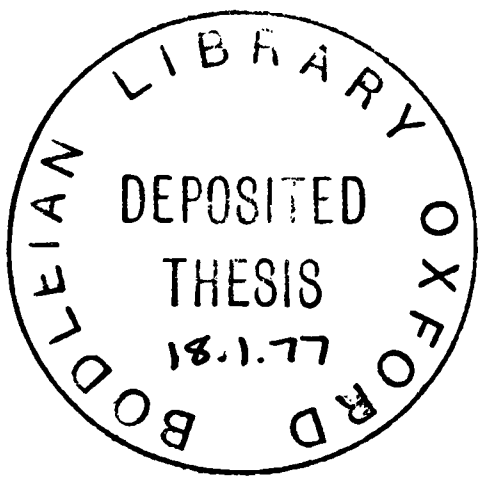
VISUAL AND TACTILE PERCEPTION IN NORMAL AND MONGOLOID (DOWN'S SYNDROME) INFANTS

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Thesis submitted for the degree of Doctor of Philosophy

March 1976

ABSTRACT

This thesis examines some aspects of visual and tactile perception in young mongol and normal children of similar mental ages.

In Chapter 1 the mongol person is introduced as a member of a discrete group which is well defined clinically and which is characterised by several chromosome aberrations. It is seen that the mongol can be identified at birth on the basis of clinical characteristics and his condition can be confirmed by chromosome analysis. Mongols therefore provide the research worker with the opportunity to study the very early development of a relatively homogeneous group of mentally handicapped children.

In the remainder of Chapter 1 the development of the mongol is considered. Four aspects of his development are examined: intellectual ability, motor ability, verbal ability and perceptual ability. It is argued that the areas of visual and tactile perception provide the most exciting prospects for research with the young mongol, since the visual abilities of the adult mongol seem to be similar to those of persons of the same mental age, whereas his tactile abilities seem to be deficient. Therefore in Chapter 2 the development of visual and tactile abilities of normal children and the ways in which these are studied in the young normal child are reviewed. It is seen that the normal child is able to perceive and remember many features of visually and tactually presented patterns from an early age.

Chapter 3 describes the subject populations of mongol and normal children who took part in the experiments. It is demonstrated that the sample of mongol children was fairly representative of the mongol population in terms of birth weight, parental ages, birth order and number and age of siblings, although the effects of maternal age and birth order were smaller than reported in other studies. It is proposed that these differences could be accounted for by the observed shift towards earlier childbearing ages in the general population.

The first experiment (Experiment 1) is described in Chapter 4. Normal and

mongol children were matched for mental age, sex and social class, and their visual exploration and memory of simple two dimensional patterns were compared. There was little difference in the way in which the mongol and normal children responded visually to two such patterns. Both groups showed less visual interest when the two patterns were identical compared with when they were of different shapes and colours. In a similar way, the children's interest decreased when one pair of patterns was presented repeatedly and increased following a change in either the positions of the two different patterns or the shape and colour of the two identical patterns. It was also found that the older mongol and normal children made more eye movements than the younger children did. This experiment therefore established a baseline for the study of visual perception in young mongol children.

In Chapter 5 (Experiment 2) the finding often reported in the literature that the adult mongol has a tactile deficit was investigated in the young mongol. For procedural reasons a direct test of the ability of the young mongol child to distinguish between three dimensional objects by touch alone was not possible. Instead two tactile-visual cross-modal tasks and two visual within-modal tasks using a pair of ellipsoids and a pair of cubes were employed. The mongol children were matched with normal children for mental age, sex and social class. There were two age groups with mean mental ages of about 12 and 17 months. The mongol children performed at chance level on both tactile-visual cross-modal tasks whilst the normals performed above chance level with at least one pair of objects. The older mongols performed above chance level on the visual within-modal task with the ellipsoids: therefore their failure on the cross-modal task with this pair is due either to a tactile deficit or to a failure to integrate tactile and visual information. The chance level performance of the younger mongols on the within-modal tasks could account for their poor performance on the cross-modal tasks.

This second experiment demonstrated that the young mongol child may have some form of tactile deficit and also showed that his ability to distinguish visually between three dimensional objects is inferior to that of the normal child of similar mental age. The normal child is capable of distinguishing visually between three dimensional objects; also his ability to perform above chance level

on a tactile-visual cross-modal task with different pairs of objects increases as he gets older.

