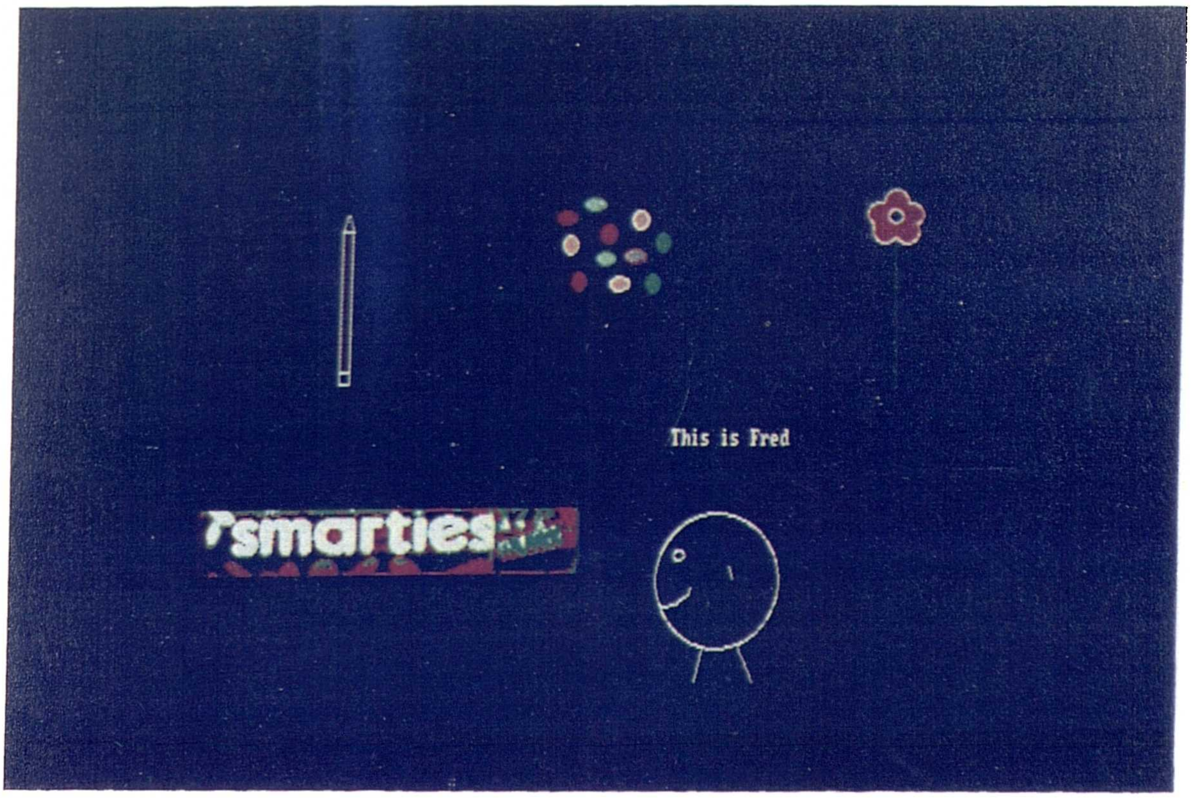


Figure 9.15

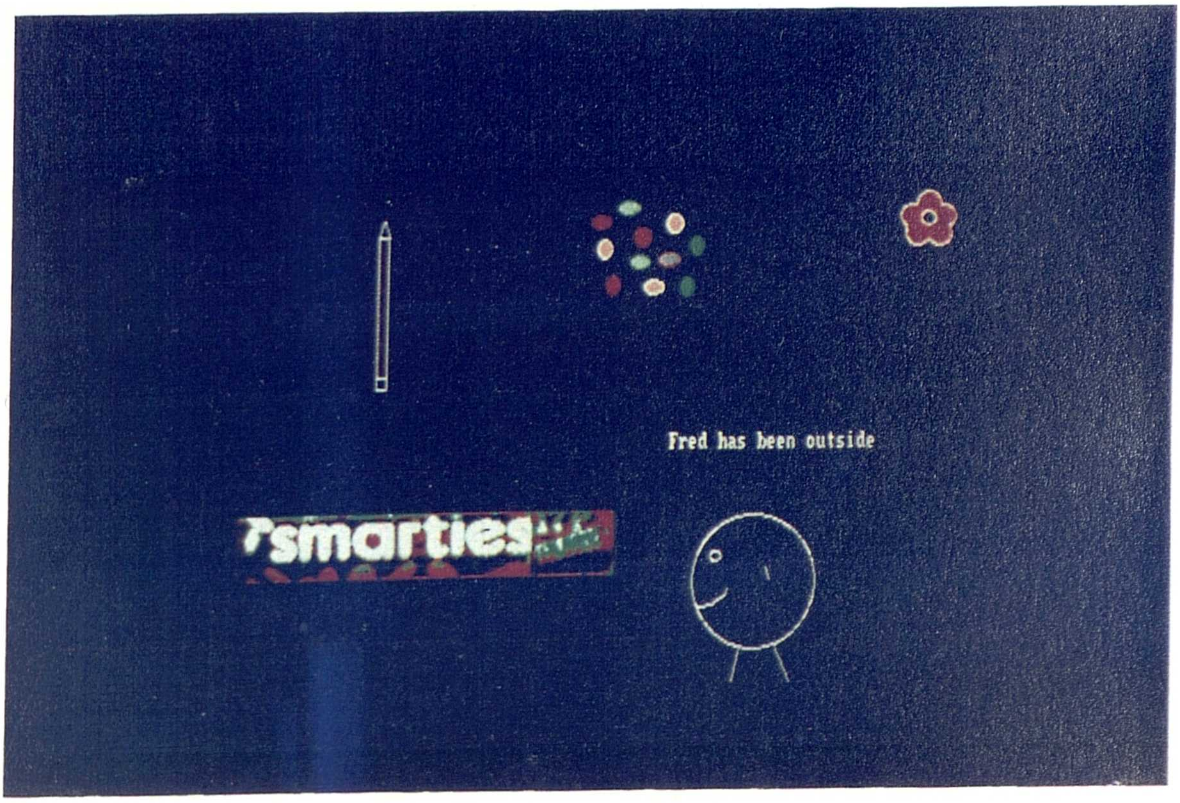


Figure 9.16

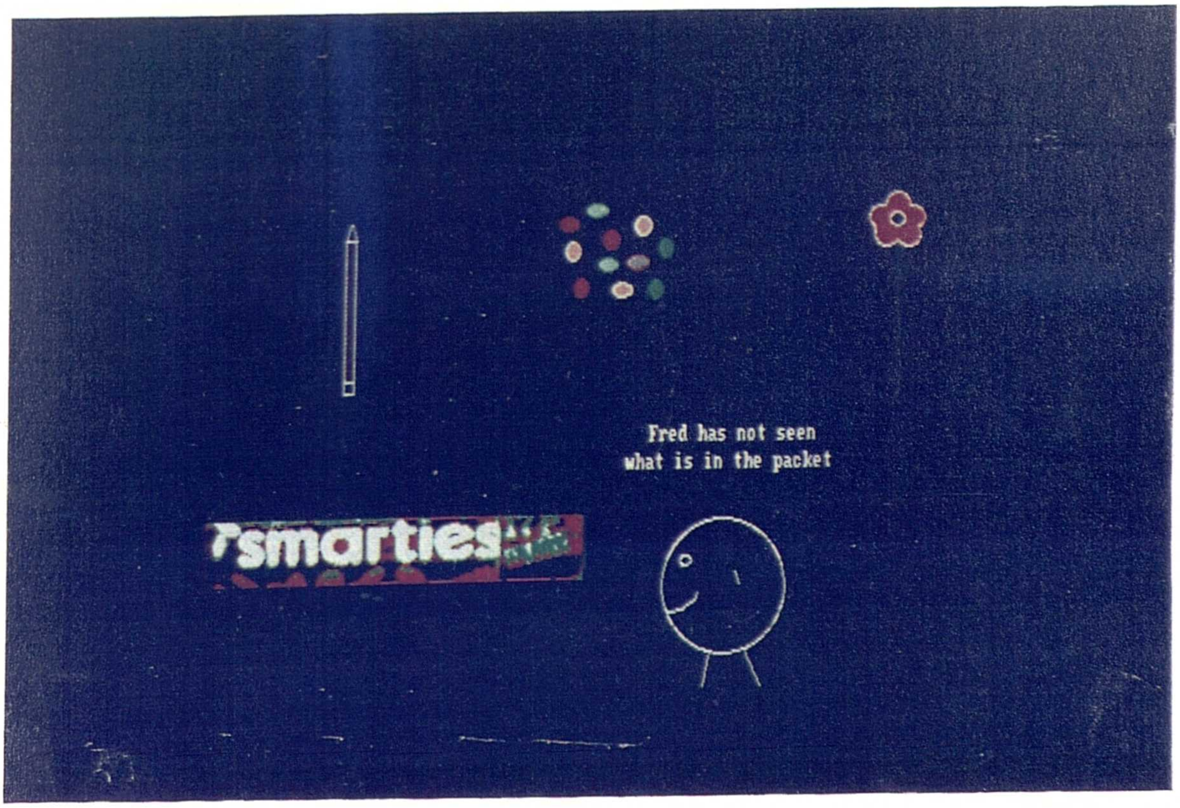


Figure 9.17

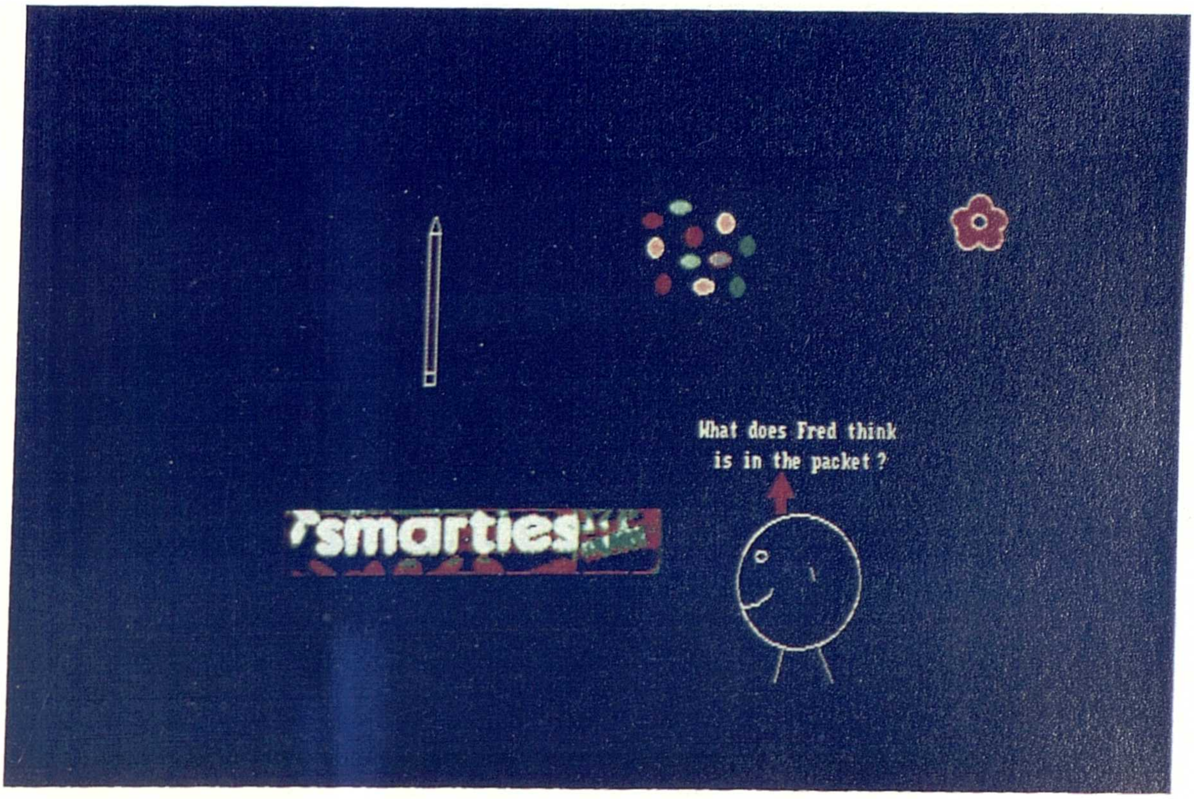


Figure 9.18

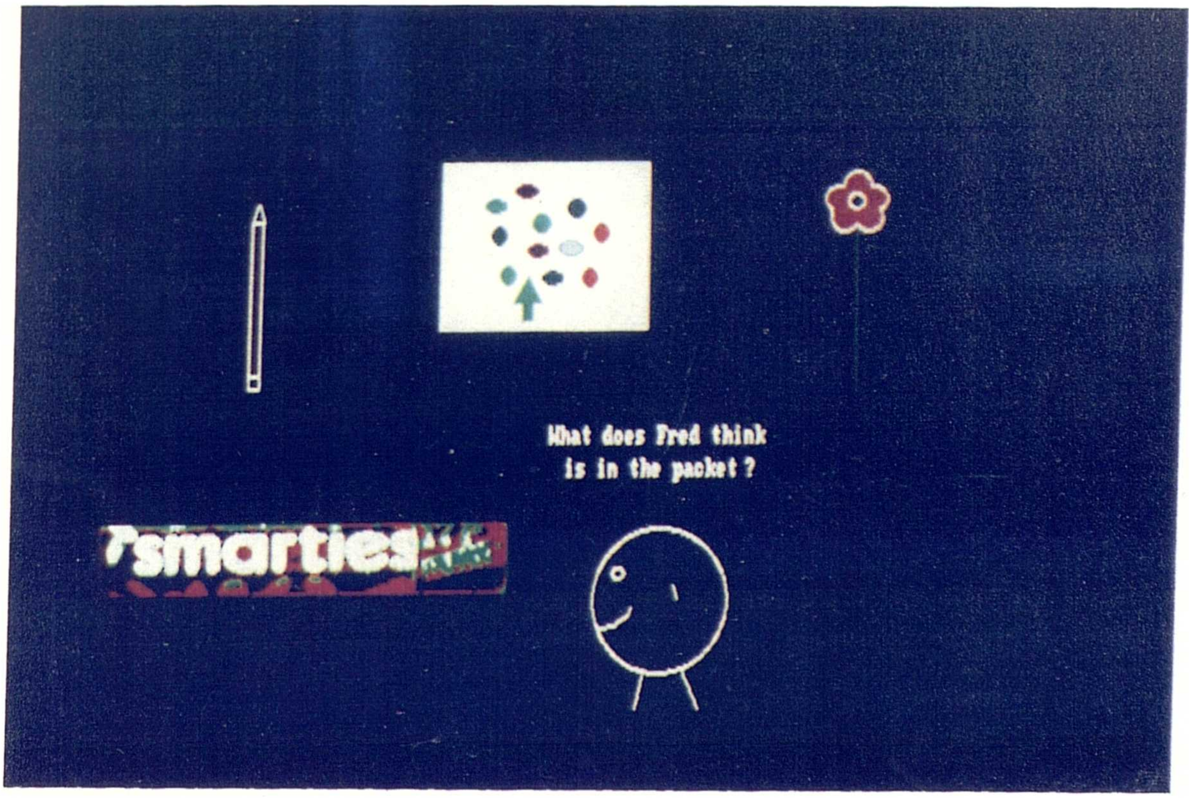


Figure 9.19

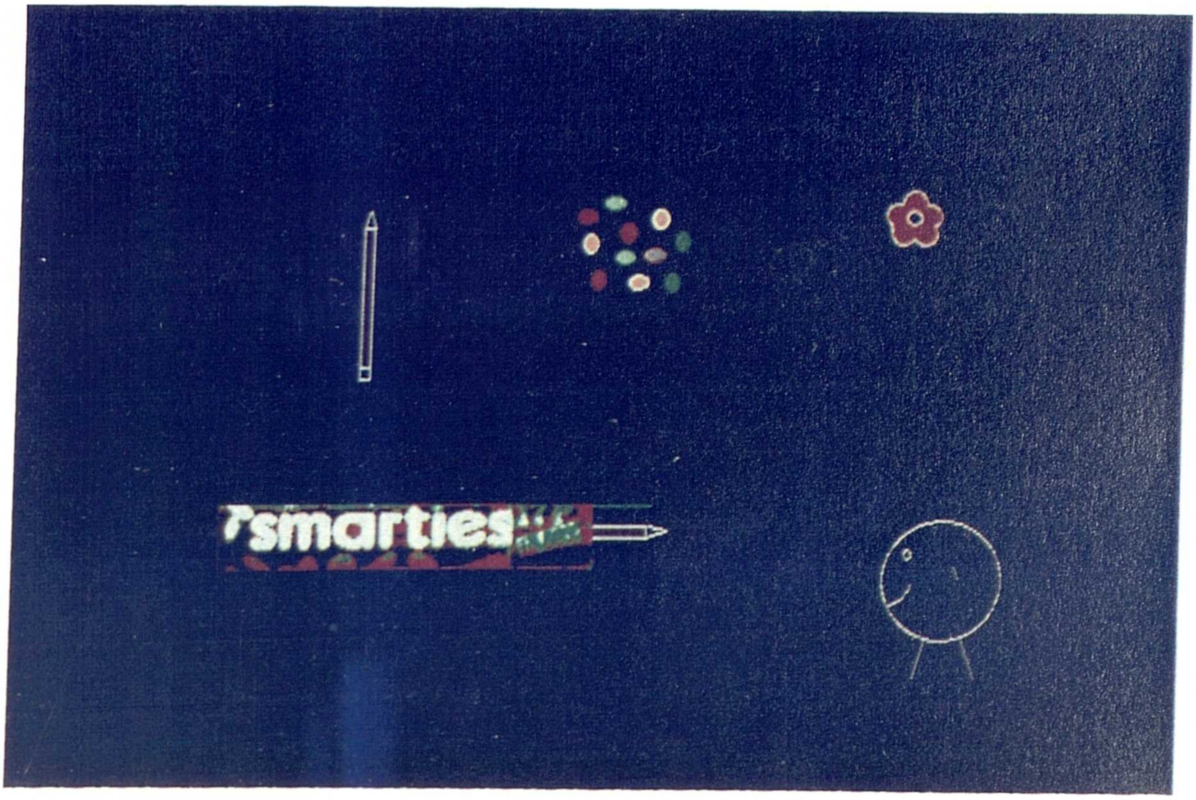


Figure 9.20

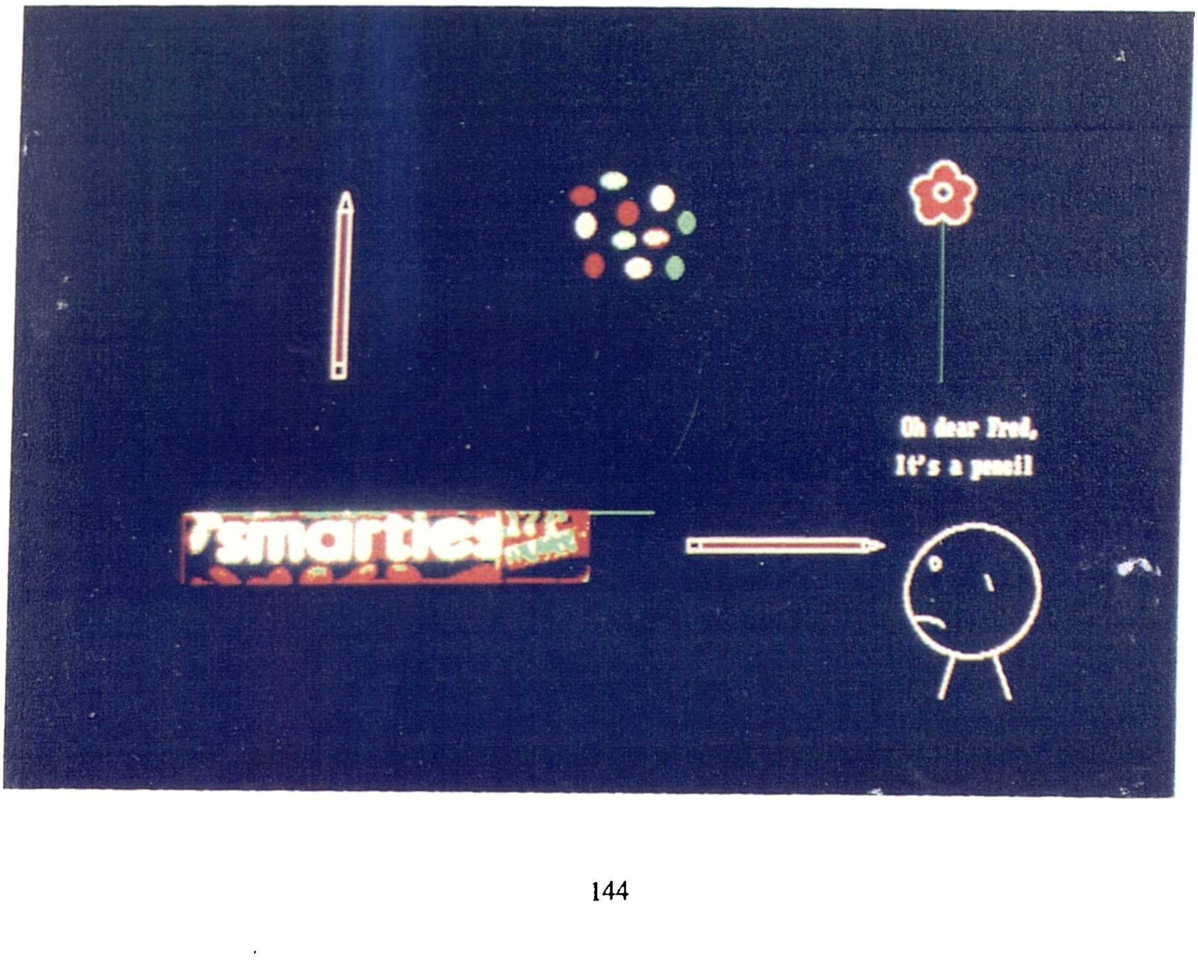
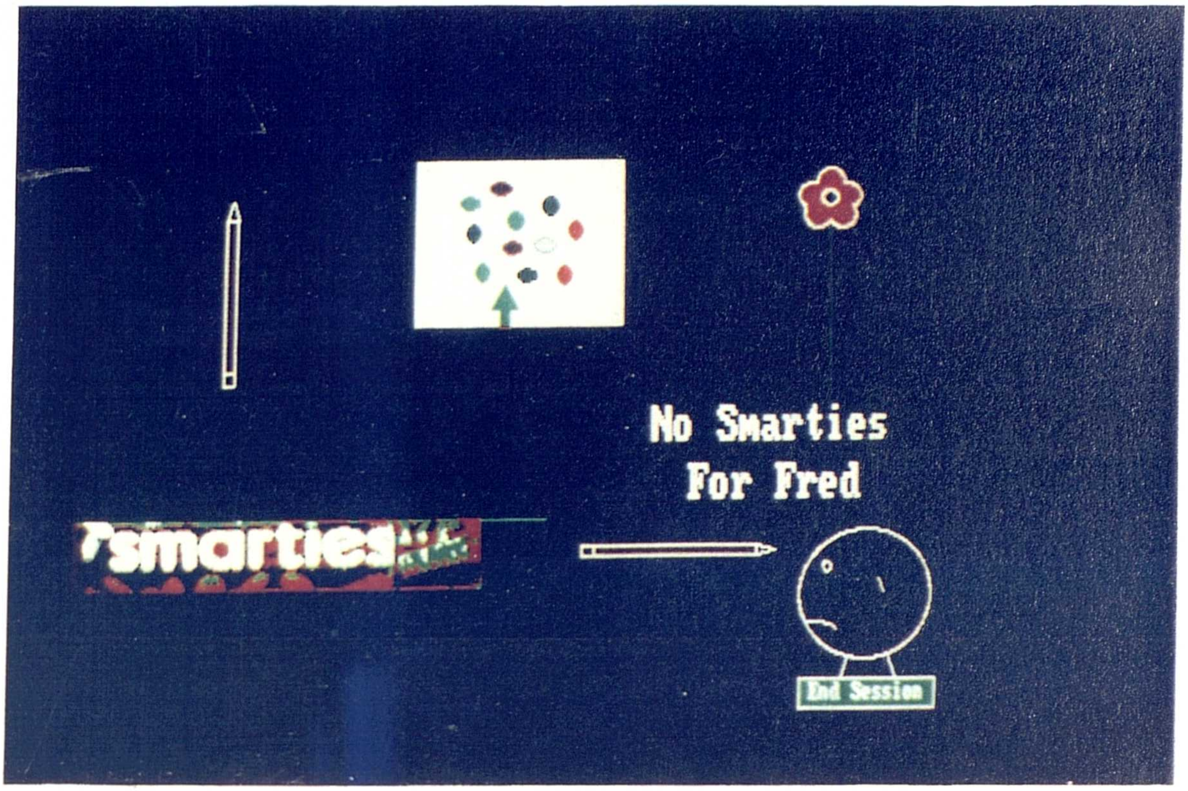


Figure 9.21



RESULTS

Table 29 shows the results of experiment 3 (smarties task) for the standard presentation and for the computer presentation. The responses of each subject to the test question and the three control questions are shown under the following column headings:-

T False belief test question - "What will (name) think is in the packet?"