The next experiment (Experiment 3) which is described in Chapter 6 investigated the possibility that the mongol's poor visual discrimination of three dimensional objects was a result of the way in which he looked at them. Normal and mongol children were presented on successive trials with two dimensional patterns which could not be touched, and with three dimensional patterns which could be touched. A number of measures were taken of the way in which the children responded to the patterns. These were the total length of fixation, the number of fixations, the number of comparisons made between the patterns, the number of repeated fixations of one pattern, the times taken to fixate both patterns, the average fixation length, the lengths of the first fixation to both patterns and the amount of time which the children touched the three dimensional patterns. Both groups of children showed greater visual interest in the three dimensional patterns than they did in the two dimensional patterns. However, the normal children, especially at a mean mental age of six and a half months, fixated the three dimensional patterns in a different way from the way in which they fixated the two dimensional patterns. In particular these younger normal children made more comparisons between three dimensional patterns than they did between two dimensional patterns. The younger mongol children made fewer comparisons between three dimensional patterns than did the younger normal children. However, the mongol children, but not the normal children, made more repetitions of fixation to two dimensional patterns than to three dimensional patterns. The normal children made more repetitions of fixation to three dimensional patterns than did the mongol children.

Thus this experiment provided some evidence for a difference in the way in which normal and mongol children look at three dimensional patterns, and confirmed the similarity in their visual responses to two dimensional patterns. The normal children seemed to be more active perceptually, particularly when they were looking at three dimensional patterns, since they moved their eyes more extensively than did the mongols.

One possible problem with this experiment was that the three dimensional

patterns could be touched but the two dimensional patterns could not. The next experiment (Experiment 4) which is reported in Chapter 7, investigated the possibility that the difference in the tactile abilities of the mongol and the normal children which was found in Experiment 2, could account for the difference in the ways in which the mongol and the normal children fixated the three dimensional patterns in Experiment 3, in that three dimensional patterns offer more tactile information than do two dimensional patterns.

This possibility was tested in this experiment (Experiment 4) by allowing the children to touch and look at the patterns on half of the trials, and on the remaining trials only allowing them to look at the patterns. On each trial two patterns were presented side by side, and these were sometimes both two dimensional, sometimes both three dimensional and sometimes one of each. The measures were the same as those scored in Experiment 3. The results failed to replicate the difference found in Experiment 3 in the ways in which the mongol and normal children fixated two and three dimensional patterns. However, this may have been due to the fact that the younger children in Experiment 4 were older than the younger group in Experiment 3: it was in this latter group of children that the difference in fixation pattern was most marked in Experiment 3.

Nevertheless this experiment confirmed that three dimensional patterns attract more visual attention and are also touched for longer than two dimensional patterns, although overall the normals touched for longer than the mongols did. It was also found that the older children touched the patterns more and made more visual comparisons than the younger children did. This was taken as evidence for a development towards more extensive exploration of these patterns with increasing age. However the most exciting result and one which was quite unexpected, was that the opportunity to touch the patterns resulted in both the mongol and the normal children paying more visual attention to the patterns. Thus although the mongols have some form of tactile deficit which probably resulted in them touching the patterns for a shorter time than the normals did, their visual behaviour is affected by touch, and appears to be affected as much as it is in normal children.

In this experiment (Experiment 4) there was an indication in some of the results that when a two dimensional pattern was presented with a three dimensional

pattern the visual response was affected by the relative left-right positions of the two patterns. Therefore the aim of Experiment 5 which is described in Chapter 8, was to explore spatial influences in more detail. This experiment compared the visual response to two patterns arranged horizontally with the visual response to two patterns arranged vertically. The patterns could not be touched and as before two and three dimensional patterns were used. Once again both the mongol and the normal children looked longer at a pair of three dimensional patterns than at a pair of two dimensional patterns.

The previous findings of Experiment 4 of visual responses to a pair of two dimensional and three dimensional patterns being influenced by their relative left-right positions were not replicated in Experiment 5. However there was a marked effect of the two axes. Patterns arranged along a horizontal axis were compared more frequently than were patterns arranged vertically. On the other hand, patterns arranged vertically received more repetitions of fixation than did horizontally arranged patterns. The effect of the spatial arrangements of the patterns was found for both the mongol and the normal children, although there was some indication that the normal children moved their eyes more actively than the mongol children did. However within both groups there was a sign of more active scanning by older than by younger children.

In Chapter 9 the results of the experiments are considered with respect to six questions. Three of these concern the way in which the children looked at two dimensional patterns, at three dimensional patterns and at patterns in different spatial locations. Two others concern the tactile perception of the children and the amount of touching which occurred. The final question concerns the effect which touch has on visual behaviour. It is concluded that the experiments have furthered our understanding of the way in which the normal child investigates patterns through the modalities of touch and vision, and have indicated two areas of perceptual deficit in the young mongol: (1) some form of tactile deficit, and (2) a deficit in his visual exploration of patterns. The possible role of these deficits in the mongol's subsequent cognitive development is examined and finally some ideas for future experiments are outlined.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the help and encouragement which I have received from many people. In particular my supervisor, Dr. Peter Bryant, has been of invaluable assistance throughout, especially by his thorough reading of various approximations to the chapters which follow and by his frequent perceptive suggestions for improvements. I have learnt a great deal from him about research, specifically the value of simple experiments and the importance of clarity of expression. Any failings in this thesis on either of these counts are due entirely to me and not to my mentor.

I should also like to thank Guy Claxton, Hugh Fairweather, Simon and Kathy Hewson and Andrew Ridgers who have given me the motivation to continue on those frequent occasions when I was prepared to give up. Betty and Victor Lewis have provided constant support and I shall always be indebted to them both.

I owe thanks to the Medical Research Council who made it financially possible for me to carry out my research, to Mr. Dennett who in his inimitable way made transport available for this research, and to Professor Weiskrantz who allowed me to use the facilities in the Department of Experimental Psychology, Oxford.

My thanks go to Dr. H.C. Dawkins of the Department of Forestry, Oxford, who has given me advice on statistics on many occasions and who has allowed me to use several of his computer programmes for analysing my data.

For technical assistance I am grateful to Derek Clifton who helped me to build boxes and to make stimuli. Jerry Broad and Pauline Willis took the photographs (and should not be blamed for the poor colour reproduction). Mrs. Maureen Stone typed the final manuscript from my various rough drafts and remained calm despite my handwriting and a large number of tables.

My final thanks go to the children and to their parents without whom none of this thesis would have been possible. I have learnt a great deal from them

and I shall always be grateful, particularly to the parents of the mongol children who were willing to let me into their homes. I hope that it was not a one way process and that they learnt something from me.

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CHAPTER I

The Classification and Selected Abilities of the Person with Down's Syndrome (Mongolism)

I. INTRODUCTION: THE MONGOL IS NOTICED

J. Langdon H. Down wrote in 1866:

> Those who have given any attention to congenital mental lesions, must have been frequently puzzled how to arrange, in any satisfactory way, the different classes of this defect which may have come under their observation. Nor will the difficulty be lessened by an appeal to what has been written on the subject. The systems of classification are generally so vague and artificial, that, not only do they assist but feebly, in any mental arrangement of the phenomena which are presented, but they completely fail in exerting any practical influence on the subject.

In the same article he considered

> the possibility of making a classification of the feeble-minded, by arranging them around various ethnic standards.

From his observations of patients at Earlswood Hospital he found

> that a considerable portion can be fairly referred to one of the great divisions of the human family other than the class from which they have sprung.

In particular he found representatives of the Caucasian, the Ethiopian, the Malay and the Mongolian family.

This thesis is concerned with those children, who, in this early attempt at classification by Down would have been likened to members of the Mongolian race. However we can first follow the development in the classification of these persons over the hundred years or so since Down first drew our attention to them.

Down (1866) in this classic report drew special attention to the mongol. He wrote:

> A very large number of congenital idiots are typical Mongols. So marked is this, that when placed side by side, it is difficult to believe that the specimens compared are not children of the same parents.

He remarked upon the close resemblance of these idiots to one another in mental power, and although he did not elaborate this, he gave the following description of a mongol boy.

> The hair is not black, as in the real Mongol, but of a brownish colour, straight and scanty. The face is flat and broad, and destitute of prominence. The cheeks are roundish, and extended laterally. The eyes are obliquely placed, and the internal canthi more than normally distant from one another. The palpebral fissure is very narrow. The forehead is wrinkled transversely from the constant assistance which the levatores palpebrarum derive from the occipito-frontalis muscle in the opening of the eyes. The lips are large and thick with transverse fissures. The tongue is long, thick, and is much roughened. The nose is small. The skin has a slight dirty yellowish tinge, and is deficient in elasticity, giving the appearance of being too large for the body.

He also commented

> They have considerable power of imitation, even bordering on being mimics. They are humorous, and a lively sense of the ridiculous often colours their mimicry.... They are usually able to speak; the speech is thick and indistinct, but may be improved very greatly by a well-directed scheme of tongue gymnastics. The co-ordinating faculty is abnormal, but not so defective that it cannot be greatly strengthened. By systematic training, considerable manipulative power may be obtained.
>
> The circulation is feeble, and whatever advance is made intellectually in the summer, some amount of retrogression may be expected in the winter. Their mental and physical capabilities are, in fact, directly as the temperature.

There is no doubt that the condition which Down described is the same as that which is now referred to as mongolism, although Down's ethnic classification of idiots later proved only to be based on a superficial resemblance. There are earlier reports of individuals who fit the category (e.g. Seguin, 1846) but the classification is usually attributed to Down. For this reason the nomenclature Down's Syndrome is frequently used. In this thesis the condition will be referred to as mongolism and the children as mongols.

After Down's original paper there were many reports which confirmed his observations (e.g. Ireland, 1877; Shuttleworth, 1883). However it was not until recently that a mongol could be identified unequivocably (Böök, Fraccaro and Lindsten, 1959; Ford, Jones, Miller, Mittwoch, Penrose, Ridler and Shapiro, 1959;

Jacobs, Baikie, Court Brown and Strong, 1959; Lejeune, Gautier and Turpin, 1959). Until then all mongols were classified on the basis of the clinical characteristics which they possessed.