C1 First Response control question - "What do you think is in the packet?"

C2 Reality control question - "Now what do you think is in the packet?"

C3 Own-Response control question - "When I first asked you, what did you think was in the packet?"

Table 29 also shows the summarised results of the Sally-Anne experiment (experiment 1) and retesting (experiment 2) alongside the results of the smarties experiment so that easy comparison of performance of each subject can be made across the three experiments.

The results showed that only five of nineteen children tested on the smarties task were able to pass the false belief test question. From the remaining 14 children who failed the test question, all but one passed the control questions correctly.

There was no difference between the results of the standard presentation and those of the computer presentation. Table 30 summarises the performance for the two different modes of presentation.

Table 29. Smarties Experiment Data

Standard Presentation

	Smarties Task				Expt1.		Expt 2.	
Subj	T	C1	C2	C3	TestQ	Cont	TestQ	Cont
A1	0	/	/	/	000	/	000	/
A2	/	/	/	/	000	/	0/	/
A3	/	/	/	/	///	/	///	/
A4	/	/	/	/	//	/		
A6	/	/	/	/	//	/	///	/
A8	0	/	/	/	000	/	000	/
A9	0	/	/	/	000	0	000	0
A10	/	/	/	/	///	/		
A12	0	/	0	/	000	0	000	0
A13	0	/	/	/	000	/	000	/
A14	0	/	/	/	000	0		
A15	0	/	/	/	0/0	0	000	0
A16	/	/	/	/	000	/	000	/
A17	0	/	/	/	000	/		
A18	0	/	/	/	000	0		
A19	0	/	/	/	000	0		
A20	0	/	/	/	000	/	000	/
A21	0	/	/	/	000	/	000	/
A23	0	/	/	/	000	/		

Computer Presentation

	Smarties Task				Expt1.		Expt 2.	
Subj	T	C1	C2	C3	TestQ	Cont	TestQ	Cont
A1	0	/	/	/	000	0	000	0
A2	/	/	/	/	00/	0	///	/
A3	/	/	/	/	///	/	//	/
A4	0	/	/	/	000	0		
A6	/	/	/	/	///	/	///	/
A8	0	/	/	/	000	/	00	/
A9	0	/	/	/	00	/	///	/
A10	/	/	/	/	/	/		
A12	0	/	0	/	0	0	/0	0
A13	0	/	/	/	000	/	00	/
A14	0	/	/	/	000	/		
A15	0	/	/	/	0/0	/	0/	/
A16	/	/	/	/	/0	/	0/	/
A17	0	/	/	/	000	/		
A18	0	/	/	/	000	/		
A19	0	/	/	/	000	/		
A20	0	/	/	/	000	/	00	/
A21	0	/	/	/	00	/	00	/
A23	0	/	/	/	000	/		

Table 30. Smarties Task. Comparison of performance on different modes of presentation

<table>
<tr><td colspan="4" rowspan="3"></td><td colspan="4">Standard Presentation</td></tr>
<tr><td colspan="4">Control Qns</td></tr>
<tr><td colspan="2">Pass</td><td colspan="2">Fail</td></tr>
<tr><td colspan="4"></td><td colspan="2">Test Qn</td><td colspan="2">Test Qn</td></tr>
<tr><td colspan="4"></td><td>Pass</td><td>Fail</td><td>Pass</td><td>Fail</td></tr>
<tr><td rowspan="4">C O M P U T E R</td><td rowspan="4">Control Qns</td><td rowspan="2">Pass</td><td>Test Q Pass</td><td>5</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fail</td><td>0</td><td>12</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Fail</td><td>Test Q Pass</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fail</td><td>0</td><td>0</td><td>0</td><td>2</td></tr>
</table>

The format for Table 30 is the same as for similar tables shown in Chapter 8 (eg. Table 25). The number in each cell refers to the number of children who performed that combination of responses for the Computer and Standard presentations.

Summarised comparisons of the results of the Smarties task with the results of the Sally-Anne task (experiment 1) are shown in tables 31 and 32. Since performance on the Smarties task was the same for both modes of presentation (see Table 30), the results from the Smarties task shown in tables 31 and 32 refer to both Standard and Computer presentation.

Table 31. Summarised comparison of performance on the Smarties task with performance on the Standard presentation of the Sally-Anne task

<table>
<tr><td colspan="5"></td><td colspan="4">Sally-Anne Task
(Standard Presentation)</td></tr>
<tr><td colspan="5"></td><td colspan="4">Control Qns</td></tr>
<tr><td colspan="5"></td><td colspan="2">Pass</td><td colspan="2">Fail</td></tr>
<tr><td colspan="5"></td><td colspan="2">Test Qn</td><td colspan="2">Test Qn</td></tr>
<tr><td colspan="5"></td><td>Pass</td><td>Fail</td><td>Pass</td><td>Fail</td></tr>
<tr><td rowspan="4">SMARTIES TASK</td><td rowspan="4">Control Qns</td><td rowspan="2">Pass</td><td rowspan="2">Test Q</td><td>Pass</td><td>3</td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>Fail</td><td>0</td><td>7</td><td>0</td><td>5</td></tr>
<tr><td rowspan="2">Fail</td><td rowspan="2">Test Q</td><td>Pass</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fail</td><td>0</td><td>0</td><td>0</td><td>2</td></tr>
</table>

The numbers on the diagonal represent those subjects who performed the same on the Smarties task as they did on the Sally-Anne task. Twelve of the nineteen subjects showed the same performance. There were two subjects who passed the test question and the control questions on the Smarties task but who had failed the test question and passed the controls on the Sally-Anne task. These 2 subjects were A2 and A16. Their overall performance will be mentioned in more detail in the discussion. Five subjects who had failed the test question and the controls on the Sally-Anne task, again failed the test question on the Smarties task but passed the Smarties task controls. This suggests that the control questions in the Smarties task were conceptually easier than those in the Sally-Anne task.

Table 32. Summarised comparison of performance on the Smarties task with performance on the Computer presentation of the Sally-Anne task

		Sally-Anne Task (Computer Presentation)			
		Control Qns: Pass		Control Qns: Fail	
		Test Qn: Pass	Test Qn: Fail	Test Qn: Pass	Test Qn: Fail
SMARTIES TASK: Control Qns Pass	Test Q Pass	3	1	0	1
	Test Q Fail	0	11	0	1
Control Qns Fail	Test Q Pass	0	0	0	0
	Test Q Fail	0	0	0	2

Table 32 shows the comparison of performance on the Smarties task and the computer presentation of the Sally-Anne task. Most of the numbers fall on the diagonal (16 out of 19), showing that performance on the two tasks was almost the same. There were only 3 subjects who did not perform in the same way on the two tasks. One subject (A2) who had failed both test question and control question on the original Sally-Anne task passed both test question and control on the Smarties task. Two subjects (A1 and A4) had failed test question and control question on the Sally-Anne task but on the Smarties task failed the test question and passed the control questions. Finally, subject A16 passed all the Smarties task but failed the test question of the Sally-Anne task, whilst passing the control questions.

DISCUSSION

In experiment 3, nineteen autistic children, from our original sample of twenty-three, were tested using the "Smarties" task. This task tested false belief but differed from the Sally-Anne task of experiments 1 and 2 as it involved using a deceptive appearance paradigm.

The results from the "Smarties" task provided further evidence that autistic children have difficulty understanding false belief. Most of the autistic children (68%) failed the false belief test question whilst passing the control questions, whilst only 26% passed the test question and controls. Only 1 autistic child (6%) failed the control questions and this subject also failed the test question.

The "Smarties" task was presented both in standard form and on the computer. Both of these forms of presentation yielded the same results. This would suggest that the standard and computer presentations are both measuring the same aspects of understanding and that it is the conceptual nature of the task (understanding of false belief) that causes the autistic children to fail.

We also compared the results of the "Smarties" task with the results of the Sally-Anne task (using the data from the first presentation of the Sally-Anne task which included all the subjects used in experiment 3). In other words we compared performance across two different types of tasks, both of which tested understanding of false belief. It was found that the performance of the autistic children was remarkably similar on the two different types of tasks, and this was true for both standard and computer presentations (see tables 31 and 32). This comparison demonstrates the consistency of the results and the robust nature of the finding that autistic children have difficulty understanding false belief.

Despite the concordance between the results from the Sally-Anne task and the Smarties task, there were some minor differences in performance that are worth mentioning. The main difference in the results was that more children passed the control questions on the Smarties task (although still failing the test question). This is not surprising however, given that the Smarties task involved fewer control questions and far less memory recall.

Two subjects passed the Smarties task having previously failed on the Sally-Anne task. A2 had failed the Sally-Anne task on the first experiment, but passed the Sally-Anne task on retesting with the computer version. A16 had shown a combination of passing and failing the computer version of the Sally-Anne task. For these subjects we might speculate that a gradual improvement in understanding of false belief was taking place in the first two experiments, and that this understanding enabled them to pass a different test of false belief in the form of the Smarties task. The third experiment took place 12 months after the first experiment. If they had passed the Sally-Anne experiment simply by learning some algorithm for the task (without understanding false belief) then it would be unlikely that they would pass the Smarties task.

Alternatively, subjects A9 and A15 showed a different pattern of results. A9 had improved on the Sally-Anne experiment to the extent that he was able to pass the computer version on retesting, having failed all previous trials. However, this subject failed the Smarties task. A15 showed a combination of passing and failing the Sally-Anne task but also went on to fail the Smarties task. It is possible that these subjects had passed the Sally-Anne task using some sort of algorithm, and since they had not developed an understanding of false belief, went on to fail the Smarties task.

If these two alternative explanations are correct then it is interesting that the subjects who we argue have truly developed understanding of false belief, A2 and A16, are much older (14:8 and 17:9 years) than the two subjects, A9 and A15, who had developed an alternative method of passing the Sally-Anne task (11 and 10:6 years). It follows that older autistic children develop understanding of false belief at this lower level, whereas younger children have not yet developed understanding but may be able to use a workable algorithm, within a specific situation.

To summarise the work so far, we have examined autistic children's understanding of false belief using different mediums of presentation and using different types of tasks. Despite our efforts to construct a task which may enable autistic children to display an understanding of false belief we still find that most autistic children fail to show this understanding. There are a few exceptions to this however, including a minority of children who pass all the tasks consistently and a small number who show a combination of responses.

We now have a profile of our autistic subjects which includes performance on two different types of tasks, each presented in different ways, chronological age, verbal and nonverbal mental age. In the next experiment, we intend to explore how these profiles are related to measures of cognitive and social behaviour in everyday life. If failure to form adequate metarepresentations is indeed the central cognitive deficit of autism, then its extent and nature should relate to everyday observed behaviours.

CHAPTER 10.

EXPERIMENT 4.

INTRODUCTION

The experimental work so far offers strong support for the hypothesis that autistic children have a specific deficit in their theory of mind. Such a deficit was found despite relevant changes to the text of the "Sally-Anne" task and despite changing the medium of presentation to one of computer graphics, which it was argued might be more accessible to autistic children. The deficit was also found on retesting and when using a different and new form of false belief task. These data support the recent findings of other researchers, that autistic children are unable to attribute mental states to others (Baron-Cohen, Leslie and Frith, 1985, 1986; Dawson and Fernald, 1987; Baron-Cohen , 1989a; Leslie and Frith, 1988; Perner, Frith, Leslie and Leekam, 1989; Harris and Muncer, 1988).

The next experiment considers the "ecological validity" of the theory of mind hypothesis,(ie the extent to which ability to use a theory of mind predicts a range of social and communicative behaviours, as measured by existing assessment instruments). This is done by examining whether performance on two theory of mind tasks (the revised Sally-Anne task and the Smarties task) is related to measures of adaptive behaviour.

Adaptive behaviour refers to the individual's "effectiveness in areas such as social skills, communication, and daily living skills, and how well the person meets the standards of personal independence and social responsibility expected of his or her age by his or her cultural group" (American Psychiatric Association, 1987). Although impairments in adaptive behaviour have long since been included in the definition of mental retardation, it is only recently that tests of adaptive behaviour have been adequately standardized with firmly established norms.

In this study a newly revised assessment instrument, the Vineland Adaptive Behaviour Scale (Sparrow et al, 1984), was used to document adaptive behaviour in autistic and Down's Syndrome children. This scale has been nationally standardized and is intended for use with children and adults with mental retardation. The scale has also been shown to have high reliability and validity (Cicchetti and Sparrow,1981; Sparrow et al,1984). There are three editions of the scale. In this study we used the Survey form , as it was the most appropriate for research and diagnosis. The Vineland Adaptive Behaviour Scale is administered by interviewing either the parent or caregiver of the subject. In this case the primary caregiver was interviewed, since many of the children were resident at the schools.

The Vineland is scored in terms of four domains: Communication, Daily Living Skills, Socialization and Motor Skills. Only the first three domains are used for ages 6 and over. Also, these domains can be divided into the following subdomains: (Communication) receptive, expressive, and written language; (Daily Living Skills) personal, domestic, and community; (Socialization) interpersonal relationships, play and leisure time, and coping. These features are summarised in table 33 below.

Table 33. Description of VABS contents used.

Domain	Subdomain	Content
Communication	Receptive	Understanding of communiction
	Expressive	Expressive communication
	Written	Reading and written communication
Daily living skills	Personal	Eating, dressing, self care skills
	Domestic	Household activities
	Community	Use of time, money, phone, job skills
Socialization	Interpersonal relationships	Social interaction
	Play & leisure	Use of play and leisure time
	Coping skills	Responsibility, sensitivity to others.

A child can be given any one of five possible scores on each item in the Vineland. Table 34 shows the scoring system.

Table 34. Key to Vineland Scoring System.

Score	Scoring criteria for activity
2	Usually or habitually performed.
1	Performed only sometimes.
0	Never performed.
N	No opportunity for it.
DK	Respondent does not know whether the individual can or cannot perform it.

A literature search revealed only a handful of studies which have used the Revised Vineland Adaptive Behaviour Scale (VABS) with autistic populations. These studies were concerned with differences between clinical groups rather than between subjects with differing cognitive abilities. The first of these (Sparrow et al, 1986) was a longitudinal study comparing "autistic-like" children with normals at preschool age and at 7 years of age. Between-group differences were found on all domains of the VABS at both ages, the Socialization Domain showing the greatest difference. Volkmar et al (1987) compared autistic children on the VABS with non-autistic children matched for age, gender, and Mental Age. Again it was found that autistic children exhibited significantly greater deficits in the Socialization Domain than non-autistic children. Loveland and Kelly (1988) measured adaptive behaviours of young adult autistic and Down's Syndrome subjects. For this age range, no significant differences in adaptive behaviour were found between these groups when matched for Verbal Mental Age. However there was a trend towards greater deficits in socialisation within the autistic group; furthermore, those with autism were found to be significantly less advanced in communication and socialization than were Down's Syndrome subjects with similar Non-Verbal Mental Age. Finally, Freeman et al (1988) also reported lower scores for autistic children compared to Down's Syndrome children in the Socialization Domain.

All of these studies then, have found that the VABS is a useful instrument for documenting autistic behaviour and that a deficit particularly in the Socialization Domain is characteristic of autistic children. These studies have also shown that autistic children are impaired, to a lesser extent, in the Communication Domain, but remain largely unimpaired, relative to Mental Age, in the Daily living Skills Domain.

The present study uses a group of autistic subjects and a group of Down's Syndrome subjects. Our main interest is whether subjects who fail the false belief task differ from subjects who pass. Each clinical group is divided into subgroups of those who pass and those who fail the theory of mind tasks. Any differences in adaptive behaviour between the subgroups of children who pass and fail the tasks will be of great interest in the light of the theory of mind hypothesis, since this hypothesis claims to explain real behaviour in terms of cognition. It will also be possible to find out whether there are any interaction effects, ie: whether the clinical groups differ in terms of the effects the cognitive deficit has on behaviour. Finally, we can also examine whether there is an overall difference between the clinical groups in their level of adaptive behaviour, after controlling for performance on the theory of mind tasks.

Comparison of the Pass and Fail subgroups

A number of predictions can be made, consistent with the theory of mind hypothesis. Firstly, if this cognitive deficit does produce deficits in social behaviour, then we would expect that the subgroup who fail the false belief task would show greater deficits than those who pass, in the Socialization Domain, especially on those items that employ a theory of mind. We might also expect those who fail to be more impaired in the Communication Domain, although this would depend on the extent to which the Communication Domain measures the specific aspects of communication that require understanding of mental states. In addition, we would predict that the Daily Living Skills Domain score, which may not require a theory of mind, would not be related to performance on the false belief tasks. Finally, if we assume that Passing or Failing means the same for subjects in any clinical group, then our predictions should be true regardless of clinical group.

If differences between the Pass and Fail subgroups are found within certain subdomains, it will then be of interest to find out exactly which items are involved using an item analysis. There are three possible outcomes. The items that differentiate the subgroups might be:-

1. Only items which require a theory of mind.
2. Items which require a theory of mind plus other items.
3. A variety of items (where some items requiring a theory of mind are not involved).

The first outcome is the strongest prediction of the theory of mind hypothesis; that failure on the cognitive tasks is associated with failure only on items requiring a theory of mind. Other items of adaptive behaviour should not be affected (ie items not requiring the use of metarepresentations). This outcome would validate the cognitive tasks by showing that performance on the tasks is related to "real life" behaviours involving theory of mind.

The second outcome would suggest that failure on the cognitive tasks is associated with items relevant to theory of mind but also to additional factors. This could either be because the cognitive deficit causes more widespread disability, (eg. affecting the learning of other social skills), or that the cognitive deficit is simply an associated symptom, rather than a cause. In other words, those with the cognitive deficit may also have some general social deficits (Goodman, 1990).

The third outcome would be the most unpredictable and surprising finding. If the items differentiating the pass and fail subgroups bear no relation to items requiring a theory of mind, then this would refute the "ecological validity" of the theory of mind hypothesis. There might be a number of possible explanations for such a result. One would be that the understanding of false belief (and hence, metarepresentational capacity) does not relate to behaviour. Another is that the tasks lack validity. A third explanation might be that the items chosen by independent judges to "require a theory of mind" were inappropriate in some way.

Comparison of the Autistic and Down's Groups

It will also be possible to make an overall comparison of the adaptive behaviour profile of the autistic group with that of the Down's Syndrome group. However, it should be noted that the subjects in these groups have been selected according to their performance on the cognitive tasks (ie a stratified random sample rather than a simple random sample), so that there are an equal number in each subgroup within the groups. This means that our groups are not a good representative sample of the clinical groups as a whole. The autistic group has far more passing subjects than one would expect from a randomly selected sample, and the Down's Syndrome group has more failing subjects.

The comparison between the Down's and autistic groups remains an interesting one, given that the two groups have equal numbers of "pass" and "fail" subjects. Our null hypothesis, based on the simplest scenario that "passing" and "failing" means the same in terms of cognitive capacity for both groups, would be that there will be no overall difference and no interaction between the clinic groups and the performance subgroups. In other words, if we contend that the cognitive deficit underlies deficits in behaviour, and is the only or major cause, then groups matched for cognitive performance should not differ in their adaptive behaviour profile.