I.A. Clinical Classification

In order to be able to classify a person with one group or another it is necessary to ensure that each characteristic which is selected fulfils the following requirements (Gibson, Pozsonyi and Zarfas, 1964). It must differentiate the members of the particular group from those of other groups. It must be relatively constant across age groups and across races. It must be reliably identified and finally it must represent the major systems of pathology characteristic of the total group.

There have been many reports which have concentrated on one or more of the clinical characteristics of mongol persons, and it is not intended to deal with those here. For a useful summary the reader is referred to Penrose and Smith's excellent account of the mongol person (1966). However, those characteristics which fit the above requirements will be mentioned briefly.

Starting at the head and working down, bachycephaly is common among the mongol population. This is shortening of the anteroposterior diameter and flattening of the occiput. The result is an increased cephalic index since this is the ratio of the width to the length of the head. Moving to the eyes, the palpebral fissures are oblique and narrow laterally, and epicanthic folds are characteristic. The nose is often small, with a flattened bridge and nostrils which point forward. The tongue is usually furrowed, and the teeth, when they appear, are normally irregular. The ears too may be different, often small and in particular the lobe may be reduced in size or even absent.

The hands have attracted much attention, especially the dermatoglyphic characteristics. They are typically broad and stumpy, and the little finger is likely to be short and crooked and with only one crease. In many mongols there is a characteristic fold across the palm called the four finger crease or simian line. It also has been reported that the joints are hyperflexible. A further well known characteristic is a wide space between the first and second toe, although this tends to occur in other mental handicaps.

If a person possesses four or more of the above characteristics and is retarded in his mental development, he is in all likelihood a mongol. However, it is no longer necessary to rely entirely on these features for a diagnosis. The mongol person also has a characteristic chromosome pattern which may be examined to confirm or not a diagnosis which is suspected on the basis of the clinical signs.

I.B. Genetic Classification

Four years before man's normal chromosome complement was shown to be 46 (Tjio and Levan, 1956; confirmed by Ford and Hamerton, 1956), Mittwoch (1952) studied the chromosomes of a mongol during gamete formation and concluded that there were 24 pairs present. Mittwoch was later shown to be correct in terms of mongolism being genetic in origin, but incorrect in the actual number of chromosomes present. It was not until 1959 that the most usual chromosomal aberration resulting in mongolism was identified independently by Lejeune, Gautier and Turpin (1959) in Paris, and Jacobs, Baikie, Court Brown and Strong (1959) in Edinburgh. In both papers it was reported that persons who had been clinically identified as mongols possessed 47 chromosomes as compared with the normal number of 46.

The additional chromosome is in the smallest acrocentric group or G group which contains autosomal chromosome pairs 21 and 22 and the Y sex chromosome. Chromosomes 21 and 22 are extremely similar in size, but it is usually considered that chromosome 21 is trisomic in mongolism. Recent banding techniques have in fact suggested that the trisomic chromosomes are smaller than the others in the G group, but the nomenclature of trisomy 21 remains (Lindenbaum 1975, pers. comm.). This karyotype is variously labelled standard trisomy, trisomy 21 or autosomal trisomy G and accounts for about 95 per cent of all mongol persons.

Approximately three per cent of mongols have yet another type of genetic abnormality. Polani, Briggs, Ford, Clarke and Berg (1960) and Fraccaro, Kaijser and Lindsten (1960) reported cases of a girl and a boy respectively, both clinically identified as mongols, but who only have 46 chromosomes. This suggested one or more mongol karyotypes involving a translocation. In a

translocation the major part of a trisomic autosome of the G group is fused onto the major part of another chromosome of the same group or the D group (chromosome pairs 13 to 15 inclusive). The former karyotype is usually referred to as a G/G translocation and accounts for about one and a half per cent of mongols, whilst the latter is termed a D/G translocation and is of about the same prevalence. Since two chromosomes have been fused in these translocations, there will be 46 chromosomes in each cell as opposed to the 47 in the standard trisomy.

In the case of parents, who have normal karyotypes, producing a translocation mongol the mechanism is as yet obscure. However, there have been many reports, the first by Penrose, Ellis and Delhanty (1960), of one of the parents being a translocation carrier. A carrier has 45 rather than 46 chromosomes, but since one chromosome is the translocation, he or she will have a similar amount of chromosome material as a person with 46 chromosomes. Such a person will be phenotypically normal.

The remaining two per cent of mongols are termed mosaics because they have at least two cell lines, in the majority of cases, normal cells and cells with the mongol characteristics. This final type of mongol was first described in Oxford by Clarke, Edwards and Smallpeice (1961).

The mechanism by which a translocation mongol is produced is at present unknown, but those involved in standard trisomy and mosaicism are described in Appendix A.

I.C. The implications of genetic classification

The identification of several genetic abnormalities which manifest themselves in a single clinical entity, mongolism, has been important from a research point of view for several reasons.

Prior to genetic identification mongols were classified apart from normal and other retarded persons on the basis of a group of clinical characteristics which they selectively possessed. The genetic advances have enabled definite inclusion in or exclusion from the mongol group. This means that the research worker can be certain that he is dealing with a single clinical entity. This has

important implications for the study of mental deficiency. As more retarded persons can be classified into discrete clinical entities, research can be directed towards differences between these groups as opposed to differences between persons of differing intelligence levels for example. However even this has its limitations, for although the genetic criteria for classifying a person as a mongol mean that one is dealing with an homogenous group as far as genetics are concerned, it must not be forgotten that there may still be considerable variability within the group as far as other aspects such as intelligence, are concerned.

This acknowledgement of possible variability within the mongol group leads to a second implication that the genetic studies have had for research. If it is assumed that the clinical criteria used to identify a mongol person were relatively foolproof, then the advent of the genetic studies will have added little except further conformation.

However, the genetic studies have identified several chromosome abnormalities amongst people who have been classified clinically as mongols. On the other hand there appears to be no clinical differencebetween these persons with different karyotypes (Gustavson, 1964; Gibson and Pozsonyi, 1965; Johnson and Abelson, 1969). It is therefore conceivable that by studying mongols with different karyotypes some of the variability within the mongol population will be accounted for. However, since translocation and mosaic mongols form only a small proportion of the total mongol population, the analysis of any difference in behaviour of mongols with different karyotypes may prove impossible. It will either be necessary to deal with extremely small groups or to draw together isolated cases reported in the literature. Both of these apprcaches have serious limitations.

A third, and, for the present thesis, the most important implication of the genetic advances is that young children who are clinically diagnosed as mongols can be confirmed without the investigator waiting to see how the child develops mentally and physically.

II. THE DEVELOPMENT OF THE MONGOL

Up to this point the mongol person has only been considered in terms of how he may be identified as distinct from other retarded persons and normal persons. The emphasis has been on his physical and genetic characteristics. But we shall now turn to his mental characteristics. There is a fairly large literature on the intelligence of mongol persons, and this will be reviewed in the next section following a brief discussion of the quantification of intelligence and the classification of persons with retarded development. This section will provide evidence that there are factors which seem to affect the measured intelligence of the mongol person, in particular his age and his environment.

II.A. Quantification of intelligence

All valid intelligence tests are standardised on a population of persons similar to, if not identical with, those persons to whom the test will be administered. Performance at a particular level can therefore be related to the average chronological age (abbreviated to C.A.) at which that level should be reached. Each person who is tested will attain a certain performance level, and the average C.A. which corresponds to this level is taken as the person's mental, maturational or developmental age (abbreviated to M.A.).

Intelligence quotients (abbreviated to I.Q.s) are derived from some relationship between the M.A. and the C.A. of each person, whether it be a simple ratio ($I.Q. = \frac{M.A.}{C.A.} \times 100$) or a more complicated form taking standard deviations into account. I.Q.s can be derived for a person of any age. It is customary to term the I.Q. of children of less than three years of age, developmental quotients (abbreviated to D.Q.s). The rationale behind this is presumably that it is especially difficult to ensure that the abilities, which are being tested in the child of under three years, have anything whatever to do with what is referred to as adult intelligence.

For an average person taken from the same population as that on which the test was standardized, his C.A. should be the same as his M.A. This person will therefore have an I.Q. of 100. For the backward person his C.A. will exceed his M.A. and so his I.Q. will be less than 100. The extent to which his I.Q. is below 100 will reflect the C.A.-M.A. discrepancy and hence the degree of his

retardation. Conversely, a person with an I.Q. greater than 100 will have a M.A. in advance of his C.A.

This appears to be straightforward, but because I.Q. can be calculated in different ways this can lead to difficulties in how it is to be interpreted. This is well illustrated by an example from the literature on the intelligence of the young mongol. Carr (1970) calculated D.Q.s of mongol babies by taking into account the standard deviation of the standardized population. She found the most rapid decline in mongol D.Q. between one and a half and ten months, whereas Dicks-Mireaux (1966) found the maximum increase in D.Q. between three and nine months. Now, Dicks-Mireaux used the simple ratio method of D.Q. $= \frac{\text{M.A.}}{\text{C.A.}} \times 100$, and when Carr applied this ratio to her data, she found the average D.Q. to increase between one and a half to six months

On the ratio method the D.Q. at one and a half months was two standard deviations below the mean; by the other method it was just over one. This is because at one and a half months, one standard deviation on the Bayley Scale, which Carr used, included nearly two weeks of M.A. Therefore by the simple ratio method the child would have a D.Q. of 67. At six months, the D.Q. by Carr's method was two standard deviations below the mean, representing 1.3 months of M.A., or by the ratio method a D.Q. of 78. The simple ratio method would therefore show an increase in mongol ability from one and a half months to six months, whereas the one and a half month old mongol is only one standard deviation below the normal and the six month old mongol is two standard deviations below the normal.