In the event that differences were found between the clinical groups in certain subdomains, an item analysis was planned in order to find out which items might be most relevant.

METHOD

SUBJECTS

Subjects were 20 autistic children and 20 Down's Syndrome children, individually matched for Chronological Age, Verbal Mental Age and Non-Verbal Mental Age, (See Tables 35. and 36 for details).

Autistic subjects

Eleven of the autistic subjects had been used in previous experiments in this thesis. The remaining nine autistic subjects were recruited from either Radlett School or Brondyffryn School (see Chapter 5 for details). The group consisted of 15 males and 5 females, which reflects the male:female ratios found in epidemiological studies (Rutter and Schopler,1987). All these subjects had a primary diagnosis of autism according to DSM-III criteria. There were no subjects with a Verbal Mental Age below 4 years, as measured on the British Picture Vocabulary Scales (BPVS). All of these subjects were resident at school during week days, returning home at the weekend.

Down's Syndrome subjects

The Down's syndrome group consisted of 12 males and 8 females. All had trisomy 21. All the subjects in this group had a Verbal Mental Age above 4 years, on the BPVS. Subjects were recruited from either Dee Bank School or Foxfield School (see Chapter 5 for details). In contrast to the autistic children, none of the Down's Syndrome children were resident at the school.

Subjects were required to meet strict criteria of consistent performance on the two false belief tasks in order to be included in either the pass subgroup or the fail subgroup. In particular, it was required that all the subjects passed all the control questions on both cognitive tests. This was done to ensure that subjects differed only in their understanding of the crucial belief questions on the tasks. As a result the majority of the subjects used in this study were "high functioning" for their clinical group.

Criteria for inclusion in the Pass or Fail subgroup.

Subjects were placed into one of two subgroups, or left out of the study, according to their performance on the false belief tasks.

Pass subgroup:	Subjects included in the Pass subgroup had passed both the Sally-Anne and the Smarties tasks (standard versions). This included passing the belief and the control questions.
Fail subgroup:	Subjects included in the Fail subgroup had failed one or both of the false belief tasks. In order for tasks to be counted as a "fail" the subject had to have passed all the control questions on that task, whilst failing the crucial belief test question.
Excluded subgroup:	Subjects who failed both the belief and control questions.

MATCHING

The matching procedure first concentrated on the autistic group, since these subjects were hardest to find. The subgroups were first matched for Chronological Age. Verbal Mental Age and Non-Verbal Mental Age were kept as similar as possible across the subgroups. A similar procedure was then carried out for the Down's group, matching the Pass and Fail subgroups. During the Down's group matching an attempt was also made to keep the clinical groups as similar as possible. The purpose of matching is to ensure that Chronological Age and Mental Age are not the source of any differences found between the clinical groups or subgroups in Vineland Adaptive Behaviour Scale scores, although statistical control of these factors was also employed.

Subjects received the Leiter International Performance Scale and the British Picture Vocabulary Scale which measure Non-Verbal and Verbal IQ respectively. These are standard IQ tests, appropriate for the clinical groups in this study (see Chapter 5).

PROCEDURE

The study involved two sessions with each child and a third session interviewing a teacher or caregiver.

Session 1

In the first session each child was presented with the two false belief tasks (non-computer versions) used previously in the thesis.

The Sally-Anne task used was the revised version of the task used by Perner, Leekam and Wimmer to test false belief understanding in young normal children (Perner, Leekam and Wimmer, 1987), and includes added text and a further three control questions. Although this version had not been used with autistic children before (and so may not be considered "standard"), it was used in the previous experiments of the thesis. The second false belief task used was the Smarties task devised by Perner et al (1987), which was also previously used in the thesis. The order of presentation of these tasks was counterbalanced.

Session 2.

In the second session each child was tested using the 2 standard IQ tests; The Leiter International Performance Scale and The British Picture Vocabulary Scale.

Session 3.

The primary caregiver was interviewed using a semistructured interview format using the Revised Vineland Adaptive Behaviour Scale Survey Form (Sparrow et al, 1984). Each interview lasted approximately 40 minutes. Both interviewer and caregiver were aware of the final diagnosis of the child. Raw scores were obtained for three domains (Communication, Daily Living Skills and Socialisation). Following the protocol of the Vineland Adaptive Behaviour Scale, scores were not obtained for the Motor Skills domain as subjects were over 6 years of age. Also, no scores were obtained for the optional maladaptive behaviour domain.

Theory of mind item reliability.

In order to interpret the item analysis it is necessary to have some rating to indicate which items might reflect behaviour requiring a theory of mind and which items reflect behaviour not requiring a theory of mind.

Twenty-four items were selected by the experimenter, twelve of which were thought to be "theory of mind items." Most of these items were in the Socialization Domain, although a small number of items were to be found in the Communication Domain. Four independent judges, all psychologists, were asked to assess which of these items "requires the use of a theory of mind" (see appendix for details of items used). "Theory of mind" was defined in simple terms to the judges as "being able to take into account one's own or someone else's mental states." In addition, the judges were told "examples of mental states are -: thinking, pretending, knowing, dreaming and wanting."

RESULTS

The details of each subject's Chronological Age, Verbal Mental Age and Non-Verbal Mental Age are shown in Table AA. and Table BB. below. The tables show the subjects divided into Pass and Fail subgroups within each Group. The Means and Standard Deviations for each subgroup are also shown.

Table 35. Subject Characteristics (Autistic Group)

	Fail				Pass		
Sn	CA	VMA	NVMA	Sn	CA	VMA	NVMA
A30	10:11	10:3	8:0	A6	10:5	10:4	7:8
A8	11:1	5:5	8:6	A29	11:0	6:1	6:7
A13	13:10	7:9	6:10	A3	13:9	8:7	14:6
A1	14:3	7:2	6:7	A27	14:1	7:4	7:2
A2	14:5	7:11	6:5	A25	14:9	7:9	6:0
A20	14:10	8:5	10:5	A26	14:6	8:7	10:3
A21	15:4	7:4	10:6	A24	15:0	7:9	8:1
A17	16:10	7:7	10:9	A31	16:11	7:1	10:0
A32	16:9	15:1	13:1	A10	16:7	15:4	12:10
A23	16:10	11:5	9:4	A28	16:10	10:9	8:7
Mean	14:6	9:0	9:1		14:5	9:2	9:2
SD	2:2	2:9	2:2		2:3	2:8	2:9

Table 36. Subject Characteristics (Down's Syndrome Group)

	Fail				Pass		
Sn	CA	VMA	NVMA Sn		CA	VMA	NVMA
D33	10:4	6:3	6:7	D43	10:6	6:2	7:0
D34	11:1	6:3	9:0	D44	11:0	6:4	8:6
D35	11:10	7:6	7:1	D45	11:10	7:6	7:10
D36	12:6	7:6	7:1	D45	11:10	7:3	9:4
D37	14:3	8:6	8:2	D47	14:5	8:8	8:4
D38	15:2	9:5	9:1	D48	16:1	9:1	9:4
D39	16:9	9:7	8:9	D49	17:2	9:3	8:3
D40	17:8	10:1	7:8	D50	17:8	10:9	8:2
D41	13:2	8:3	7:2	D51	13:6	8:1	7:4
D42	14:8	8:4	7:6	D52	14:4	8:5	7:6
Mean	13:9	8:2	8:1		13:10	9:0	8:2
SD	2:5	1:4	1:0		2:7	3:0	0:9

Key to Table 35. and Table 36.

CA	Chronological Age
VMA	Verbal Mental Age
NVMA	Non-Verbal Mental Age
Sn	Subject number
y:m	years:months

These data show that the subjects were closely matched on all three measures. However, since the subjects were not perfectly matched, a stepwise analysis of covariance was employed with covariates Chronological Age, Verbal Mental Age and Non-Verbal Mental Age. This procedure was carried out in order to calculate the contribution of these covariates in accounting for Group and subgroup differences in Vineland Adaptive Behaviour Scale scores, and where any of these predict, to control for bias and to improve the power of subgroup comparisons.

None of these measures were found to be significant predictors of Vineland score on the Communication Domain and its subdomains or on the Socialization Domain and its subdomains. However, Chronological Age was found to be a significant predictor of the Daily Living Skills Domain and its three subdomains. These results are shown in Table 37.

Table 37. Chronological Age as a predictor of Vineland scores.

Domain/Subdomain	Raw Score		Age Eq Score	
	F	p	F	p
Daily Living Sk.	47.6	<0.001	43.0	<0.001
Personal	31.2	<0.001	22.9	<0.001
Domestic	60.7	<0.001	57.6	<0.001
Community	30.0	<0.001	27.2	<0.001

Two sets of analyses were subsequently carried out. Raw scores were used in the first set of analyses. For the second set of analyses, raw scores were converted to age equivalent scores, using the Vineland Norms tables. Age equivalent scores are useful when comparing subjects ranging in ages and are appropriate given the developmental nature of the subdomains. Age equivalent scores were used in preference to standard scores which cannot be derived below a score of 20.

Due to the large number of items being examined (N= 225 in the Vineland) a strategy of hypothesis testing was necessary in order to avoid compromising the a-priori probability levels.

For each of the 3 Domains and 9 subdomains a linear model was used of the form:

subdomain score = Constant + (1)performance + (2)clinical group + (3) performance * clinical group+ random error term.

For the Daily Living Skills Domain and its subdomains, Chronological Age was included in this model as a covariate. Only where there was statistical evidence of an effect on any of the factors (1)-(3) was this investigated by analysing in a similar fashion the individual items making up the subdomain.

A Normal model was assumed when analysing the subdomains, applying standard maximum likelihood methods for analysis of variance/covariance. When analysing the individual items a binomial model was assumed, again using maximum likelihood after a log-linear transformation.

An analysis of variance was carried out for each Domain and subdomain using these raw scores. Firstly, the analysis of variance tests for an interaction, in other words whether a pass/fail effect is found to be significantly greater for one clinical group compared to another. Where there was no evidence of an interaction, the scores of those subjects who pass were compared with those who fail the cognitive task, regardless of clinical group, and the scores of the autistic group as a whole were compared with the scores of the Down's syndrome group regardless of performance on the cognitive tasks. Where there was evidence of an interaction separate analyses were carried out for each clinical group to assess the effect of performance, and for each performance group to assess the effect of clinical group.

Table 38. shows the mean raw scores for each subgroup on the three Domains and nine Subdomains.

Table 38 Mean Raw Scores

Domain/Subdomain	Autistic Gp.			Down's Gp.		
	Pass Mean	Fail Mean	Group Mean	Pass Mean	Fail Mean	Group Mean
Communication	80.8	79.7	80.3	90.2	86.7	88.5
Receptive	24.0	23.8	23.9	25.6	25.8	25.7
Expressive	46.2	44.6	45.4	53.8	49.7	51.8
Written	11.6	11.3	11.5	10.8	11.2	11.0
Daily Living Sk.	108.2	107.3	107.8	114.9	115.5	115.2
Personal	67.1	66.3	66.7	68.2	69.0	68.6
Domestic	16.8	16.9	16.9	19.5	19.2	19.4
Community	24.3	24.1	24.2	27.2	27.3	27.3
Socialization	76.9	48.9	62.9	94.0	77.1	85.6
Interpers.	36.6	28.0	32.3	43.9	38.5	41.2
Play & Leis.	21.4	11.8	16.6	24.5	22.5	23.5
Coping	18.6	9.1	13.9	25.6	16.1	20.9

Key

Daily Living Sk.	Daily Living Skills
Interpers.	Interpersonal Relationships
Play & Leis.	Play and Leisure Time

nb Subdomains inset.

For the Daily Living Skills Domain and its subdomains the means have not been adjusted for Chronological Age as the differences in the estimates with and without this covariate were negligible, reflecting the adequacy of matching.

Table 39. shows the results of the analysis of variance calculations, displaying the F ratio and the p value for each domain and subdomain.

Table 39. Analysis of Variance (Raw Scores)

Domain/Subdomain	Pass vs Fail		Aut vs Downs		Interaction	
	F	p	F	p	F	p
Communication	0.9	0.361	10.9	0.002	0.2	0.635
Receptive	0.0	1.000	18.2	<0.001	0.2	0.642
Expressive	4.3	0.045	21.3	<0.001	0.8	0.371
Written	0.1	0.965	0.2	0.689	0.1	0.759
Daily Living Sk.	0.1	0.944	10.5	0.003	0.2	0.699
Personal	0.1	0.983	8.0	0.007	1.0	0.327
Domestic	0.1	0.901	12.3	<0.001	0.1	0.998
Community	0.1	0.961	6.4	0.016	0.1	0.829
Socialization	48.2	<0.001	49.1	<0.001	3.1	0.086
Interpers.	29.3	<0.001	47.3	<0.001	1.6	0.221
Play & Leis.	14.5	<0.001	20.5	<0.001	7.3	0.011
Coping	63.7	<0.001	34.6	<0.001	0.0	1.000

Interaction effects

Interaction effects reflect a larger pass-fail difference in one clinical group than another.

There was some evidence of an interaction in the Socialization Domain overall (F=3.1, p=0.086), this being attributed mainly to the Play and Leisure Time subdomain (F=7.3, p<0.011). The main effect results of performance and clinical group for this Domain and subdomain should therefore be treated with caution and separate t-tests are required since the performance effect is not constant across the two clinical groups. However, for the remaining areas of adaptive behaviour no evidence of an interaction was found.

Pass vs Fail comparison.

There was strong evidence of a difference between the Pass and Fail subjects on the Interpersonal Relationships subdomain ($F=29.3, p<0.001$) and on the Coping Skills subdomain ($F=63.7, p<0.001$). The mean scores shown in Table 38 show that the Pass subjects scored consistently higher than that for the Fail subjects in these subdomains. This trend is also true of the Socialization Domain and Play and Leisure Time subdomain where there is an interaction effect.

Separate t-tests comparing (a priori) the mean scores for the Pass and Fail subgroups within each Group were carried out. For the Socialization Domain the difference between the means was significant for the Down's Group ($t=6.26$, $p<0.001$) and for the autistic Group ($t=4.93$, $p<0.001$). For the Play and Leisure Time subdomain, the Pass and Fail subgroup mean scores differed for the autistic Group ($t=3.88$, $p<0.001$), but there was no evidence of a difference in these scores for the Down's Syndrome Group ($t=1.49$, $p=0.155$)

Analysis of variance also produced evidence of a difference between the Pass and Fail subgroups on the Expressive subdomain ($F=4.3$, $p=0.045$).

Pass and Fail subjects did not differ on the Communications Domain, the Daily Living Skills Domain or any of the remaining subdomains.

Autism vs Down's Syndrome comparison.

Table 39 shows strong evidence that the Groups differ in Vineland scores in all areas apart from the Written subdomain ($F=0.2$, $p=0.689$). Table 38 shows that the Down's Syndrome subject's mean score was consistently higher than the autistic subject's, in both performance categories.

Separate t-tests were carried out for the Socialization Domain and the Play and Leisure subdomain since there were interaction effects in the analysis of variance. When the subjects who passed the cognitive tests were analysed separately the Down's Group had a significantly higher mean score than the autistic Group on the Socialization Domain ($t=3.38$, $p=0.007$), but there was no difference between the Groups on the Play and Leisure Time subdomain ($t=1.32$, $p=0.210$). When the Fail subjects were analysed separately, autistic and Down's Syndrome subjects both differed on both the Socialization Domain ($t=7.55$, $p<0.001$) and the Play and Leisure Time subdomain ($t=6.81$, $p<0.001$)

Age Equivalent Scores

Analyses were also carried out using Age equivalent scores. Table 40 shows the mean age equivalent scores for each subgroup on the three Domains and nine subdomains. The basic pattern of results mirrored the findings for the raw scores.

Table 40. Mean Age Equivalent Scores

Domain/Subdomain	Autistic Gp			Down's Gp		
	Pass Mean	Fail Mean	Group Mean	Pass Mean	Fail Mean	Group Mean
Communication	57.3	55.7	56.5	68.9	64.5	66.7
Receptive	55.8	53.7	54.8	84.6	89.3	87.0
Expressive	49.1	44.8	47.0	70.3	57.1	63.7
Written	73.6	73.0	73.3	71.8	72.8	72.3
Daily Living Sk.	75.1	73.5	74.3	83.3	84.4	83.9
Personal	77.5	73.2	75.4	82.4	87.4	84.9
Domestic	75.1	76.0	75.6	87.3	85.5	86.4
Community	74.5	73.1	73.8	81.1	81.2	81.2
Socialization	64.9	28.4	46.7	90.9	62.1	76.5
Interpers.	57.4	27.9	42.7	104.6	62.1	83.4
Play & Leis.	58.9	15.6	37.3	69.1	57.6	63.4
Coping	74.9	48.6	61.8	100.4	66.5	83.5

Analysis of variance tests were computed for each Domain and subdomain using age equivalent scores. The results are shown in Table 41 which shows the F ratio and p value for each calculation. Adjustment was made for Chronological Age in the Daily Living Skills Domain.

Table 41. Analysis of Variance (Age Equivalent Scores)

Domain/Subdomain	Pass vs Fail		Aut vs Downs		Interaction	
	F	p	F	p	F	p
Communication	1.0	0.334	11.1	0.002	0.2	0.654
Receptive	0.1	0.860	19.2	<0.001	0.2	0.649
Expressive	4.8	0.035	17.5	<0.001	1.2	0.272
Written	0.1	0.924	0.2	0.632	0.1	0.705
Daily Living Sk.	0.1	0.894	10.4	0.003	0.2	0.665
Personal	0.1	0.996	4.2	0.049	1.0	0.320
Domestic	0.1	0.900	12.0	<0.001	0.1	0.918
Community	0.1	0.863	6.2	0.017	0.1	0.764
Socialization	46.0	<0.001	38.4	<0.001	0.6	0.431
Interpers.	43.4	<0.001	55.5	<0.001	1.4	0.239
Play & Leis.	8.7	0.006	7.9	0.008	3.1	0.088
Coping	57.3	<0.001	29.8	<0.001	0.9	0.346

Interaction effects

There was some evidence of an interaction in the Play and Leisure Time subdomain (F=3.1, p=0.088). It was therefore necessary to carry out separate t-tests for this subdomain. However, Interaction effects were not found on any of the other Domains or subdomains.

Pass vs Fail comparison.

There was strong evidence of a difference between the Pass and Fail subjects on the Socialization Domain (F=46.0, p<0.001), the Interpersonal Relationships subdomain (F=43.4, p<0.001) and the Coping Skills subdomain (F=57.3, p<0.001). The mean scores shown in Table 40 show the Pass subjects score consistently higher than the Fail subjects in these subdomains. This trend is also true of Play and Leisure Time subdomain where there was an interaction effect.

Separate t-tests comparing the mean scores for the Pass and Fail subgroups within each Group were carried out on the Play and Leisure Time subdomain. The Pass and Fail subgroup mean scores differed for the autistic Group (t=2.70, p=0.024), but there was no evidence of a difference in these scores for the Down's Syndrome Group (t=1.37, p=0.186)

Analysis of variance also produced evidence of a difference between the Pass and Fail subgroups on the Expressive subdomain (F=4.8, p=0.035).

Pass and Fail subjects did not differ on the Communications Domain, the Daily Living Skills Domain or any of the remaining subdomains.

Autism vs Down's Syndrome comparison.

Table 41 shows strong evidence that the Groups differ in Vineland scores on all areas apart from the Written subdomain (F=0.2, p=0.689). Table 40 shows that the mean score of the Down's Syndrome subjects was consistently higher than the autistic subjects.

Separate t-tests were carried out for the Play and Leisure Time subdomain since there was some evidence of an interaction effect in the analysis of variance. When the subjects who passed the cognitive tests were analysed separately there was no evidence of a difference between the Groups (t=0.60, p=0.560). However when the Fail subjects were analysed separately, autistic and Down's Syndrome subjects differed on the Play and Leisure Time subdomain (t=6.69, p<0.001), such that the autistic Fail subgroup scored particularly low on this subdomain, whereas the Down's

Fail subgroup had a similar mean score to the Pass subjects of both clinical group.

Item Analysis.

The item analysis was carried out only where there was any effect in the subdomain; furthermore, only that effect was considered in the analysis. In fact, the results of the initial analyses, shown above, made it necessary for item analyses to be carried out on each subdomain with the exception of the Written subdomain. The Pass/Fail effect was only considered in the Socialization subdomains and the Receptive subdomain (of the Communication Domain), where differences in this effect had been found in earlier analyses. The overall difference between clinical groups (ie the autism/Down's effect), however, was considered for each subdomain, apart from the Written subdomain of the Communications Domain where no effect was found. First though, it was necessary to consider interaction effects in order to decide whether separate analyses were required.

Only the scoring possibilities "2", "1" and "0" (see introduction, Table SS) occurred in the present study.

For the purposes of statistical analysis, these three possible scores were collapsed into two dichotomized categories. These categories were as follows:
Not usually performed = Scores 0 and 1
Usually performed = Score 2

A Log Linear item analysis, giving rise to Likelihood Ratio (LR) Chi-square figures was carried out using the raw score for each item.

No interaction effects were found for the item analyses on any of the subdomains. This was in spite of there being an interaction effect in the Play and Leisure subdomain overall. The apparent difference in the two analyses probably reflects the reduced power of the item analyses as much as the cumulative nature of the interaction effect across items. This finding allowed us to look at the relevant effects for each item without further breakdown (ie looking at the pass/fail effect overall and the autism/Down's effect overall).

The item analysis for the autism/Down's effect revealed no significant items in the Daily Living Skills subdomains in spite of there being a significant effect overall. Certain items in the Communications Domain and the Socialization Domain showed significant differences in the item analysis. The results are displayed in four tables below (one table for the Communication subdomain items and a table for each of the Socialization subdomains). Table 42. 43. 44. and 45. show those items found to be significant on the item analysis, with an LR above 3.84 (ie $p<0.05$). The value of LRX^2 and the probability level are both given, as well as a "theory of mind" rating (see key). Table 46. shows the actual frequency of subjects scoring 2 (ie. usually performed) on the items found to be significant on the item analysis.