The view taken in the present thesis is in accord with Carr's. If a D.Q. can only be computed by the simple ratio method, the age equivalent should be used. D.Q.s should only be used when the standard deviations of the standardized population are taken into account.

Having said that, it seems reasonable to ask what information is provided by an I.Q., D.Q. or M.A. It is possible to obtain such measures from any person provided that he can be tested and his ability falls within the range of the test employed. Early workers tended to think of intelligence as a general ability (Spencer, 1855; Galton, 1870; Spearman, 1904), but even they did not deny the

existence of more specific abilities. It is now generally accepted that intelligence encompasses many different abilities (e.g. Thurstone, 1938; Vernon, 1950; Guilford, 1956). It is therefore possible that in a particular person these different abilities may each be developed to varying degrees.

The question is how may we obtain information about the qualitative nature of a person's I.Q.? There are two ways. The first, and most obvious, is to use an intelligence test which provides quotients for different abilities. For example, the verbal and performance I.Q.s of the Wechsler scales, the verbal and non-verbal I.Q.s of the Minnesota Preschool Scale of Intelligence, the motor, adaptive, language and personal-social quotients of the Gesell Scales or the locomotor, personal-social, hearing and speech, eye and hand, and performance divisions of the Griffiths Scale. The Gesell and the Minnesota Preschool Scales have been used to assess the intelligence of mongol persons and have shown that these persons do not have the same level of ability on each subscale (e.g. Lyle, 1959). The main drawback to this is that the number of tests from which to choose is reduced.

The second way, which is less satisfactory but more practical, relies on the assumption that items in any particular test are ordered in terms of relative difficulty, independent of what abilities they reflect. A person who possesses all the abilities involved to an equal degree will be able to perform successfully all items up to a particular level and no more. However, the person who possesses the abilities to differing degrees will not have such a straightforward profile. Items at which he succeeds will be surrounded by those he fails. The last item which a person passes before his first failure is termed his basal level, and the age which corresponds to that level, his basal age. The most difficult item that he passes is his ceiling level, or terminal/ceiling age. His overall performance will lie somewhere between the two since it relates to the overall number of items passed.

The knowledge of the basal and ceiling levels gives more information than that of the overall performance alone. For example, two persons A and B might have average scores on an intelligence test, but A might have a difference of 20 items between his basal and ceiling level, whereas B might only have one. In other words, A can do some items which B fails and which fall above A's overall

capabilities, but fails some more elementary items which B passes and which fall below A's overall capabilities. By giving basal and ceiling levels one is not evaluating test scores qualitatively, but this additional information may indicate that it is worthwhile looking for qualitative differences.

This same point is made by Cornwell and Birch (1969) in a study of 44 home reared mongols aged from 4 to 17 years. Using the Stanford Binet, they found the maximum increase in basal age over the 13 year span to be 2.6 years, whilst the maximum increase in the ceiling age was 5.0 years. As a result of looking at the types of items passed and failed, Cornwell and Birch comment

> children of all ages with Down's Syndrome appear to be anchored to a low basal age, which reflects their limitations in language and numerical skills. The terminal age restriction, on the other hand, despite considerably greater uneveness is limited by their inability to develop concept formation and the conceptualization of relations amongst objects.

This suggests that when a person is assessed as having a particular I.Q., this information should be treated with caution. However, as the next section will show, I.Q. has been and still is used by many to classify a person at a certain level of retardation.

II.B. Classifications of mental retardation

Early definitions of mental retardation considered it as a unitary mental ability which was impervious to change. They focussed primarily on incapacity and inability to achieve social competence (Tredgold, 1937; Benda, 1954; Kanner, 1957). In 1959 the American Association on Mental Deficiency (A.A.M.D.) published the following definition of mental retardation: "Mental retardation refers to subaverage general intellectual functioning which originates during the developmental period and is associated with impairment in adaptive behaviour." (Heber, 1959). In this definition, persons with subaverage general intellectual functioning are those whose I.Q.s fall one standard deviation or more below the population mean; impairment in adaptive behaviour refers to ineffectiveness in adapting to the demands of the environment. The A.A.M.D. identified five levels of retardation based on Binet I.Q.s: Borderline (I.Q. 68-85); Mild (I.Q. 52-67);

Moderate (I.Q. 36-51); Severe (I.Q. 20-35) and Profound (I.Q. < 20).

In England, two standard deviations below the population mean (I.Q. < 70) is taken as indicative of mental retardation or subnormality. As with the American classification system, the British one is according to the grade of defect. Three levels have been considered, although it is now more common to put mentally retarded persons into one of two categories. The three levels are termed 1) Feebleminded, subnormal persons or morons (I.Q. 50-70); 2) Imbeciles (I.Q. 20-50); and 3) Idiots (I.Q. < 20). The imbecile and idiot levels are now more commonly combined as low grade or severely subnormal (abbreviated to S.S.N.) persons. The feebleminded group is termed high grade or subnormal. Children in the latter group who in addition to having an I.Q. in the required range (50 to 70) are also educable in terms of not having behaviour problems making them unsuitable for school, are referred to as educationally subnormal (E.S.N.).

Classifications according to the grade of defect, as measured by performance on intelligence tests, indicate the extent to which the person's performance deviates from average, but as was suggested in the previous section, it is more useful to question the manner of particular types of defect. Penrose in 1933a wrote:

> A person is judged to be mentally defective or otherwise according to his social behaviour, and a fault involving a quantitative diminution in any part of the learning apparatus may lead to mental deficiency.... It is commonly held that what defectives specifically lack is intelligence as shown in the failure of the standard mental functions, such as memory and association.

Be that as it may, most of the literature on the intelligence of persons with Down's Syndrome, which is reviewed in the next section, reports the level of intelligence without recourse to its make-up.

II.C. The intelligence of the mongol person

There is a wide range of opinions in the literature on the level of the mongol's intelligence. However, several consistent features do emerge. The first is that a mongol's I.Q. does not seem to be constant over different ages, but tends to decrease as the person gets older. This raises a number of questions.

The first of these questions concerns the position on the intelligence scale of the young mongol. Does he begin life with normal intelligence or is he retarded from birth? We may then consider the intelligence of the adult mongol and ask whether mongol persons who have different karyotypes are also different in intelligence. Third is whether the observed decrease in I.Q. over age represents a real regression in development or merely a rate of development which is slower than found for the normal person. Finally, one of the most important questions from the point of view of development is whether there is any relationship between a mongol's I.Q. at different ages.

The second feature to emerge from the literature is that the mongol who is raised at home has a higher I.Q. than a mongol who is not raised at home. One of the questions which is raised by this is whether in fact it can be concluded that the difference in environment is the cause of the difference in intelligence, or whether there are other differences between home and non-home reared mongols which could also account for this observed difference in I.Q. Another question concerns the age at which the environmental or other parallel effect shows up in the I.Q. scores. Finally we may consider whether there is any carry-over from a home environment to a non-home environment, if the mongol is first reared at home and later placed in an institution.

II.C.1. The young mongol

This section considers the I.Q. of the mongol in his first year until late teens. There seems to be general agreement that although the mongol has an I.Q. often around 70 in his first year, it falls to the imbecile level as he gets older. However, there is some disagreement as to whether he begins life with an average level of intelligence or is retarded from birth. We begin with this disagreement.

There is a single study which reports that the three month old mongol's I.Q. is not different from that of the normal population (Dameron, 1963). The California First Year Mental Scale was administered to 12 institutionalised mongols at 3, 6, 9, 12, 15 and 18 months, and D.Q. was found to decline from 94 at 3 months to 46 at 18 months. There are four points which should be noticed about this study.

First, there were only a few children at some of the ages. Six mongols were seen at 3, 12 and 15 months; five were seen at 18 months; ten were seen at 9 months and eleven at 6 months.

Second, Dameron reports that the scoring of items was modified due to the specific pathology of the children:

> That is, certain elementary responses may appear either very late or not at all, though the subject has moved beyond this level to the more advanced items. An example of this is the item which requires smiling upon perceiving the examiner's face. Many mongoloid infants do not smile at all, and this item was simply coded as passed when more advanced items were achieved.

This procedure would artificially increase the recorded performance of the child, especially at six months and younger since elementary responses should appear at this stage.

Third, D.Q. was calculated using the ratio method ($D.Q. = \frac{M.A.}{C.A.} \times 100$) and this may not reflect the actual performance (section IIA).

Fourth, Dameron's results have not been replicated by some more recent research (Dicks-Mireaux, 1966, 1972; Carr, 1970). Dicks-Mireaux (1966) using Gesell's Development Scales of Motor, Adaptive and Social Development, and also using the ratio method to calculate D.Q. found 12 home reared mongols aged 16 weeks to be below average on all three scales (Motor D.Q. = 73, Adaptive D.Q. = 64, Social D.Q. = 68). She replicated these results in 1972, this time with 21 mongols.