Table 42. Item Analysis Results for the Communication Domain.

Item	Item description	A/D	P/F	T.O.M
C27r	Follows intructions in "if-then" form	** 8.14	NS	NR
C20e	Spontaneously relates experience in simple terms	* 4.73	NS	NR
C34e	Uses phrases or sentences containing "but" and "or"	* 6.21	NS	NR
C46e	Expresses ideas in more than one way without assistance	NS	*** 14.12	3

Table 43. Item Analysis Results for the Interpersonal Subdomain (Socialization Domain)

Item	Item Description	A/D	P/F	T.O.M
S15i	Laughs or smiles appropriately in response to positive statements	** 7.97	NS	NR
S22i	Shows preference for some friends over others	* 7.16	* 7.16	0
S31i	Responds verbally and positively to good fortune of others	** 7.97	** 7.97	3
S53i	Initiates conversation on topics of particular interest to others	NS	*** 29.67	4
S56i	Responds to hints or indirect cues in conversation	NS	*** 17.81	3

Table 44. Item Analysis Results for the Play and Leisure Subdomain (Socialization Domain)

Item	Item Description	A/D	P/F	T.O.M
S21p	Engages in elaborate make-believe activities, alone or with others	NS	** 8.66	4
S26p	Shares toys or possessions without being told to do so	** 9.95	NS	NR
S27p	Names one or more favourite TV programmes and tells on what days and what channels progs. are being shown	** 9.61	NS	NR
S35p	Plays one or more board games or card games requiring skill and decision making	*** 22.69	NS	NR

Table 45. Item Analysis Results for Coping Skills Subdomain (Socialization Domain)

Item	Item Description	A/D	P/F	T.O.M
S32c	Apologizes for unintentional mistakes	NS	*** 31.74	4
S38c	Responds appropriately when introduced to strangers	** 10.66	* 5.68	0
S40c	Keeps secrets or confidences for more than one day	NS	*** 31.74	4
S42c	Ends conversations appropriately	* 7.51	*** 11.52	0
S44c	Refrains from asking or making statements that might might embarrass or hurt	NS	** 8.66	4
S45c	Controls anger or hurt feelings when denied own way	*** 12.20	NS	NR
S46c	Keeps secrets or confidences for as long as appropriate	NS	*** 38.80	4
S51c	Apologizes for mistakes or errors in judgement	NS	** 8.66	3

Key to Tables 42. 43. 44. and 45..

A/D	Autism vs Down's difference (Likelihood Ratio)
P/F	Pass vs Fail difference (Likelihood Ratio)
T.O.M	Number of independent judges (out of 4) rating the item as "requiring a theory of mind"

Item code

C	Communication Domain
r	Receptive subdomain
e	Expressive subdomain
S	Socialization Domain
i	Interpersonal relationships subdomain
p	Play and Leisure subdomain
c	Coping skills subdomain

Probability level code

*	$p<0.05$
**	$p<0.005$
***	$p<0.001$

The independent judges ratings for "theory of mind" items are shown in Table A. of the appendix. Each item has a score of 0 to 4 according to the number of judges rating it as a "theory of mind" item. If an item has a maximum score of 4, this means that all four judges rated it as "requiring a theory of mind."

Table 46. Number of subjects scoring "2" (usually performed).

Item	Autistic Group		Down's Syndrome Group	
	Pass	Fail	Pass	Fail
C27r	5	5	9	9
C20e	9	7	10	10
C34e	7	8	10	10
C46e	8	3	10	4
S15i	8	6	10	10
S22i	10	5	10	10
S31i	5	2	10	5
S53i	9	1	9	2
S56i	8	1	5	1
S21p	7	2	8	4
S26p	8	5	10	10
S27p	7	6	10	10
S35p	4	3	10	10
S32c	9	2	9	2
S38c	9	4	10	10
S40c	9	2	9	2
S42c	8	2	10	7
S44c	7	2	8	4
S45c	8	4	10	10
S46c	8	1	10	1
S51c	7	2	8	4

Ten items were rated by at least three of the four independent judges as requiring a theory of mind (see appendix). All of these items showed a pass-fail effect. A further three items showed a pass-fail effect which all four judges rated as not requiring a theory of mind.

Twelve items showed an autism-Down's effect. Seventeen of the twenty one items showing any significant effect on the item analysis were found in the Socialization Domain.

The results for the significant items were in the predicted direction for each of the items showing a pass-fail effect. In other words, there were more subjects scoring 2 (usually performed) in the pass subgroup than the fail subgroup. For each item showing an autism-Down's effect there were more subjects scoring 2 in the Down's Group than in the autism Group.

Discussion.

This study suggests that there is a relationship between theory of mind capacity and adaptive behaviour, particularly in the area of socialization skills. This finding is consistent with the "theory of mind hypothesis" and offers evidence to support its ecological validity. In addition, a detailed item analysis pinpoints specific items from the Vineland Adaptive Behaviour Scale that differentiate those who pass and those who fail on the theory of mind tasks. Most of these items had been rated by all four independent judges as "requiring a theory of mind". Knowing which of these items is affected by the cognitive deficit may have important implications for our understanding of how a deficit in theory of mind manifests itself in behaviour, and could be of value for educational and training purposes.

Finally, data from two clinical groups (autistic and Down's Syndrome) raises some interesting questions concerning how these groups might differ in terms of adaptive behaviour and theory of mind capacity.

Pass vs Fail comparison

In our first set of analyses we looked at three Domains of adaptive behaviour. In general, we found that those subjects who passed the false belief tasks scored significantly higher than those who failed on the Socialization Domain. This effect was not found for the Daily Living Skills Domain or the Communication Domain. This finding was as predicted in the introduction. It is of interest that previous studies using the Vineland have suggested that the Socialization Domain is most typically impaired in autism. If a deficit in understanding mental states is linked to a deficit in their socialization behaviours, then it would not be surprising to find low Socialization Domain scores in a clinical group such as autism, where the majority of subjects fail false belief tests.

Looking more closely at each subdomain separately, we found that there were in fact four subdomains showing a pass/fail difference in mean scores:- Interpersonal Relationships, Play and Leisure, Coping Skills (all from the Socialization Domain) and Expressive (from the Communications Domain). It was also interesting to find an interaction effect in the Play and Leisure subdomain, such that a pass/fail difference was found for the autistic group but not for the Down's Syndrome group. When age equivalent scores were used instead of raw scores this effect was smaller, however it remains an interesting finding.

In order to look in still greater detail at this effect, item analyses were carried out on the relevant subdomains. Thirteen items showed a significant pass/fail effect, with no interaction effects found. Most of these items were to be found in the Interpersonal subdomain (four items) and the Coping skills subdomain (seven items) of the Socialization Domain.

Only one item was found to show a significant pass/fail effect in the Play and Leisure subdomain. This item, "engages in elaborate make believe activities alone or with others," was highly significant, and was also rated by all four independent judges as "requiring a theory of mind." This item is of particular interest in the light of the theory of mind hypothesis which suggests that there is a link between understanding of false belief and ability to engage in pretend play; that link being the ability to form metarepresentations (Leslie, 1987). These results then, strongly support the existence of that link. It should also be noted that the effect for this item was found regardless of clinical group.

One item, "expresses ideas in more than one way without assistance" from the Expressive subdomain (of the Communication Domain) showed a pass/fail difference. This item had also been independently rated by three judges as a "theory of mind" item.

In the introduction to this study we speculated on three possible outcomes to this item analysis. The items that differentiate the groups might be:-

1. Only items which require a theory of mind.
2. Items which require a theory of mind plus other items.
3. A variety of items (where some items requiring a theory of mind are not affected).

It was interesting then, to find that all of the items rated as "requiring a theory of mind" did show a difference between the pass and fail group. It should be stressed that judges were told to rate items that can only be achieved with a theory of mind. In other words, a strict definition of "theory of mind" items was employed. This finding rules out the third outcome which may have cast doubt on the validity of either the theory of mind hypothesis or the false belief tests. In fact, our findings are in line with the second outcome, "Items which require a theory of mind plus other items are affected." Before discussing the implications of this outcome, let us first look at what the relevant items were.

Of the thirteen items where a pass/fail difference was found, ten were rated by three or four independent judges as "requiring a theory of mind". These items were as follows -:

1."Expresses ideas in more than one way without assistance."

2."Responds verbally and positively to good fortune of others."

3."Initiates conversation on topics of particular interest to others."

4."Refrains from asking or making statements that might embarass or hurt others."

5."Responds to hints or indirect cues in conversation."

6."Apologizes for mistakes or errors in judgement."

7."Apologizes for unintentional mistakes."

8."Keeps secrets or confidences for as long as appropriate."

9."Keeps secrets or confidences for more than one day."

10."Engages in elaborate make believe activities alone or with others."

Subjects who failed the false belief tasks then, had difficulties with these specific behaviours, whereas those who passed the tasks did not. It seems reasonable to argue then, that these behaviours may be directly affected by a cognitive deficit in theory of mind as measured by the false belief tasks used in earlier experiments of the thesis.

It may be useful to cluster these items into three general areas. The first seven items refer to social communication. Taking mental states into account is clearly important for social communication skills such as knowing when to apologize (items 6 and 7), knowing when to say the appropriate thing (item 2) and when an utterance is inappropriate (item 4), taking into account the knowledge and interests of others (items 1 and 3) and perhaps at a more advanced level, reading subtle hints (item 5). Secondly, understanding the concept of keeping secrets (items 8 and 9) is an unusual social skill which requires understanding that knowledge is available to some people but not to others. Thirdly, Pretend play (item 10) requires the understanding of the mental state of pretend and is, according to Leslie (1987), a prerequisite of being able to use a full theory of mind.

There were also three other items showing a pass/fail difference in our item analysis which were not considered, by the independent judges, to be "theory of mind" items. These items were -:

1."Shows preference for some friends over others."

2."Responds appropriately when introduced to strangers."

3."Ends conversations appropriately."

In the introduction to this study we suggested that this outcome may be evidence that the cognitive deficit causes more widespread deficit in adaptive behaviour than the theory of mind hypothesis would predict. Certainly this would seem to be true for item one, for which a direct connection with being able to use theory of mind would seem tenuous. However, the second two items would not seem inappropriately placed along with the "social communication" items (the first 7 items) of the above list. For these items at least, the connection with taking mental states into account is not unreasonable. It is also interesting to note when looking at all thirteen significant items, that the effect was not large for these three items in comparison to the other items, suggesting a weaker association with the cognitive deficit.

It is unclear exactly how the cognitive deficit might affect items not concerned with theory of mind, particularly items such as, "Shows preference for some friends over others." However, we might speculate that the those behavioural deficits which are directly related to the cognitive deficit might disable or inhibit the learning of other social skills.

An alternative hypothesis might be that the cognitive deficit is simply an associated symptom typical of subjects showing this a particular pattern of deficits in socialization behaviour, rather than a cause of that behaviour. In other words, this correlation between failure on the false belief tasks and deficits in social adaptive behaviour, does not necessarily mean that a cause and effect relation exists. Nevertheless, the findings of this study do fit neatly into the theoretical argument that a deficit in theory of mind can explain typically autistic behaviour and adds weight to the plausibility of such a theory. In addition to this, we have been able to pinpoint specific behaviours which those who fail theory of mind tasks tend to have difficulty with. Knowledge of these behaviours may be useful for future research, as well as for the education of autistic children.

Autism vs Down's Syndrome comparison.

The design of the study also allowed us to look at the adaptive behaviour profiles of two different clinical groups, matched for performance on the false belief tasks. We found that while both clinical groups showed a difference between pass and fail subgroups in some areas, there was also an overall difference between the clinical groups. This was contrary to our prediction that the clinical groups would not differ. This prediction was made on the basis of two main assumptions. Firstly, that the ability to use a theory of mind is the lone predictor of adaptive behaviour and secondly, that passing and failing the false belief tasks means the same in terms of this cognitive ability for both clinical groups. These two assumptions were derived by considering the simplest possible scenario in order to form our null hypothesis. If these assumptions were correct and the two groups were matched for passing and failing the false belief tasks, then the groups should not have differed in adaptive behaviour.

How, then, can we account for the overall difference between the groups which existed on all the subdomains apart from the Written subdomain?

One explanation is that ability to use a theory of mind is not the only factor important in the development of adaptive behaviour. In fact, the assumption that it is the lone predictor of behaviour does seem oversimplified. Whatever the other factors are, they affect the clinical groups differently such that the adaptive behaviour score for the Down's subjects is higher than for the autistic subjects. We can only speculate as to what these factors might be.

One possible influence is understanding of emotions and emotion recognition (Hobson 1989) being deficient in autistic children. If this were a factor this would be consistent with the idea that a more complete theory of the autistic disorder should incorporate not only the cognitive deficit theory but also Hobson's theory (1989) taking into account autistic children's understanding of emotions.

Another possible factor which may affect the groups differently is the environment the children grow up in. It may be that autistic and Down's children have different opportunities presented to them as a result of their handicap, both at school and at home, and may also be treated and perceived differently by others.

A third possible explanation for the difference in overall scores for the clinical groups is that although the groups were matched for passing and failing the false belief tasks, this may not mean that they are matched in terms of their ability to use a theory of mind. This argument becomes clearer if we consider the idea that understanding of false belief may be just one stage along a developmental continuum (Baron-Cohen, 1991).

This developmental continuum may begin with joint attention (Baron-Cohen, 1989a), progressing to pretend play, followed by understanding of false belief and through to the more complex abilities to form second order and third order metarepresentations.

One possibility then, is that the autistic children who pass the tasks are not as far along the developmental continuum as the Down's Syndrome children who pass. Baron-Cohen (1989b) found that autistic children who were capable of passing the Sally-Anne task were unable to attribute beliefs at a more advanced level (eg. Mary thinks that John thinks the icecream van is in the park), whereas matched Down's Syndrome children could. This would suggest that autistic and Down's syndrome passing subjects may still be at different levels on the developmental continuum, autistic children being specifically delayed in the acquisition of a more complex theory of mind.

Likewise, it could be argued that the autistic children in the fail subgroup may be more delayed along the continuum than the Down's children in the fail subgroup. For example, the autistic children may have still been impaired in their of joint attention skills. This of course would depends on whether joint attention does relate to theory of mind.

Recently, it has been argued that joint attention behaviours do require metarepresentation (Baron-Cohen, 1989a; Leslie and Happe, 1989), since in order to understand joint attention behaviours in another person the child must understand that the person is either interested or not interested in a particular object. As Baron-Cohen (1989) points out, this may involve representing "another person's representation of an object as being tagged with a positive or negative valence (ie interesting or uninteresting)." If this is the case, then joint attention would indeed be the earliest manifestation of the ability to form metarepresentations. There have also been a number of recent studies which suggest that a range of joint attention behaviours are impoverished in autistic children compared with non-autistic children, matched for Mental Age (Mundy et al, 1986; Sigman et al, 1986).

It is possible then that the autistic children in the fail subgroup are impoverished not only in understanding belief but also in their understanding of joint attention behaviours, and so are more delayed than the Down's Syndrome children in the fail subgroup in terms of their theory of mind capacity.

It is particularly interesting to note that in a number of subdomains the autistic pass subgroup mean score is actually lower than the Down's Syndrome fail subgroup. One interesting possibility is that autistic children who pass the false belief tasks are actually passing via use of an algorithm for the task, and in fact we are overestimating their ability to use a theory of mind. This idea is of course highly speculative, and it should be noted that the difference in mean scores was not significant. Furthermore, the interpretation that an algorithm was being used was reserved for evidence of an Interaction. However, this possibility will be explored in the next experiment when we attempt to train autistic and Down's Syndrome children on false belief tasks they normally fail on. This will allow us to examine whether it is possible for autistic children to learn to pass the false belief task, and we will also be able to look for clues that subjects are using an algorithm for the task.

The item analysis revealed twelve items showing a significant Autism/Down's effect, with no interaction found (see Table 41). It is interesting to note that nine of these items were to be found in the Socialization Domain. In other words, as with the pass/fail effect, the items differentiating the clinical groups were mainly found in the Socialization Domain (most typically impaired in autism). This further suggests that the Socialization Domain is the crucial area of adaptive behaviour specifically impaired in autism. Again, identifying these particular behaviours may be important for future research and for education.

We have presented two alternative theories as to why there should be a difference between the clinical groups. Our first suggestion was that other factors, apart from the cognitive deficit, may be involved in contributing to the difference. If this were so, then these items may be important in identifying such factors. One idea is that understanding of emotions may differentiate the groups (Hobson, 1989). We can only speculate as to which of the items involve such understanding, but perhaps the following are relevant:-

"Controls anger or hurt feelings when denied own way."

"Responds appropriately when introduced to strangers."

"Responds verbally or positively to good fortune of others."

"Laughs or smiles appropriately when introduced to strangers."

The second suggestion was that the subjects were not necessarily matched for metarepresentational capacity, and this was reflected in the difference between the clinical groups. Items which may be important for this hypothesis were those also showing a difference between the pass and fail subgroups. These were as follows:-

"Shows preference for some friends over others."

"Responds verbally and positively to good fortune of others."

"Responds appropriately when introduced to strangers."

"Ends conversations appropriately."

It should be noted of course, that all but the second item in this list were rated as not "requiring a theory of mind."

We can only conclude that it is not clear why these items should show a difference between the clinical groups. Further research is necessary in order to clarify this issue.

Summary

We have found evidence to suggest that a cognitive deficit in understanding of false belief is indeed related to adaptive behaviour, in both autistic and Down's Syndrome children. Furthermore we have found that despite being matched for performance on two false belief tasks the clinical groups still differ in terms of their overall adaptive behaviour scores. Two possible explanations for this have been put forward; one involving the cognitive deficit hypothesis (which may have implications for our knowledge of the relative metarepresentational capacities of the two clinical groups), and the other, perhaps more likely, speculating that there are additional factors affecting autism, one of which may involve understanding of emotions. It is, of course, important not to rule out the possibility that both of these explanations are important to our understanding of autistic-like adaptive behaviour.

CHAPTER 11.

EXPERIMENT 5

INTRODUCTION

A natural progression from the previous work in this thesis is to investigate theory of mind further with a training study. The previous work in this thesis suggests that the computer offers a rich new environment which children find motivating and rewarding. This pilot study then, attempts to use the computer as a training tool.

When we retested the autistic subjects on the Sally-Anne task in experiment three, we found that four of the subjects showed some improvement in their performance on the computer task. Two of these subjects went on to pass a different test of false belief, suggesting that they had learned or developed the concept. These subjects may have developed this concept naturally between the time of testing and retesting. However, it is also possible that repeated trials on the computer may have been effective in teaching these subjects to pass the false belief task.

In this experiment a modified computer version of the Sally-Anne task will be used as a basis for attempting to train subjects, who usually fail on false belief tasks, to pass the Sally-Anne task and ultimately to understand the concept of false belief.

We will first be interested in whether subjects can learn to pass the computer task consistently during training and the speed with which any improvement takes place. If subjects do learn to pass the computer task however, we will still be uncertain as to whether they have learned the concept of false belief or whether they have simply learned an algorithm which allows them to pass the task without any genuine understanding of the concept. For this reason, performance on pre-test false belief tasks and post-test transfer tasks will be used to evaluate the effects of training.

Learning the concept

If a child learns the concept of false-belief in training then s/he may be able to generalize this understanding so that s/he can pass other sorts of false belief tasks involving different scenarios. The implication of this would be that prior to training, the cognitive mechanisms required for such a concept are available but not "linked up" or functioning. This outcome would be the most promising finding in terms of the child's cognitive makeup, since it suggests that the child has the potential for understanding the concept.

Learning an algorithm

The child may learn to pass the false belief task by learning some compensatory strategy or algorithm which has nothing to do with understanding mental states. For example, one simple algorithm for passing the Sally-Anne task might be "*choose the container where the ball is not found.*" Another rule might be "*choose the container where Sally first put the ball.*" If a subject fails the post-test transfer tasks after passing the training tasks then we must assume the simplest explanation that some sort of algorithm has been used to pass the training task, rather than concluding that the child understands the concept.

It will also be possible to look for evidence of the sort of algorithm that has been used by looking at changes in performance on the control games of the Sally-Anne computer task, given before and after training, since these games involve true belief (ie the character looking for the ball where it really is). For example, a subject who passes the control games prior to training, may learn to pass the test games using an algorithm that "Sally always goes to the container where the ball is not found." If the subject continues to use this same algorithm when subsequently tested on the control games (despite the subtle differences in the scenarios) then s/he will fail the control games. It should be noted though that this will only occur if such a simple algorithm is used and the subject was unable to distinguish between the test games and the control games.

Three diagnostic groups will be used in the experiment: autistic, Down's syndrome and young normal children. The autistic and Down's

Syndrome children will be matched for Chronological Age. All three groups will be matched for Mental Age. All subjects will have failed the pre-test transfer tasks whilst passing all the control questions on those tasks. We will be interested in whether any differences in the effects of training are found according to diagnostic group, Chronological Age, Verbal Mental Age, Non-Verbal Mental Age and speed of acquisition on the training task. What specific prediction can we make regarding these factors?

Diagnostic Group

We will be interested in looking for differences between the groups in outcome on the post-test transfer tasks. If we were to find that one of the diagnostic groups learned the training task by algorithm, whilst the other two groups learned the concept, then this would suggest that the cognitive mechanisms for understanding false belief in that group are impaired in a qualitatively different way to the other two groups.

Chronological Age and Mental Age

Another hypothesis might be that ability to learn this concept is related to developmental level. This would be consistent with the specific developmental delay hypothesis (Baron-Cohen, 1989b). We might therefore predict that subjects with high Mental Ages (particularly Verbal Mental Age) would be more likely to learn the concept than subjects with low Mental Ages. Also we may find that Chronological Age predicts ability to learn the concept, since the older children have more experience of social interaction.

From our own experiments (see expts 2 and 3), of the four subjects who showed some improvement on the Sally-Anne task, the younger children, with lower Verbal Mental Ages, failed to generalise whilst the older children, with higher Verbal Mental Ages, did generalise and appeared to have learned the concept rather than a compensatory strategy.

Speed of acquisition

The diagnostic groups may differ in speed of acquisition on the training task. Also Chronological Age and Mental Age may predict speed of acquisition. However, it is difficult to predict whether speed of acquisition will be related to the learning of an algorithm or the learning of the concept.

Contents of the Training task

The training task is based around the Sally-Anne computer task. The main difference is that the training task is designed to include text which gives information and explanation concerning the conceptual nature of the task. This gives the best possible chance and encouragement for the subject to learn the concept.

Another important feature of the training task is that this explanation is not given directly by the experimenter. Instead, the impression is given that the information comes from the characters. The computer is being used as the main channel of communication. If the child is able to read the text aloud then s/he is encouraged to do so; however, if the child is unable to read, the experimenter reads the text out by reporting what a character or the computer has said.

The two versions of the test condition game on the Sally-Anne computer program will be used for training. The versions differ in the original location of the ball at the start of the game (and consequently in the correct location of the final answer). Each version will be presented three times, in random order with the other version, during a training session.

If the subject completes the game correctly, s/he will be rewarded with music and a flashing, colour changing message "YES, WELL DONE" which will also be read out by the experimenter, saying "The computer says well done."

If the subject gives an incorrect response the characters will not move. A message next to Sally will appear saying "*I think it's in the red box because that's where I left it.*" The experimenter will tell the child that "Sally says that she thinks the ball is still in the red/blue box because that's where she left it." After a short delay the message "*try again*" will be displayed. The experimenter will tell the child that "the computer says try again." The program will remain at the same point (ie. the whole scenario will be re-enacted). If the child chooses the wrong container again then the same message will appear. However, if a third attempt is made to click over the wrong container, a message reading *"try the red/blue box"* will appear. The experimenter will then tell the child that "the computer says try the red/blue box." At this point the only active area on the screen will be the correct box, so that the child can only proceed if the correct box is chosen. The first response on each trial will be recorded.

Further prompts will also be given on the computer in the training task. The first three prompts take place, one after the other, just after Sally has hidden the ball:-

Prompt 1. *"I put the ball in the red/blue box"*
Prompt 2. *"Now I think the ball is in the red/blue box"*
Prompt 3. *"I must remember to look in the red/blue box if I want my ball"*

Anne makes the next two prompts just after moving the ball:-

Prompt 4. *"Sally hasn't seen me move her ball"*
Prompt 5. *"Sally will think that the ball is still in the red/blue box"*

Using a set number of trials

It was decided to train subjects using a set number of trials rather than training to an artificially set criterion. This ensured that subjects had received equal exposure to training before being compared on their post-test transfer task performance.

Transfer tasks

There will be five transfer tasks, all designed to test the child's understanding of false belief. Each of these tasks will be presented before training (Pre-test) and after training (Post-test transfer tasks). These tasks can be divided into two categories; close transfer tasks and distant transfer tasks.

i. Close transfer tasks

The first two transfer tasks will be the Sally-Anne computer task (complete with control games) and the revised version of the Sally-Anne task with dolls. Each of these tasks will be presented three times. Both these tasks are described in detail in Experiment 1.

Subjects are considered to have passed a task only if they succeed in passing all three trials of that task. The control questions (or in the case of the computer presentation, the control games), must also be completed correctly.

These tasks are described as close transfer tasks because they use the same scenario as the training task. This means that an algorithm or compensatory strategy for passing the training task could be used effectively in passing these transfer tasks.

However, some transfer will have taken place since these tasks do differ slightly from the training task. The computer transfer task does not involve the prompts and explanation of the training task and the dolls presentation differs in that it uses a different medium of presentation (dolls instead of computer images) and also different text. Subjects passing these transfer tasks might only have generalized to the extent of this difference.

ii Distant transfer tasks

There will be three distant transfer tasks; the Smarties task (described in Experiment 3), and two new tasks called the Cornflakes task and the Tom task. All of these tasks require an understanding of false belief in order to pass and involve different scenarios to the training task.

These tasks are described as distant transfer tasks because both the scenario and the surface form of each task differs from the training task. This means that an algorithm used to pass the training task could not be used to pass these transfer tasks. If a subject can pass these transfer tasks after training then this suggests that the concept of false belief has been learned and generalised. Once again subjects must pass all trials of a task in order to be counted as passing the task as a whole.

a) The Cornflakes task

The Cornflakes task uses the same "deceptive appearance" paradigm as the Smarties task. However, instead of a smarties packet containing a pencil, this task used a cornflakes packet containing an orange and a milk carton containing water.

The child was presented with a packet of cornflakes, a milk carton, a bowl and a spoon. The child was reminded that this was "just like breakfast." The child was first asked what s/he thought was in the cornflakes packet. After the child answers cornflakes the experimenter opens the packet to reveal an orange, which is then tipped into the bowl. Then the child is asked what s/he thinks is in the carton. The child replies that the carton contains milk. However, the carton is found to contain water, which is also poured into the bowl.

The water and the orange are returned to the containers and the experimenter then checks that the child knows what s/he first thought was contained in the packet and the carton and what s/he now knows is inside these containers. As with the Smarties test, the child is then asked what another person, who hasn't seen inside these packets, will think they contain. In order to answer this test question correctly, the child must understand that the person who has not seen inside the packets will have a false belief about the contents.

The text used for this task is shown in Table 47 below.

Table 47. Cornflakes task text.

1. What do you think is in the packet?
2. Now what do you think is in the packet?
3. But when I first asked you, what did you think was in the packet?
4. [name] hasn't seen what's in the packet. What will [name] think is in the packet?

These four questions are asked about both the cornflakes packet and the milk carton. Where [name] is written in the text, the experimenter substitutes the name of a child known to the subject, who has not already done the task with the experimenter.

The Cornflakes task then, uses the same principles as the Smarties task but with different materials. It was considered worthwhile to use different examples of this paradigm for an number of reasons. Firstly, using only the Smarties task runs the risk that some surface artifact of this task is responsible for subjects failing. Also, if the subject is able to narrow the answer down to two possibilities (smarties or pencil) on the basis of what has already been discussed, then s/he has a 0.5 probability of guessing the correct answer. Using two more examples decreases the probability of guessing the correct response. Secondly, we were concerned that the smarties task had been used before by other researchers so that subjects may have simply learned to respond automatically with the same answer each time.

c) The Tom task

The Tom task was a new task devised for the experiment. This task uses nine line drawings on white card (see appendix). The experimenter uses these cards to illustrate the text concerning a character, Tom, who has a false belief about either the weather (raining or sunny) or the time (day or night). The text and picture numbers are shown in Table 48 below. Subjects are required to predict Tom's behaviour on the basis of his false belief (line 6) and also, as a control question (line 7), to indicate what time it really is, or what the weather is really like by pointing to the appropriate cards. In addition, two prompt questions (lines 4 and 5) are asked prior to the test question in order to check that the subject has followed the story.

The experimenter reads the text out to the subjects, presenting the pictures appropriate for each line of text in sequence. The pictures are covered over after being used. For lines four to seven of each scenario two pictures are presented side by side. The child answers the question given in the text for that line by pointing to one of the two pictures.

Table 48. Text for TOM task and picture sequence used

	Picture
A	
1. This is Tom	1
2. Tom thinks it's sunny outside	2
3. But really it's raining outside	3
4. What does Tom think the weather is like?	2 & 3
5. What is the weather like really?	2 & 3
6. Will Tom wear his T-shirt or will Tom wear his raincoat to go outside?	4 & 5
7. What is the weather like really?	2 & 3
B	
1. This is Tom	1
2. Tom thinks that it's daytime	6
3. But really it's night time	7
4. What time is it really?	6 & 7
5. What does Tom think the time is?	6 & 7
6. Will Tom go to bed or will Tom play football?	8 & 9
7. What time is it really?	6 & 7
C	
1. This is Tom	1
2. It's really sunny outside	2
3. But Tom thinks it's raining outside	3
4. What is the weather like really?	2 & 3
5. What does Tom think the weather is like?	2 & 3
6. Will Tom wear his T-shirt or will Tom wear his raincoat to go outside?	4 & 5
7. What is the weather like really?	2 & 3
D	
1. This is Tom	1
2. It's really daytime	6
3. But Tom thinks it's night time	7
4. What time does Tom think it is?	6 & 7
5. And what time is it really?	6 & 7
6. Will Tom go to bed or will Tom play football?	8 & 9
7. What time is it really?	6 & 7

The order of presentation for the four scenarios, A to D above, is counterbalanced.

This task also differs in scenario and surface form from the training task and requires an understanding of false belief and how it predicts behaviour in order to pass. This task also differs from the other transfer tasks in that the text makes it clear that the character has a belief which is alternative to reality, whereas in the other false belief tasks the subject has to work out that a false belief will be present.

This experiment was first piloted at Mill View Primary School, Chester, with 15 normal children between the ages of four years six months and five years, at which point normal children are able to understand false belief (Astington and Gopnik, 1991). All of these children passed the task, suggesting that subjects who could understand false belief were capable of understanding the task.

Finally, a three month follow up will also be carried out with each child. This will involve testing each child on close and distant transfer tasks. These results will provide an indication of how well a newly learned concept or algorithm is held over time. Of course, it may be that some natural development has taken place over time to account for subjects passing the tasks; such development would certainly be predicted in the young normal subjects. However, for the Down's Syndrome and autistic children we would not expect natural development to be a factor over such a short period of time, so that if these subjects can still pass the transfer tasks, we can reasonably assume that they have maintained what they have learned in training, whether that is a learned algorithm or understanding of false belief.

This will be a small scale study using eight subjects in each group and looking specifically at the understanding of false belief, as an example of a concept requiring the use of a theory of mind. The study is intended to provide a useful pointer for future work.

METHOD

SUBJECTS

Subjects were eight autistic children, eight Down's Syndrome and eight normal children, individually matched for Verbal Mental Age (BPVS) and Non-Verbal Mental Age (Leiter). The autistic and Down's Syndrome groups were also matched for Chronological Age. Subjects' Chronological Ages range from five years six months to fifteen years ten months. Details of subject characteristics are given in tables 49 to 51 below.

Autistic subjects

Six of the autistic subjects were recruited from Radlett School and two from Brondyffryn School (see Chapter 5 for details). All subjects were male. This reflects the high male:female ratios found in epidemiological studies (Rutter and Schopler, 1987). All of these subjects had a primary diagnosis of autism according to DSM-III criteria. The subjects were all resident at the school during week days only. Subjects' Chronological Ages ranged from five years six months to fifteen years ten months.

Down's Syndrome subjects

There were eight Down's Syndrome subjects, all with trisomy 21. The group consisted of seven males and one female. Subjects were all attending Dee Banks School (see Chapter 5). Subjects' Chronological Ages ranged from five years nine months to fifteen years six months.

Normal subjects

All eight young normal children attended Boughton Nursery (see Chapter 5). This group consisted of three female and five male subjects. Subjects' Chronological Ages ranged from three years and three months to three years and eight months. All of the children in this group, then, were below the age at which understanding of false belief normally develops.

Criteria for inclusion

i Matching

A single-subject design was employed in this study. Using this design individuals were first matched for Verbal Mental Age, since this was considered to be most important for understanding these tasks. Non-Verbal performance was kept as similar as possible across the three groups, and

Chronological Age was also kept as similar as possible for the Autistic and Down's Syndrome groups.

ii Pre-training performance

Only subjects who fail all the test questions of all the pre-test transfer tasks whilst passing all the control questions were included in the study. Subjects were therefore matched in their understanding of aspects of the tasks which did not require a theory of mind (although they all failed to understand false belief).

In addition, all the subjects were required to complete the computer mouse training program successfully.

PROCEDURE

The entire procedure involved an initial assessment (involving pre-test transfer tasks, computer mouse training and IQ testing), false belief training, post-test transfer tasks and three month follow-up.

INITIAL ASSESSMENT

i). Pre-test Transfer Tasks and Computer mouse training.

The three pre-test sessions took place during the *week prior to* training.

Session 1

a). Computer mouse training.

Subjects were also required to complete two runs of the mouse training program (described in detail in Experiment 1). The second run was completed without assistance from the experimenter. Successful completion of the second presentation was a prerequisite for inclusion in the study.

b). Computer transfer task

Subjects were given the Sally-Anne computer task (described in detail in Experiment 1). They were given three presentations of the Test condition games and a single presentation of each of the control games.

Session 2
c). Non-Computer transfer tasks

Each subject was presented with the four non-computer pre-test transfer tasks. The standard presentations of the Sally-Anne task and the Smarties task, followed by the two new false belief tasks, the Cornflakes task and the Tom task.

The order of presentation of these transfer tasks was counterbalanced within each group, with the same order of presentation in the post-test sessions.

Session3
ii). IQ Testing

Verbal IQ was measured for each subject using the British Picture Vocabulary Scale. Non-Verbal IQ was measured using the Leiter International Performance Scale.

FALSE BELIEF TRAINING

Training took place over four days (Monday to Thursday). Subjects completed two sessions per day on the training program on each of these days, making eight sessions altogether. The two daily sessions were no less than two hours and no more than five hours apart. Each session consisted of six trials of the training task (three trials of each version).

Training Timetable

DAY		TRAINING SESSION
1	am	1
	pm	2
2	am	3
	pm	4
3	am	5
	pm	6
4	am	7
	pm	8

POST-TEST TRANSFER TASKS

The post-test transfer tasks were run on day five of the training week. The tasks used were identical to the pre-test transfer tasks.

THREE MONTH FOLLOW-UP

The same transfer tasks (with the exception of the computer close transfer task) were also used to test all the subjects in a follow-up, three months after the end of the training sessions.

RESULTS

The details of each subject's Chronological Age, Verbal Mental Age and Non-Verbal Mental Age are shown below in Table 49. Table 50. and Table 51. below. The Means and Standard Deviations for each Group are also shown.

Table 49. Subject Characteristics (Autistic Group)

Sn	CA	VMA	NVMA
A33	10:10	3:8	4:3
A34	15:10	3:8	4:9
A35	6:5	3:7	4:2
A36	5:6	3:1	3:9
A37	10:8	4:0	4:6
A38	9:0	4:1	4:3
A39	14:1	4:2	4:6
A40	13:6	2:9	3:8
Mean	10:9	3:8	4:3
SD	3:8	0:6	0:4

Table 50. Subject Characteristics (Down's Syndrome Group)

Sn	CA	VMA	NVMA
D53	11:1	3:7	4:4
D54	15:6	4:1	4:6
D55	6:8	3:5	3:9
D56	5:9	3:2	3:4
D57	11:1	4:2	4:4
D58	9:5	4:4	4:0
D59	14:1	4:1	4:3
D60	13:0	3:4	3:7
Mean	11:9	3:9	4:0
SD	4:0	0:5	0:5

Table 51. Subject Characteristics (Normal Group)

Sn	CA	VMA	NVMA
N43	3:8	4:1	4:4
N44	3:6	3:8	4:4
N45	3:4	3:6	3:8
N46	3:3	3:3	3:6
N47	3:4	3:8	3:9
N48	3:3	3:5	4:3
N49	3:8	4:0	4:0
N50	3:5	3:5	4:4
Mean	3:5	3:7	4:1
SD	0:2	0:3	0:3

Key to Table 49. Table 50. and Table 51.

CA	Chronological Age
VMA	Verbal Mental Age
NVMA	Non-Verbal Mental Age
Sn	Subjects Number
y:m	years:months

These data show that subjects were all closely matched for Verbal Mental Age (VMA) and Non-Verbal Mental Age (NVMA). The Autistic and Down's Syndrome subjects were also closely matched for Chronological Age. However, since subjects were not perfectly matched analysis of covariance was employed with covariates CA, VMA and NVMA. This was done in order to calculate the contribution of these covariates in accounting for group differences in Training Scores, Post-test Training Score, and Follow-up Score.

None of these covariates were found to be predictors of performance at the 5% level of significance.

Three sets of results were analysed: The Training session results, the Post-test transfer task results and the Follow-up results. In addition, the relationship between these sets of results was also examined.

TRAINING SESSION RESULTS

Table 52. (parts A,B and C) shows the results for the eight training sessions. The number of correct trials on each of the training sessions is shown in the columns headed s1 to s8. Two summary scores were computed for each subject. The Overall Training Score is the number of correct trials for the eight sessions. Although this overall score is a useful indication of success during training an additional score, the Session Acquired Score was also derived to estimate the session in training when a subject reached a criterion, set post-hoc to represent the acquisition of consistent success on the task. This criterion was set at five out of six correct trials in a session.

Two subjects failed to reach criterion of acquisition. For these subjects a score for session number when criterion was reached was unknown. However in order to include these subjects in the analysis, they were arbitrarily given a score of 9 (ie assuming that the subjects would have scored five correct on session 9). This is obviously a conservative estimate, since although subjects could not have done better than 9 they could have done worse. However, it should be noted that these subjects did achieve two correct and three correct trials in a session. In fact, the most frequent number of correct trials for other subjects in this group, in the session prior to reaching the criterion of five correct trials, was three. It is therefore not unreasonable that these subjects could have achieved five correct trials on their next session.

Table 52. Training Session Results.

A. (Autistic Subjects).

Sn	s1	s2	s3	s4	s5	s6	s7	s8	Ov	Acq
A33	1	2	3	3	6	6	6	6	33	5
A34	0	1	3	5	5	6	6	6	32	4
A35	1	1	4	5	5	6	6	6	34	4
A36	0	2	1	5	6	6	6	6	32	4
A37	0	1	1	4	6	5	5	6	28	5
A38	1	3	3	5	6	6	6	6	36	4
A39	1	2	5	4	6	6	6	5	35	3
A40	0	1	4	4	5	6	5	6	31	5
Mean	0.5	1.6	3.0	4.4	5.6	5.9	5.8	5.9		

B. (Down's Syndrome Subjects)

Sn	s1	s2	s3	s4	s5	s6	s7	s8	Ov	Acq
D53	0	1	3	5	5	5	5	5	29	4
D54	0	1	2	3	3	3	5	4	21	7
D55	1	1	1	2	2	3	2	3	15	9*
D56	0	1	2	3	2	3	3	5	19	8
D57	0	1	3	3	3	4	6	5	25	7
D58	0	1	2	3	2	2	5	6	21	7
D59	0	0	0	1	1	2	2	2	8	9*
D60	0	2	2	1	2	4	5	4	20	7
Mean	0.1	1.0	1.9	2.6	2.5	3.3	4.1	4.3		

C. (Normal Subjects).

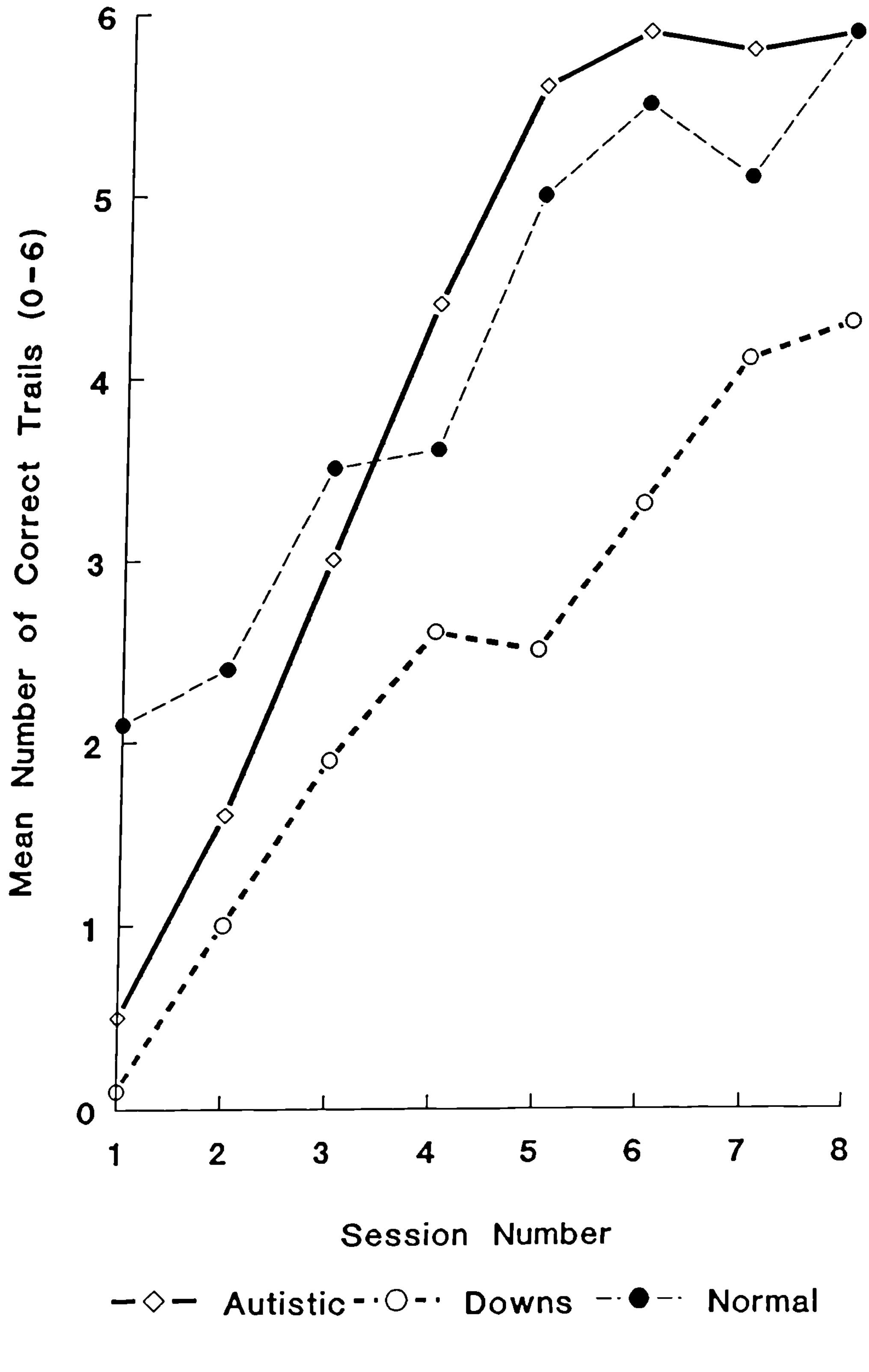
Sn	s1	s2	s3	s4	s5	s6	s7	s8	Ov	Acq
N43	2	4	3	3	2	4	3	6	27	8
N44	1	1	3	3	6	5	5	6	30	5
N45	1	1	5	5	6	6	5	6	35	3
N46	3	3	3	4	6	5	6	6	36	5
N47	3	2	3	3	6	6	6	6	35	5
N48	2	2	3	4	4	6	4	5	30	6
N49	2	3	4	5	5	6	6	6	37	4
N50	3	3	4	2	5	6	6	6	35	5
Mean	2.1	2.4	3.5	3.6	5.0	5.5	5.1	5.9		

Key to Table 52. (A,B and C)

Sn	Subject Number
s1 to s8	Session 1 to Session 8
Over	Overall Training Score
Acq	Session Acquired Score
9*	9 scored for subjects not reaching a score of 5 trials correct on a training session

The results show a general pattern of increase in the number of correct trials over the course of the 8 sessions. Figure 11.1. summarizes the results for the three diagnostic groups

Figure 11.1. Performance During Training.



It can be seen from Figure 11.1. that the normal group scores higher than the other two groups on session one. Between session one and five the normal group and the Down's Syndrome group show a similar rate of increase in the number of trials correct. However, the autistic group appears to learn quicker (showing a steeper gradient), so that the curve for the autistic group crosses that for the normal group. The autistic group and the normal group curves meet at the session 8, both groups having a mean score of 6 correct trials. The Down's group remains at a lower mean score throughout training.

A summary of the Overall Training Score (OV) and Session Acquired Score (ACQ) results and analyses are shown in Table 53. below.

Table 53. Training Session results and analysis.

	Group Means			Overall Between Groups Anova		Scheffe Pairwise Comp's		
	A	D	N	F	p	AvD	AvN	DvN
OV	32.6	19.8	33.1	23.4	<0.001	***	NS	***
ACQ	4.25	7.25	5.12	11.1	0.001	***	NS	**

Key to Table 53.

A Autistic Group
D Down's Syndrome Group
N Normal Group
AvD Autistic versus Down's Group comparison
AvN Autistic versus Normal Group comparison
DvN Down's versus Normal Group comparison
OV Overall Training Score
ACQ Session Acquired Score
Anova Analysis of Variance
Comp's Comparisons

* p<0.10
** p<0.05
*** p<0.01

Analysis of the Overall Training Scores for each group revealed that whilst the normal group and the autistic group obtained similar scores, the Down's Syndrome group scored significantly less than the other two groups.

The analysis of the Session Acquired Score also revealed significant differences between the groups. Again the Down's Syndrome group differed significantly from the other two groups.

POST-TEST TRANSFER TASK RESULTS

Table 54. (parts A,B and C) below shows the results of the five Post-test transfer tasks. A score of 1 is assigned if the subject passes the task and a score of 0 is given if the subject fails. Two sets of scores are derived from the transfer task results. The Close Transfer Score (CTr) is the sum of the scores for the computer task and the Sally-Anne task. The Distant Transfer score (DTr) is the sum of scores for the Smarties task (Sm), the Cornflakes task (Cf) and the Tom task (Tom). The Overall Training Scores and Session Acquired Scores from the training task results are also shown again in Table 54. for comparison.

Table 54. Post-test transfer task results.

A. Autistic Subjects.

Sn	Com	S-A	Sm	Cf	Tom	CTr	DTr	Ov	Acq
A33	1	1	0	0	0	2	0	33	5
A34	1	1	0	0	0	2	0	32	4
A35	1	1	0	0	0	2	0	34	4
A36	1	1	0	0	0	2	0	32	4
A37	1	1	0	0	0	2	0	28	5
A38	1	1	0	0	0	2	0	36	4
A39	1	1	0	0	0	2	0	35	3
A40	1	1	0	0	0	2	0	31	5

B. Down's Syndrome Subjects.

Sn	Com	S-A	Sm	Cf	Tom	CTr	DTr	OV	Acq
D53	1	1	1	1	1	2	3	29	4
D54	1	1	0	0	0	2	0	21	7
D55	0	0	0	0	0	0	0	15	9*
D56	1	1	1	1	0	2	2	19	8
D57	1	1	1	1	1	2	3	25	7
D58	1	1	1	0	0	2	1	21	7
D59	0	0	0	0	0	0	0	8	9*
D60	1	1	1	1	1	2	3	20	7

C. Normal Subjects.

Sn	Com	S-A	Sm	Cf	Tom	CTr	DTr	Ov	Acq
N43	1	1	0	0	0	2	0	27	8
N44	1	1	1	1	1	2	3	30	5
N45	1	1	1	1	1	2	3	35	3
N46	1	1	0	0	0	2	0	36	5
N47	1	1	1	1	1	2	3	35	5
N48	1	1	0	0	0	2	0	30	6
N49	1	1	1	1	0	2	2	37	4
N50	1	1	1	0	0	2	1	35	5

Key to Table 54.

Sn	Subject number
Com	Computer task
S-A	Sally-Anne dolls task
Sm	Smarties task
Cf	Cornflakes task
Tom	Tom task
CTr	Close Transfer Task Score
DTr	Distant Transfer Task Score
Ov	Overall Training Score
Acq	Session Acquired Training Score

Close Transfer Score

All but two subjects were successful on both Close transfer tasks. Both these subjects were in the Down's Syndrome group. These two subjects obtained the lowest Overall Training Scores throughout the three groups, and were also the only subjects who failed to reach the acquisition criterion. The mean Close Transfer Score for each of the groups is shown in Table 55.

Distant Transfer Score

The results and analysis of the Distant Transfer Score for each group are shown in Table 55 below. Non-parametric tests were appropriate for this data.

Table 55. Post-test training results and analysis.

	Group Means			Overall Between Subjects K-W Anova		Mann-Whitney Pairwise Comparisons		
	A	D	N	Chi^2	p	AvD	AvN	DvN
CTr	2.0	1.5	2.0	7.6	0.124	NS	NS	NS
DTr	0.0	1.5	1.5	7.6	0.022	**	**	NS

Key to Table 55.

A Autistic Group
D Down's Syndrome Group
N Normal Group
AvD Autistic versus Down's Group comparison
AvN Autistic versus Normal Group comparison
DvN Down's versus Normal Group comparison
CTr Close Transfer Score
DTr Distant Transfer Score
K-W Anova Kruskal-Wallis oneway analysis of variance
NS Not significant
** $p<0.05$ nb Z values were $z=2.56$ in both cases.

No differences were found between the groups for the Close transfer tasks. However, the analysis of the Distant Transfer Score showed that the autistic group scored significantly less than both the normal and the Down's Syndrome groups at 5% level of significance.

Post-test performance on control questions games.

All of the subjects passed the computer control games given after training.

Relationship Between Training Session Scores and Post-Test Transfer Task Scores

The correlation between Overall Training Score and Distant Transfer Score and also between Session Acquired Training Score and Distant Transfer Score, was calculated using Kendall's tau b statistic pooled over the diagnostic groups. This non-parametric test was used as the number of subjects used was small. Since all the autistic subjects failed on the distant transfer tasks they provided no correlational data and were omitted from this analysis.

Overall Training Score was correlated with performance on the distant transfer tasks ($tau=0.33$, $p<0.10$). Session acquired, ie. speed of acquisition, was more highly correlated with performance on the distant transfer tasks ($tau=0.60$, $p<0.001$).

Follow-Up Results

Performance on the dolls presentation of the Sally-Anne task (close transfer) and on the three distant transfer tasks for the three month follow-up are shown in Table 56. (parts A, B and C) below. This table also shows the Close Transfer Score (calculated without the score from the computer task as this was not used in follow-up), and the Distant Transfer Score, at post-test and at three month follow-up.

Table 56. Transfer Task Performance At Three Month Follow-Up.

A. Autistic Subjects.

Sn	S-A	Sm	Cf	Tom	FCTr	FDTr	Pctr	Pdtr
A33	1	0	0	0	1	0	1	0
A34	-	-	-	-	-	-	1	0
A35	0	0	0	0	0	0	1	0
A36	0	0	0	0	0	0	1	0
A37	1	0	0	0	1	0	1	0
A38	0	0	0	0	0	0	1	0
A39	1	0	0	0	1	0	1	0
A40	1	0	0	0	1	0	1	0

B. Down's Syndrome Subjects.

Sn	S-A	Sm	Cf	Tom	FCTr	FDTr	Pctr	Pdtr
D53	1	1	1	1	1	3	1	3
D54	-	-	-	-	-	-	1	0
D55	0	0	0	0	0	0	0	0
D56	1	1	1	0	1	2	1	2
D57	1	1	1	1	1	3	1	3
D58	1	1	1	0	1	2	1	1
D59	0	0	0	0	0	0	0	0
D60	1	1	1	1	1	3	1	3

C. Normal Subjects.

Sn	S-A	Sm	Cf	Tom	FCTr	FDTr	Pctr	Pdtr
N43	1	1	1	0	1	2	1	0
N44	1	1	1	1	1	3	1	3
N45	1	1	1	1	1	3	1	3
N46	1	1	1	0	1	2	1	0
N47	1	1	1	1	1	3	1	3
N48	1	1	1	0	1	2	1	0
N49	1	1	1	1	1	3	1	2
N50	1	1	1	1	1	3	1	1

Sn Subject number
S-A Sally-Anne dolls task
Sm Smarties task
Cf Cornflakes task
Tom Tom task
FCTr Follow up Close Transfer Task Score
FDTr Follow up Distant Transfer Task Score
Pctr Post-test Close Transfer Score (dolls task only)
Pdtr Post-test Distant Transfer Score

Two subjects were unavailable for retesting at follow-up, one autistic subject (A34) and one Down's Syndrome subject (D54).

For the normal and the Down's Syndrome subjects the results for the Close transfer task were the same at follow-up as they were at post-test. However, three of the autistic children who had previously passed the close transfer task failed when retested at follow-up. This change was not significant using McNemar's test.

All the autistic children once again failed all the distant transfer tasks. For this reason the autistic subjects were not included in the analysis comparing distant transfer task performance at post-test and follow-up. Table 57. below shows mean Distant Transfer Scores for the Down's

Syndrome and normal groups at post-test and follow-up. A Mann-Whitney U test was used in order test whether the change in performance for the two groups was different. Since this analysis was found to be significant, the changes were analysed separately for the two diagnostic groups using the Wilcoxon test.

Table 57. Post-test and Follow-up Distant Transfer Mean Scores.

Gp	post	foll	change	Wilcoxon		DvN change M-W Test	
				z	p	z	p
D	1.71	1.86	0.14	1.0	NS	2.05	<0.05
N	1.5	2.63	1.13	2.02	<0.05		

Key for Table 57.

Gp Group
post Post-test Distant Transfer Task Score mean
foll Follow-up Distant Transfer Task Score mean
change Change in Distant Transfer Task Score
DvN Down's versus Normal Group
M-W Mann-Whitney U Test

There was no significant change in the performance of the Down's Syndrome subjects between post-test and three month follow-up. The normal subjects improved in their performance on the distant transfer tasks at the follow-up retesting.

DISCUSSION

The training study has produced an interesting pattern of results with respect to the three diagnostic groups (autistic, Down's Syndrome and normal subjects), and may have implications for our understanding of the cognitive structures available to these children.

Performance on the training task.

During the 8 training sessions the autistic and normal groups both showed a steady and impressive rate of learning, achieving 5 out of 6 correct trials in a session (criterion for acquisition) by approximately session number 5. The Down's Syndrome group however, were not as successful on the training task, in terms of both their overall performance and how quickly they reached the criterion for acquisition. Despite their inferior performance compared to the other two groups, most of the Down's Syndrome group did show a steady rate of learning, with 6 of the 8 subjects reaching criterion by the end of training.

We also examined the contribution of Chronological Age, Verbal Mental Age and Non-Verbal Mental Age and found that none of these covariates were significant predictors of training performance.

Although the subjects were successful on the training task, we needed to look at the results of the distant transfer tasks given after training in order to assess whether subjects had learned the concept of false belief during training or whether they had learned to use an algorithm in order to pass the training task.

Post-Test Transfer Tasks

On the Close Transfer tasks, no significant difference was found between the three groups, although the two Down's Syndrome subjects who did not reach acquisition during training failed on both the computer and standard presentations of the Sally-Anne task.

This suggests that autistic, Down's Syndrome and normal children were able to generalize what they had learned from presentation using computer images to presentation using dolls. However, since the close transfer tasks involved the same scenario as was used for training, we cannot tell whether subjects generalised by using the concept of false belief or a strategy learned during training.

The diagnostic groups did differ in terms of their performance on the distant transfer tasks. Despite their success during training, all the autistic subjects failed all the distant transfer tasks. In other words, the autistic subjects failed to generalize what they had learned during training. This suggests that the autistic subjects may be using an algorithm to pass the training task and close transfer tasks. Performance on the computer control games gave no indication of the nature of such an algorithm, as all the subjects were successful on these tasks after training. This may have been because a more complicated algorithm than "look in the container where the ball is not present", was used or because the subjects were able to distinguish between the test game and the control games.

In contrast, five of the Down's Syndrome subjects and five of the normal subjects passed at least one of the distant transfer tasks, suggesting that these subjects had learned the concept of false belief and were able to use it in different situations. Performance on the distant transfer tasks was not related to either Chronological Age, Verbal Mental Age or Non-Verbal Mental Age.

The implication of this finding is that the cognitive mechanisms for understanding false belief in autistic children who fail the false belief task are impaired in a qualitatively different way to the Down's Syndrome children and the young normal children who also fail the false belief task. The autistic children may have learned an algorithm for the task, whilst normal and Down's Syndrome children had the cognitive mechanisms available to enable them to learn the concept during training. This is not to say that autistic children are incapable of acquiring this concept and using a theory of mind at this "lower level" (examples of such children are found in experiment 4), but it does appear from this pilot study that such acquisition is more difficult for autistic children than it is for young Down's Syndrome or young normal children, and the cognitive structures used for a theory of mind may be uniquely impaired in autism.

Another explanation could be that the autistic children find it easier to learn an algorithm than the other two groups. They learn this algorithm quickly, and are content to continue passing the task in this way. This would imply that autistic children are not motivated to learn the concept, perhaps because they are not attending to the mental state components of the training task.

This finding supports the hypothesis expressed in the previous experiment in this thesis that autistic children are more likely than other groups to be impaired at an earlier stage on a developmental "continuum" of theory of mind. These results suggest that although all three groups in the training study failed the false belief task, they were not at equal stages on this continuum.

The finding that some of the Down's Syndrome and normal subjects were able to pass the distant transfer tasks after training is also of great interest. Such results testify to the effectiveness of the training, but also indicate that the cognitive structures required for understanding false belief are available to these subjects. The young normal children were all below the Chronological Age when understanding of false belief has been reported to have developed (Astington and Gopnik, 1991). This therefore suggests that in normal development the structures for understanding false belief and hence using a theory of mind are available earlier than three years and nine months. It would also appear that such structures are also available to Down's Syndrome subjects, despite their low Mental Age.

The relationship between training and distant transfer

We also examined how training performance was related to ability to learn the concept (ie performance on the distant transfer tasks). Since all of the autistic subjects failed distant transfer, these subjects were excluded from the analyses. The results showed that both speed of acquisition and overall training performance were related to performance on the distant transfer tasks, for the Down's Syndrome subjects and for the young normal subjects. For these two groups the subjects who failed the distant transfer tasks performed worse than those who passed on the training program. This distinguishes them from the autistic subjects who failed distant transfer, all of whom performed well during training. One explanation for this difference may be that the autistic children tend to learn an algorithm more quickly and with more ease than the subjects in the other groups because they are not analysing the task in terms of a social situation that requires explanation.

Follow-up Results

The subjects were retested three months after training in order to find out whether the effects of training had been maintained.

The autistic subjects also failed all the distant transfer tasks at follow-up. There was also a suggestion from the data that this group had got worse at the follow-up on the close transfer task, although the difference between post-test and follow-up was not found to be significant. Four autistic subjects did maintain their original performance on the close transfer task.

The Down's Syndrome subjects maintained their performance on all the Transfer tasks suggesting that the concept they had learned was stable.

The normal subjects improved in their performance. This was probably because these subjects had developed understanding of false belief in the course of their natural development.

Subjects who learned the concept of false belief during training were still able to use the concept at three month follow-up, suggesting that this was not a short term phenomenon. It is possible that some subjects may have acquired this concept during the course of their natural development over the three months; this seems likely in the case of the normal subjects who actually improved in their performance on the distant transfer tasks. The algorithm also appeared to be reasonably well remembered over the three months amongst the autistic children.

Informal Observations.

The autistic subjects who passed at follow-up seemed to remember the Sally-Anne task remarkably well. They were able to quote much of the text used in the training program eg. "Sally thinks her ball is in the red box where she left it." These quotes were volunteered by the subjects rather than being prompted. This suggested further that rote learning of the two test games had taken place. Such rote learning might support an algorithmic method for passing the task. This memory for text was not displayed voluntarily by either the Down's Syndrome group or the normal group at follow-up, although these subjects were also able to pass the tasks.

It is also worth noting that all three groups greeted the computer training tasks with enthusiasm, which appeared to be maintained throughout the training period. This was encouraging given that the subjects were required to complete the Sally-Anne task a total of 48 times over the four days.

This pilot study then suggests that it is possible to teach normal and Down's Syndrome children to understand the concept of false belief and generalize this understanding to other tasks. However, it would appear that autistic children differ from these two groups in their ability to learn about false belief and suggests that autistic children have an innate neurologically based deficit in their theory of mind.

A more large scale training study would be useful in order to confirm these results. This might include a variety of different training approaches alongside computer presentations and a more comprehensive examination of ability to use a theory of mind. A control group of subjects being trained on something other than theory of mind tasks would also be necessary. Such a study may tell us more about the origins and development of the ability to use a theory of mind and the prospects for autistic children being able to learn a genuine concept which might ultimately alleviate some of their communication and socialization difficulties.

CHAPTER 12.

SUMMARY AND CONCLUSIONS

This final chapter is divided into a number of sections. Firstly, we give a brief summary of the hypotheses and the experimental findings of the thesis. Secondly, we discuss the implications our findings have for the "theory of mind" hypothesis and for the use of computers with autistic children. Finally, we discuss the implications of the thesis for future research.

SUMMARY

i Hypotheses

In the first two chapters of the thesis we reviewed the current knowledge concerning autism. In Chapter 1 we looked at diagnosis and identification, epidemiology and aetiology, and in Chapter 2 we discussed more recent research on the diagnostic criteria and cognitive deficits found in autism.

A number of important points emerged from this literature. Firstly, there is a consensus that autism has a biological basis. Secondly, some higher order cognitive deficit, presumably resulting from a deficit in brain functioning, might form an important part of the innate basis of autism. Three classic symptoms emerged, which always co-occur in autism (Wing, 1988):-

1. Characteristic social incompetence.
2. Impairment of verbal and non-verbal communication.
3. Lack of pretend play.

In the light of this literature it was argued that it would be useful to try and identify an underlying cognitive deficit which leads to the specific abnormalities of development characteristic of autism.

We then focussed on a cognitive theory proposed originally by Baron-Cohen, Leslie and Frith (1985,1986) which attempts to explain the triad of impairments. According to this theory, autistic children have a specific deficit in their ability to form and use metarepresentations. According to Leslie (1987) the cognitive component used to form metarepresentations is necessary for the ability to pretend and to understand pretence in others; this component also underlies the child's development of a "theory of mind" (Wimmer and Perner, 1983).

Having a theory of mind enables the child to think and reason about the content of his/her own and other peoples' mental states. We then outlined the importance of a theory and mind for explaining and predicting behaviour, in other words making sense of the social world; and for communication, for example in recognizing the speaker's belief and intentions about the message (Grice, 1975; Sperber and Wilson, 1986).

A deficit in the autistic child's ability to form and use metarepresentations, then, would explain the lack of pretend play, it would also account for a deficit in the development of a theory of mind resulting in characteristic social impairment and communicative impairment.

One aspect of theory of mind, which develops in young normal children at four years of age, is the ability to understand false belief in other people (Wimmer and Perner, 1983). Baron-Cohen, Leslie and Frith (1985, 1986) examined understanding of false belief in autistic children, Down's syndrome children and young normal children. The results showed that autistic children were specifically impaired in their understanding of false belief. These findings met with some controversy and criticisms but were convincing enough to warrant further investigation.

In addition to the theory of mind hypothesis (and considering our literature review), we then focussed on another interesting area of research; computer use and autistic children. We found that the few existing studies suggested that this was a promising area of research. We argued that for autistic children, the computer was a novel form of presentation and that as a new channel of communication it might be used effectively as an investigative tool for research or as a training device.

By considering the attributes that a computer can offer and what those attributes might capitalize on in terms of autistic cognition (such as stimulus overselectivity, ritualistic and compulsive phenomena, impoverished communication and difficulty with the social world), we argued that the computer environment might be particularly well suited to autistic children.

In designing our experimental studies, then, we were able to draw together these two areas of research by examining a cognitive deficit (understanding of false belief) in autistic children using tasks presented on computer. We could then gather information about understanding of false belief and about the efficacy of using the computer for these tasks.

We used our knowledge of autistic cognition in order to design computer programs best suited to the autistic children. In particular these programs had a minimalist design with as little reliance as possible on verbal and social abilities. We designed a mouse training program and two programs testing understanding of false belief. Logged information about performance on the training task and observational reports would provide additional information about how well autistic children work with computers.

We also presented revised versions of the false belief tasks in standard form. This enabled us to compare two versions of the false belief task with very different surface forms. If the performance was the same for both forms of presentation (as we would predict from the "theory of mind" hypothesis) then we could conclude that the autistic children's failure on these tasks must be due to the conceptual nature of the tasks rather than its surface form. If the performance differs substantially on the two versions, then we must conclude that the surface form plays a role. In addition, if those children who fail the false belief task pass the computer version, then we need to be wary of the fact that these versions are not identical in content, so that we could not then claim that passing was entirely due to the attributes of the computer.

It would also be interesting to follow the performances of these children through trials and over time as we may observe some improvement or differences in results. However distinguishing between developmental change and change due to training is a difficult task.

We then administered the Vineland Adaptive Behaviour Scale using autistic and Down's Syndrome children in order to assess whether a cognitive deficit in using a theory of mind is related to real behaviour.

Finally, we attempted to train subjects who fail on false belief tasks to understand the concept of false belief. We used a specially designed computer program for training.

ii Findings

Experiment 1.

In the first experiment we used autistic children, Down's syndrome children of around the same Chronological Age but with significantly lower Verbal and NonVerbal Mental Ages, and young normal children also with lower Mental Ages. The higher Mental Age of the autistic group allowed us to evaluate conservatively any relative disadvantages in their performance.

The first part of experiment one was an introduction to the computer and mouse using the training program. Analyses of the time spent on this program indicated that the autistic children had no special difficulties handling the computer interface. We also gave an anecdotal account of the performances of the children. These informal observations pointed to computer testing relieving many of the problems involved in working with the autistic children, and suggested that the computer work was greeted with more enthusiasm, and in many cases more concentrated effort, by the autistic children, than were other forms of work.

The second part of experiment one tested the three groups on two versions of the "Sally-Anne" false belief task (Baron-Cohen et al, 1985); a revised version of the Sally-Anne task using extra control questions and added texts (based on Perner et al, 1987) and a computer version involving a number of different games.

The pattern of results found with the computer presentation was similar to that found for the dolls presentation. For both presentations autistic children failed to understand false belief, whereas the Down's syndrome children and the young normal children passed on these tasks. This difference between the groups was found to be significant.

This experiment lends further support for the hypothesis that autistic children are specifically impaired in their theory of mind. Also, the fact that we found these results using both forms of presentation suggests that the autistic children's failure is due to something in the conceptual nature of the task rather than its surface form.

We did find a minority of autistic children who passed the false belief task. These children tended to be of higher Mental Age. However, Down's Syndrome children of lower Mental Age still passed the task, so that failure of the majority of the autistic children could not be due to Mental Age alone.

Baron-Cohen et al (1985) also found a minority group of autistic children who did pass the false belief task. However, in another experiment (Baron-Cohen, 1989) these children were found to fail on higher order levels of belief attribution, whereas mental age matched controls passed. It was proposed that autistic children have a "specific developmental delay" in the cognitive mechanisms employed in attributing false beliefs. Our findings, then, are in line with the theory of mind hypothesis, and it is not unusual for a minority of the autistic children to pass these tests of false belief.

We also found that those autistic children who passed consistently on all three trials of one presentation always passed on the other form of presentation. This suggested further that computer and doll presentations were testing the same aspects of understanding.

Only four autistic children performed inconsistently on the test questions. It was interesting to note that any inconsistency between performance on the two presentations showed failure on the dolls presentation and passing on the computer presentation. We speculated as to the possible explanations for this (see Implications section). However, there were too few children performing in this way for us to draw any strong conclusions.

Given the results of this first experiment then, we felt it would be worthwhile to retest these children. We wanted to examine how stable the results would be over time and if there was any improvement in initial performance (particularly in those children who showed inconsistent results).

Experiment 2

In the second experiment we retested 12 of the autistic children and seven of the Down's Syndrome children six months after experiment 1. The general finding was that the results from experiment 1 remained the same on retesting. We concluded that the tasks were reliable and that the results were stable. This experiment further confirmed our finding that autistic children are impaired in their understanding of false belief. In addition, it confirms that the two forms of presentation, dolls and computer, essentially measure the same cognitive skill (understanding of false belief). and with equivalent reliability.

It was interesting to note that those subjects who showed inconsistent results in the first experiment continued to do so in the second. The exceptions to the consistency of retesting were two subjects who showed improvement in their performance on the computer task, passing the test games. This improvement could be due to a development of understanding of false belief or, alternatively, it could be due to the subjects learning a compensatory strategy, in which case the computer may be functioning as a training device. Although we were only dealing with a few subjects here we felt that this "subplot" would be interesting to follow up.

We decided it would be interesting to consider how autistic children performed on a different test of false belief. If the autistic children again failed, this would provide further evidence for a deficit in understanding of false belief. In addition, we could look at the performance of those subjects who had shown inconsistent results on the first two experiments. This might give us some indication of whether they were passing the test question because they understood the concept of false belief (in which case they would pass other different tests of that concept), or whether they passed by using a compensatory strategy or algorithm for the Sally-Anne task.

Experiment 3.

In the third experiment we tested understanding of false belief in 19 autistic children (from our original sample of 23) using a different paradigm (deceptive-appearance) in the form of the "Smarties task" (Perner et al, 1987) using a computer version and a standard version of the task. This enabled us to compare performance across different types of tasks as well as between different mediums of presentation. At the time of testing this task had not been tried with autistic children.

The results provided further evidence that autistic children had difficulty understanding false belief. Again, most of the autistic children failed the false belief task.

Both standard and computer presentation yielded the same results. This suggests that both presentations are measuring the same aspect of understanding (false belief) that causes the child to fail the task.

We also compared performance across two different types of tasks and found that the results were remarkably similar for the "Sally-Anne" task and the "Smarties" task. This was true for both standard and computer presentations.

This experiment then, demonstrated the consistency and robust nature of our earlier findings from the first two experiments.

There were, however, some minor differences between the "Smarties task" results and the "Sally-Anne task" results. The most notable difference was that all the subjects, apart from one, passed the control questions, although the vast majority still failed the test question. The control questions are not so rigourous for the "Smarties task", requiring less verbal ability and memory recall, particularly for the computer task.

We were also able to make some interesting observations concerning the four subjects who had shown unpredictable results in the first two experiments. Two of these subjects passed the "Smarties task" consistently, having previously shown a combination or improvement in results in experiments one and two. This suggested that they had developed a genuine understanding of false belief during the course of the first two experiments (whether through training or through natural development over this time) which enabled them to pass the different test of false belief in experiment three. In contrast, the other two subjects, who had performed in a similar way in the first two experiments, went on to fail the "Smarties task". Possibly these subjects had passed the "Sally-Anne task" using a compensatory strategy (ie without understanding the concept of false belief) which would not generalise to a different test of false belief and would therefore not enable them to pass the "Smarties task". We also observed that subjects the first pair were considerably older than second, making them stronger candidates for true development of false belief understanding at this level.

We now had a profile of the autistic children, in terms of their performances on false belief tasks reflecting the extent of their cognitive impairment. The majority of the autistic children failed to understand false belief, regardless of the type of task or the form of presentation. In the next study we set out to examine how performance on the false belief tasks relates to everyday observed behaviours. In particular, we hypothesized that those children who failed false belief tests would be more impaired in the Socialisation Domain, since a deficit in this domain best reflects the autistic behaviour.

Experiment 4

In the fourth experiment we found evidence of a relationship between theory of mind capacity and adaptive behaviour in both autistic and Down's Syndrome children. Those who failed on two false belief tasks were significantly more impaired on the Vineland Adaptive Behaviour Scale (VABS) than those who passed the false belief tasks, particularly on the Socialization Domain.

We also identified specific behaviours which differentiate those who pass and those who fail on the theory of mind tasks. The majority of these behaviours had been rated by four independent judges as "requiring a theory of mind."

These findings suggest that a deficit in understanding mental states is linked to a deficit in everyday behaviours particularly in the Socialization Domain.

We also found that despite being matched for performance on the two false belief tasks, the clinical groups still differed in terms of adaptive behaviour score. The specific behaviours differentiating the clinical groups however, were not theory of mind items. The adaptive behaviour score for the Down's Syndrome subjects was higher than that for the autistics on all three Domains.

This suggests that although understanding of mental states is important, it is not the only factor determining behaviour. This leaves space to accommodate other theories of the underlying cause of autism, such as a deficit in perception of affective states (Hobson, 1989).

Another explanation was that children may be at different stages on a developmental continuum of ability to use a theory of mind. The autistic children in the fail subgroup may be improverished not only in understanding belief but also in joint attention and so are more delayed than Down's Syndrome children in the fail subgroup, in terms of their theory of mind capacity.

<u>Experiment 5.</u>

In the fifth experiment autistic, Down's Syndrome and young normal children were trained on a computerized false belief training program.

Speed of learning and overall training performance was the same for the autistic and normal children. The Down's Syndrome children were not as successful during training, but most eventually learned to pass the task.

When testing took place after training, only two children (both Down's Syndrome) failed the Sally-Anne task presented on computer and with the dolls. However, the diagnostic groups did differ in terms their performance on the other false belief tasks involving different scenarios (ie requiring generalization of the false belief task learned during training).

Most of the Down's Syndrome and normal children were able to generalize and hence appeared to have learned the concept of false belief. In contrast none of the autistic children were able to pass other false belief tasks, suggesting that the autistic children had learned an algorithm for the Sally-Anne task during training.

This difference between the groups in tendency to learn the concept, suggests that autistic children are uniquely impaired in terms of the cognitive structures available to them for using a theory of mind.

We speculated that this may be further evidence that the autistic children are more delayed along a development continuum.

It was also interesting that young normal children below the age of 3 years and 9 months were able to pass the false belief tasks after training, suggesting that these children are capable of understanding false belief at this early age.

At the three month follow-up we found that subjects who learned the concept of false belief during training were still able to use it to pass the distant transfer tasks. Some of the subjects may have acquired this concept during the course of natural development; this seemed to be the case for the young normal children who improved in their performance at follow-up.

The autistic children also appeared to remember what they had learned during training. In fact, those who still passed the Sally-Anne task were also volunteering text from the original computerized training program which they appeared to have learned word for word.

iii). Implications

Using a variety of tasks and forms of presentation we have found that autistic children are impaired in their understanding of false belief. The results suggest that it is something in the conceptual nature of these tasks, rather than their surface form, that contributes to the autistic children's failure. The impairment cannot be explained simply in terms of the Mental Age of the autistic children, as other matched clinical groups perform well on these tasks.

Furthermore, there was a strong relation between performance on these cognitive tasks and deficits in areas of behaviour most typically impaired in autism (in the Socialization Domain).

Finally, we have found that autistic children differ from young normal children and Down's Syndrome children in their ability to learn the concept of false belief and generalize this knowledge to other false belief tasks.

This thesis then provides strong evidence that autistic children are impaired in their understanding of false belief. This relates both theoretically (Metarepresentational Deficit Theory) and practically (Vineland Adaptive Behaviour profiles) to the behavioural impairments observed in autism. This underlying cognitive deficit draws together what seemed to be unrelated core features of autism (Wing's triad of impairments).

These findings add to the general picture that autistic children are specifically delayed in their theory of mind understanding, when added to an array of other supporting evidence (Baron-Cohen 1989, 1990, Baron-Cohen et al, 1985, 1986; Harris and Muncer, 1988; Leslie and Frith, 1988; Perner, Frith, Leslie and Leekam, 1989).

A deficit of this nature has far reaching implications for autistic children. Frith (1989) points out the importance of having a "theory" or coherent system of thought for predicting and explaining the social behaviour and communicative behaviour of others. As Frith puts it "We need to know what it means to have a mind and to think, know and believe, and feel differently to others....one needs the ability to read between the lines, and yes, to read other people's minds." Looking at the wider implications of this mentalizing ability could be conceptualised as a vital cohesive interpretive device, one which is not functioning in autistic children.

The results of the training study suggested that autistic children may have learned differently from the other two groups. This raises two important questions; why did they learn differently? and if they were learning an algorithm, can that be at all useful in terms of bringing them closer to having a genuine theory of mind? In order to address these questions we need to consider how theory of mind develops normally.

Our argument throughout the thesis is that children's understanding of the mind is innate, in other words there is some kind of theory of mind module (Leslie, 1987,1988) which is deficient in autistic children. An extreme view would be that the development of a theory of mind depends wholly on the maturation of this mechanism. A less extreme view would be that there are a number of innate precursors for later genuine conceptual development (Bartsch and Wellman, 1989; Freeman, Lewis and Doherty, 1991) such as joint attention (Baron-Cohen, 1990), language development (Bretherton and Beeghly, 1982) and judgement of emotion (Wellman and Wooley,1990). These precursors provide the infant with a certain view of the mind which is then revised as the infant learns more about experience and behaviour. The theory of mind normal children end up with is influenced by what they start with. Using this model of development it may be that autistic children start without the normal infant apparatus and so might never fully develop a theory of mind. In other words in the training task they may be able to learn the surface form of a false belief task without being able to incorporate it into a theory of mind.

Another view is that this ability develops as a result of theory formation (Carey, 1985, 1988; Gopnik, 1988, Karmloff-Smith,1988). The child develops a theory as a result of internal structural factors (for example the drive for simplicity) and external factors (such as confirming and disconfirming evidence). The theory itself influences what evidence will be collected and how it will be interpreted and the new evidence modifies the theory (Churchland, 1984, Stich, 1983). If we consider the internal structures in this model to be the theory of mind module (or innate structure), then this is similar to the model above. With such a model, providing salient evidence and counterevidence as we have done in the training program should accelerate the development of the theory of mind.

We might argue then that the normal and Down's Syndrome subjects in the training study had the necessary precursors or internal structures available to them to enable them to use the evidence during training to further formulate a theory of mind. The information was not used in the same way by the autistic children as they were unable to incorporate the evidence into an existing theory.

Is it possible then for autistic children to "bridge the gap" between knowing an algorithm and being able to use a theory of mind? Certainly since autism is a developmental disorder (Harris, 1989; Sigman, 1989) it seems likely that at least to some extent the mechanisms or innate structures for theory of mind may develop at a later stage. Perhaps a more extensive program of training with confirming and disconfirming evidence may serve to accelerate that development.

It may also be possible that understanding of mental states could develop in a different way. The intropectivist's view holds that knowledge of mental states is closely related to the child's immediate psychological experience. For example Nelson (1981) argues that psychological knowledge might organise itself into scripts. The child acquires expectations about the structure of common events and the scripts map these into a more general plan. Then, to interpret action the child searches for a general plan to fit a situation. For example the child might know that a person will do x given the psychological circumstance y without having a theory of mind. One possibility is that autistic children could form an elaborate set of plans or algorithms which they can use to predict and explain behaviour in a way that approximates to using a theory of mind but does not require the use of the innate mechanisms necessary for a genuine theory of mind.

In terms of treatment and therapy for autism, it is an important step to have gained a clearer picture of the underlying nature of the disorder. For example, this has important implications for more effective communication with autistic children. We need to be aware that what seems self-evident or redundant in our own utterences needs to be literally "spelt out" to the autistic child. Similarly, we need to be aware of how easily the autistic child may omit important features of his/her own messages. Also, we cannot make the normal assumptions in terms of interpreting the behaviour of an autistic person.

One therapeutic approach might be to present the child with a variety of social situations where s/he may need to use a theory of mind. In particular, it may be worth concentrating on those behaviours identified using the Vineland Adaptive Behaviour Scale as being affected by the cognitive deficit. It may be possible to teach autistic children to use compensatory strategies for coping with such behaviours and the situations where such behaviours are important. Alternatively, it may be possible that some genuine understanding of theory of mind can be taught. The evidence from our training study suggests that teaching autistic children to understand the concept of false belief and ultimately use a theory of mind may be extremely difficult.

The findings of the thesis also emphasised the enormous potential of the computer both as an investigative tool for cognitive psychology experiments, and as a possible teaching device for use with autistic children. The results of the false belief tasks for the computer presentation closely matched those found for the standard presentation. This suggests that the computer can be used effectively for this purpose.

There are a number of advantages of computer presentation. Firstly it creates a very controlled environment for an experiment, cutting out many of the irrelevant features which might intefere with standard human presentation. Secondly, it is clearly enjoyed by the autistic children, as our anecdotal account suggests, which is to the advantage of a researcher trying to motivate the child in an experimental situation, and thirdly, it has potential as a novel teaching device.

Another advantage of using the computer is that programs can be designed to meet the needs of individual children and to adapt appropriately as their needs change, capitalising on their skills and taking account of special difficulties. Factors such as individual learning history, ability to cope with change and communication skills can be considered in the design.

These preliminary findings concerning computer use with autistic children are promising. Future research is now required to analyze the advantages and also the possible dangers of computer programs for therapy and instruction. We need to consider what sorts of programs are most effective and most preferred by autistic children. For example, do they prefer certain sorts of music or sounds? How much control should the children have over the program? How can these programs be best structured? We also need to consider whether computer packages are useful in teaching a concept which can be generalized, or will an algorithm always be learned. If the computer can be used effectively in communicating and interacting with autistic children in may prove to be an indispensable aid to research and teaching with autistic children.

The research findings of this thesis have raised a number of questions for future research. It will be interesting to investigate further the nature of the cognitive deficit in autism. In particular,we need to look at other aspects of understanding related to theory of mind such a wishes, desires, intention, affect etc as well as possible precursors to a theory of mind such as joint attention and imitation. We also need to look more closely at the autistic child's ability to make different sorts of inferences and to build knowledge on that basis.

APPENDIX A. Vineland items rated by independent judges as requiring or not requiring a theory of mind.

Which of the following items requires the use of a "theory of mind"?

Being able to use a "theory of mind" means :
- being able to take into account one's own or someone else's mental states

Examples of mental states are :

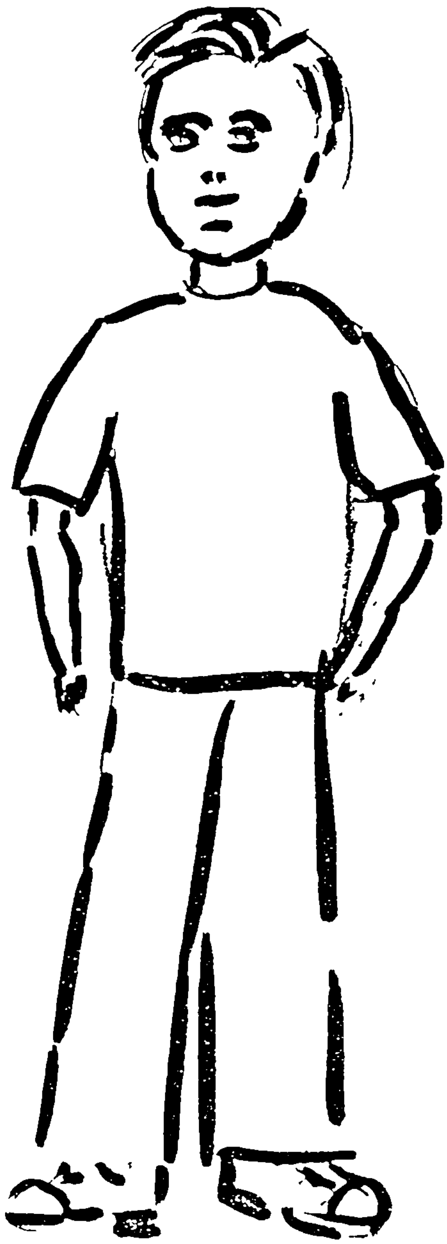
Pretending
Knowing
Believing
Dreaming
Wanting

Item	Number of judges rating item as requiring a theory of mind
1. Reaches for familiar person.	0
2. Shows interest in activities of others.	0
3. Laughs or smiles appropriately in response to positive statements.	0
4. Engages in elaborate make-believe activities, alone or with others.	4
5. Shows preference for some friends over others.	0
6. Labels happiness, sadness, fear and anger in self.	0
7. Follows rules in simple games without being reminded.	0
8. Apologizes for unintetional mistakes.	4
9. Responds appropriately when introduced to strangers.	0
10. Keeps secrets or confidences for more than one day.	4
11. Returns borrowed toys, possessions, or money to peers, or returns borrowed books to library.	0
12. Ends conversations appropriately.	0

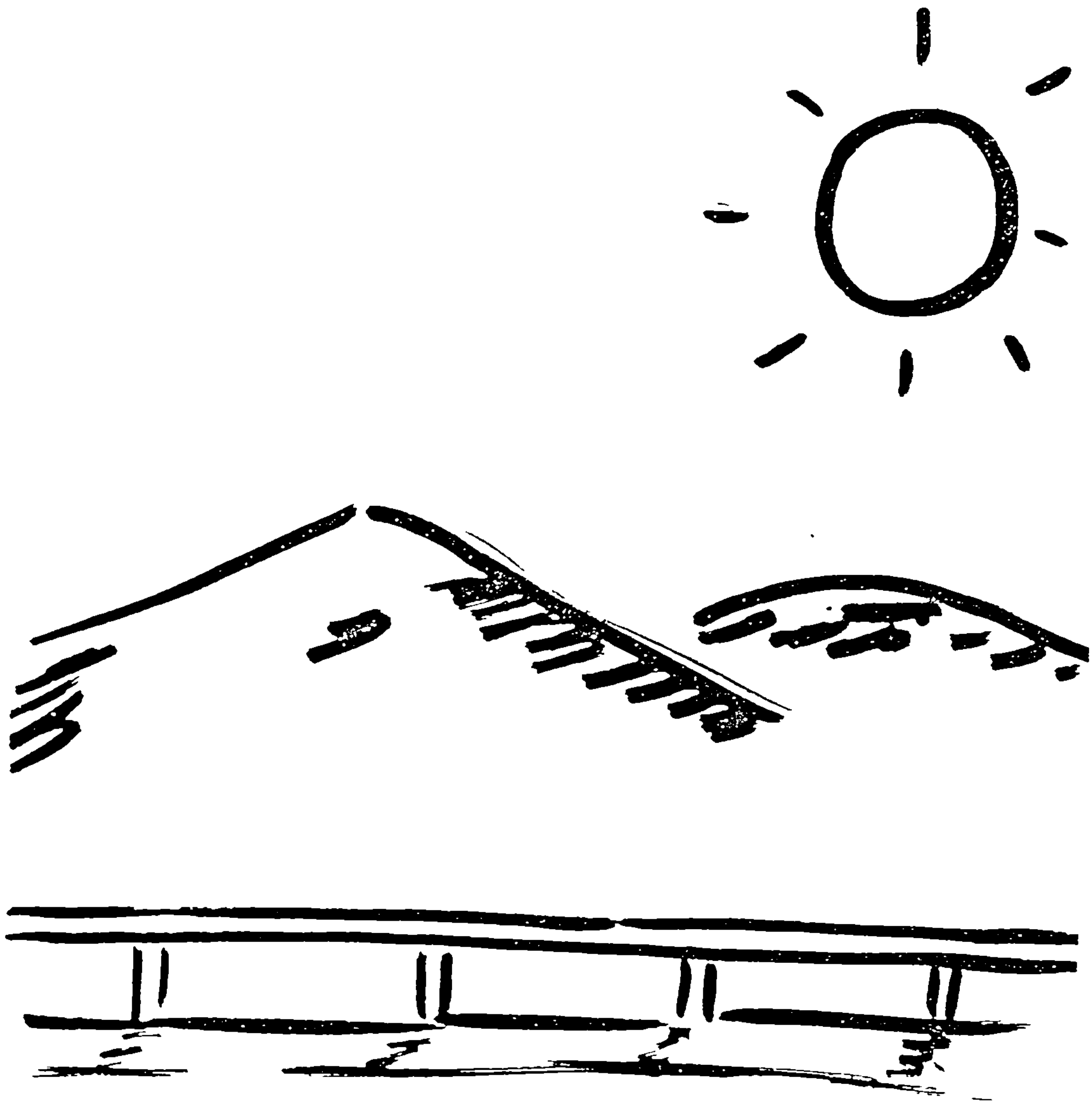
13. Refrains from asking questions or making statements that might embarrass or hurt others.	4
14. Keeps secrets or confidences for as long as appropriate.	4
15. Uses appropriate table manners without being told.	0
16. Independently weighs consequences of actions before making decisions.	0
17. Apologizes for mistakes or errors in judgment.	3
18. Initiates conversation on topics of particular interest to others.	4
19. Responds to hints or indirect cues in conversation.	3
20. Makes and keeps appointments.	0
21. Expresses ideas in more than one way without assistance.	3
22. Relates experience in detail when asked.	0
23. Responds verbally and positively to good fortune of others.	3
24. Controls anger or hurt feelings when denied own way.	0

APPENDIX B. Tom Task Pictures (Experiment 5.)

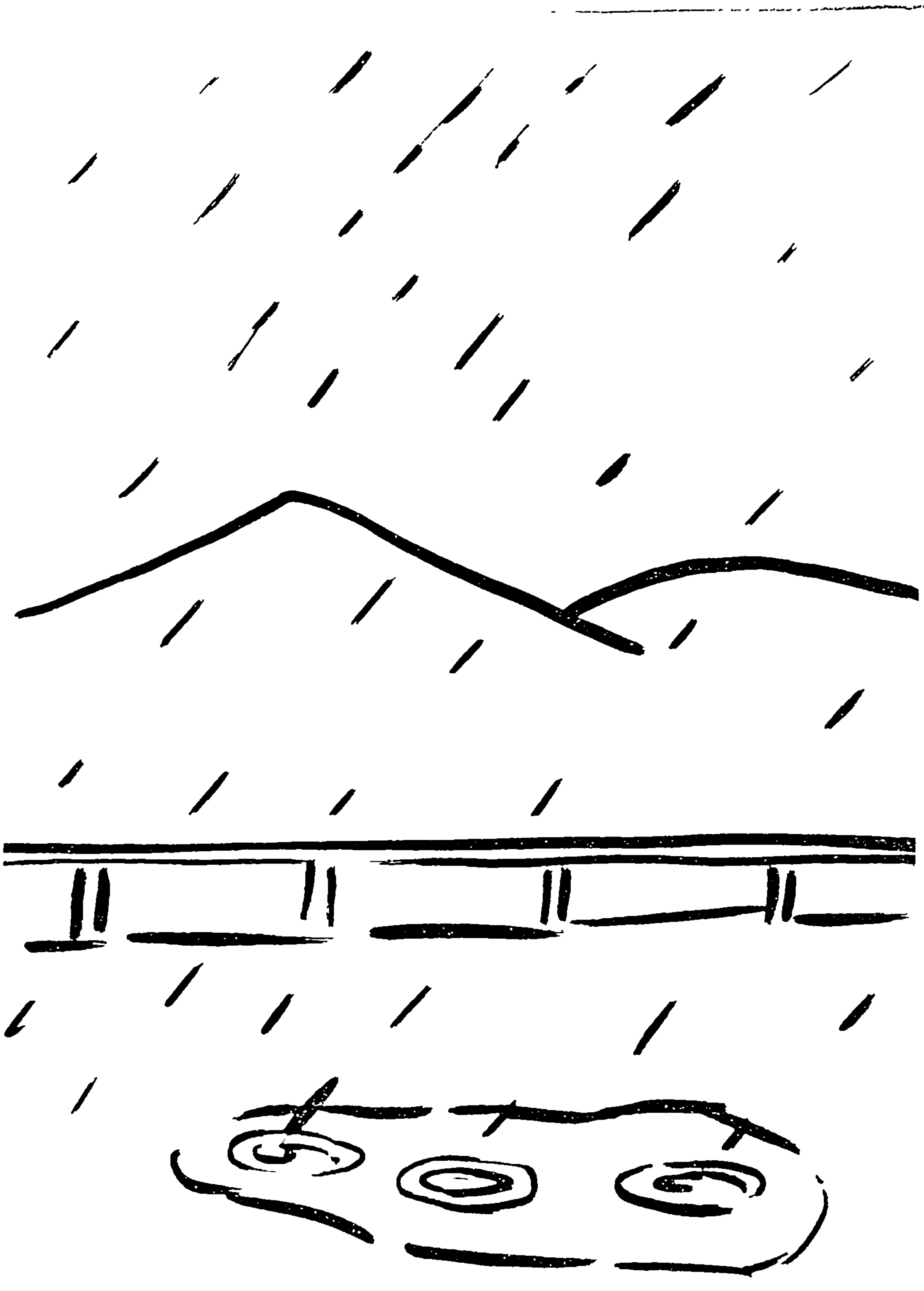
Picture 1.



Picture 2.



Picture 3.



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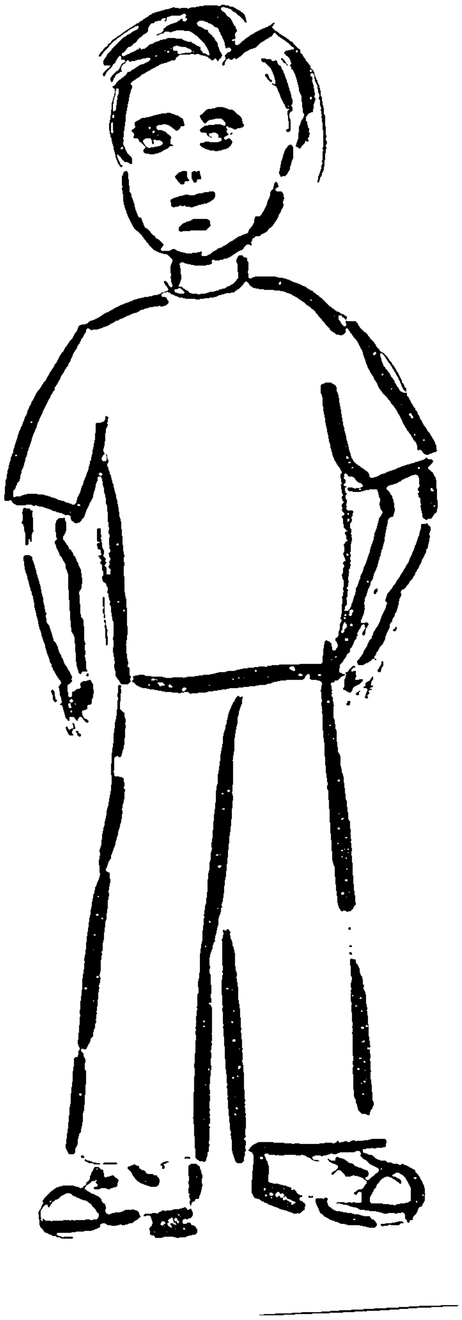
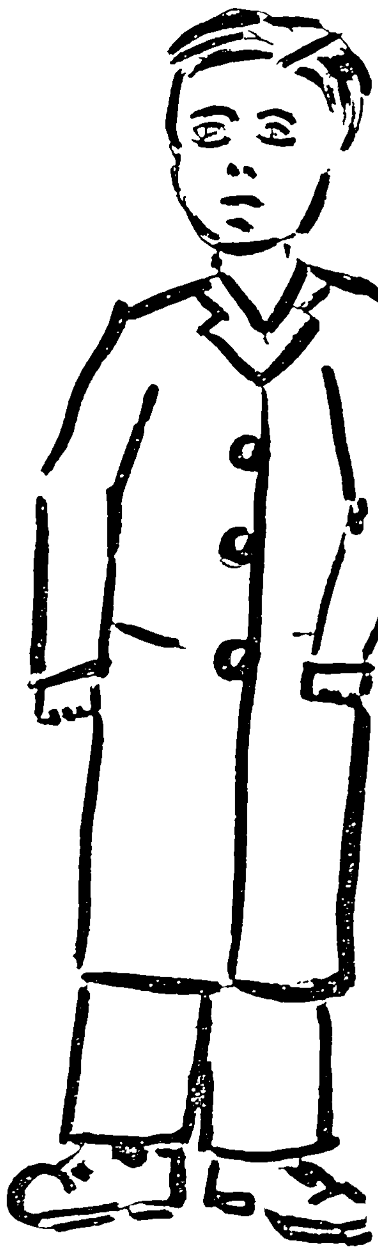
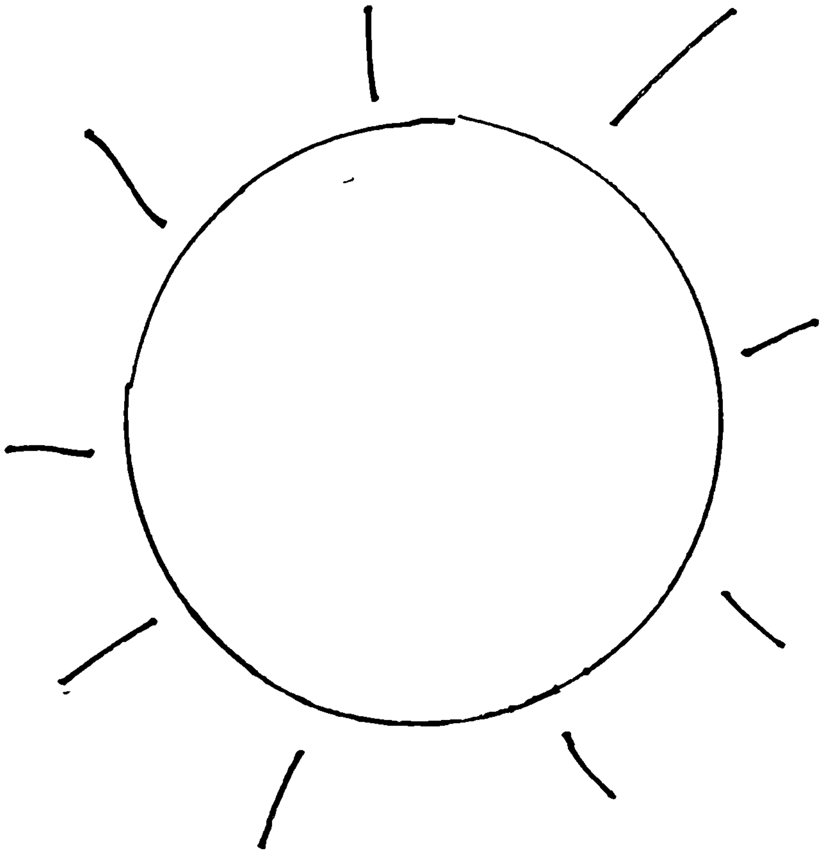


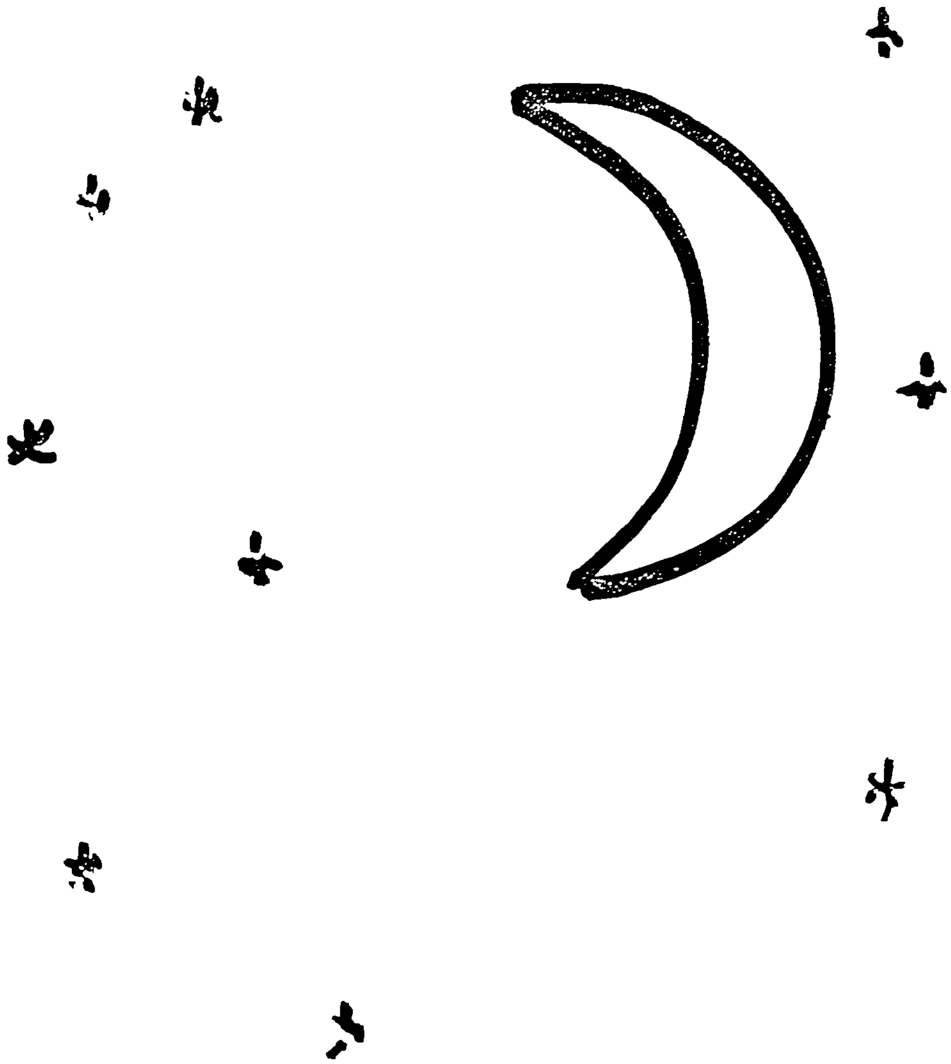
Picture 5.



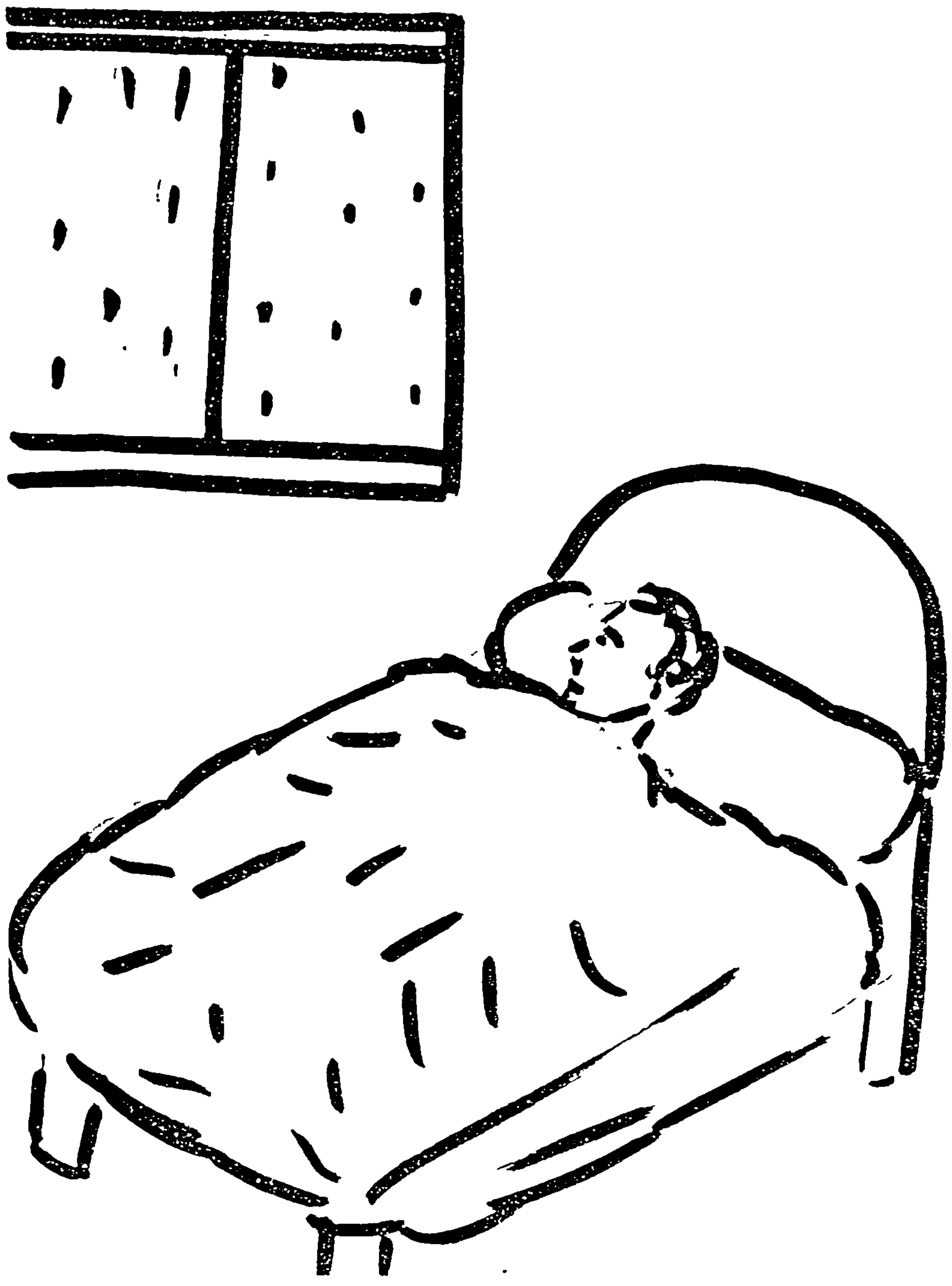
Picture 6.



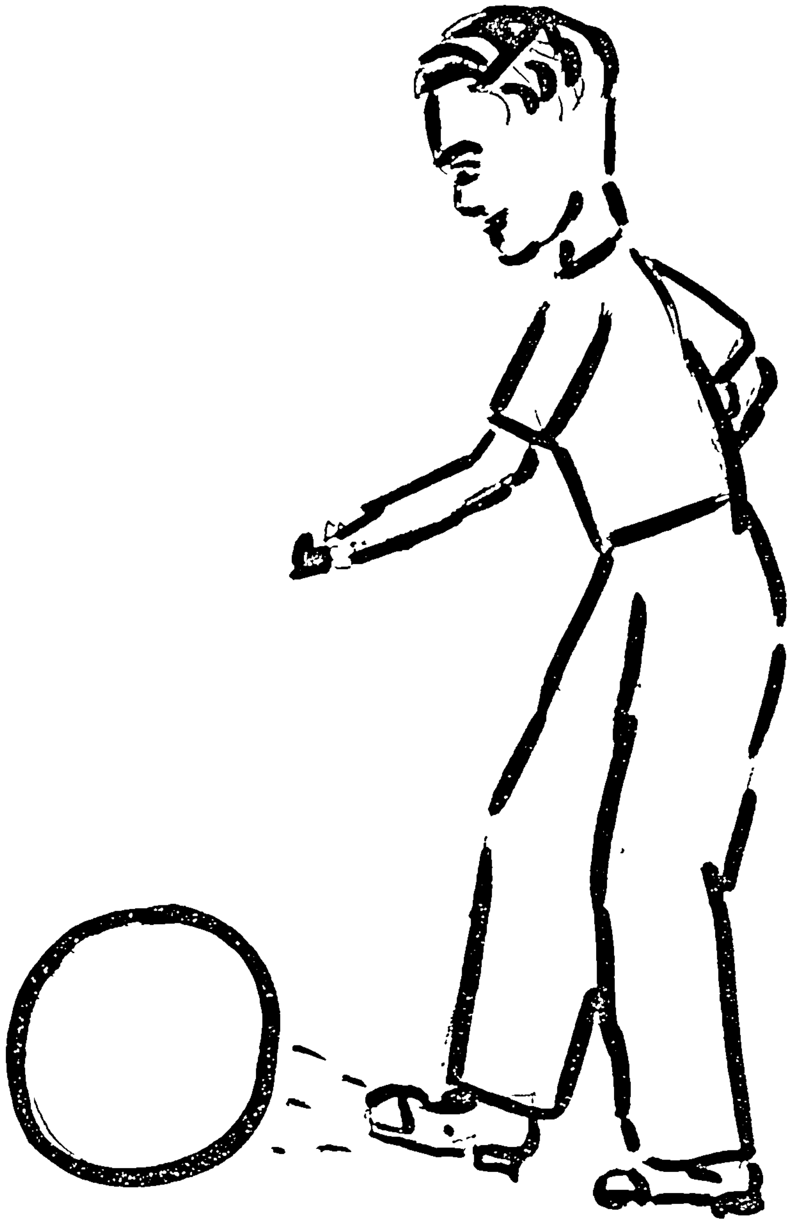
Picture 7.



Picture 8.



Picture 9.



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