The second researcher to find evidence of early retardation in mongols was Carr (1970). Twenty-nine mongols were found to be below average at six weeks of age. The test used was the Bayley Scales of Mental and Motor Development and Carr calculated D.Q.s by the sigma score method, $D.Q. = 100 \frac{x - \bar{x}}{S.D.} \times 16$, where x is the child's score, $\bar{x}$ the mean score of the standardised population and S.D. its standard deviation. The Bayley Mental Scale contains similar items to the Gesell Adaptive Scale with the addition of some items related to language development. The mean mental and motor D.Q.s at six weeks were 79 and 88 respectively. These are both significantly below average.

It is interesting to note that although all of Dameron's three month old

children were institutionalised, only 14 per cent of Carr's six weeks olds were, the rest being home reared, and all of Dicks-Mireaux's children were home reared. In view of the findings to be reviewed (section II C 5) it is surprising that the study with the highest proportion of institutionalised mongols should report the most normal D.Q.s. However, as Carr's results will be seen to show, one would not predict any difference in performance between home reared and institution reared mongols until after the age of six months.

The evidence from the three studies reporting D.Q.s of below average for mongols aged four months or younger is more substantial than the single study reporting average D.Q.s for mongols at three months, in the number of children tested, the manner of obtaining D.Q.s and by the fact of there being three reports as opposed to a single one. It seems safe to conclude that the mongol is developmentally backward from six weeks of age and possibly even earlier.

However there are two points which should not be forgotten. These are that the finding of a retardation at any age depends upon the sensitivity of the test used, and possibly on the examiner. The behavioural repertoire of the young infant is severely limited compared with that of the older child. Therefore the number of items in a developmental test which are available should increase as the child gets older. Thus it might be expected that the sensitivity of the test would parallel the increase in age. It is also possible that some examiners will have higher criteria than others, although standardised tests normally indicate the level of performance necessary for each item. For these reasons, further replication by different examiners on more children would strengthen the case, or alternatively weaken it.

We now turn to the I.Q. of the mongol as he gets older. Reports of mongols of less than one year who have I.Q.s of 70 or more are not uncommon. Øster (1953) found six out of nine, Koch, Share, Webb and Graliker (1963) found 12 out of 31, and Loeffler and Smith (1964) found 10 out of 20. The authors of the last paper also report that of 47 mongols of three years and under, 30 per cent were imbeciles, 47 per cent were feebleminded and 23 per cent had I.Q.s over 70. These proportions are similar to those found by Øster (1953) for 29 mongols aged three years and under. Of these 24 per cent were imbeciles, 55 per cent feeble-minded and 21 per cent had I.Q.s in excess of 70.

Of 34 home reared mongols aged between three and nine years, Loeffler and Smith found nine per cent to be idiots, 62 per cent imbeciles and 29 per cent feebleminded. Øster reports higher I.Q.s than these for 13 mongols aged between four and nine years. He found 23 per cent to have I.Q.s in the imbecile range and 77 per cent in the feebleminded range. However this sample was small, and Cornwell and Birch (1969) report similar proportions to Loeffler and Smith. Their sample was 27 home reared mongols aged between four and nine years. Two thirds had I.Q.s in the imbecile range, whilst the others had I.Q.s in the feebleminded range. In the same paper Cornwell and Birch report the I.Q.s of 16 mongols aged from 10 to 17 years. Of these one (6 per cent) was classified as an idiot, thirteen (81 per cent) as imbeciles and two (13 per cent) as feebleminded. Øster again reports higher I.Q.s than Cornwell and Birch for 15 mongols in the age range from 10 to 16 years. 67 per cent of these were classified as imbeciles, 33 per cent as feebleminded. It is possible that Øster's sample was more select since Dunsdon, Carter and Huntley (1960) found I.Q.s similar to Øster's for a group of mongols who were specially selected.

Dunsdon et al (1960) reported that of 44 mongols aged between $5\frac{1}{2}$ and $18\frac{1}{2}$ years, one had an I.Q. of less than 20 (2 per cent), 30 had I.Q.s in the imbecile range (68 per cent) and 12 had feebleminded I.Q.s (27 per cent). One child was untestable. The mongols in this sample were selected out of an original 390 on the basis of their having attended primary schools, private schools and E.S.N. schools. Of the original sample, Dunsdon et al estimated that between six and seven per cent had I.Q.s equal to or greater than 45, compared with over 28 per cent in the selected sample, and that only one to two per cent had I.Q.s over 55. Similarly Pototzky and Grigg (1942) found higher I.Q.s for mongols attending the Bancroft School which specially selects its pupils. Of the eleven children who were under 20 years of age, 64 per cent had imbecilic intelligence, and 36 per cent were feebleminded. Wallin (1944) compared these results with those from mongols who had been examined in two psychoeducational clinics. The I.Q.s were high for the 49 mongols aged between 4 and 15 years. The mean I.Q. was 36.6. This is lower than the mean I.Q. of 42 which Pototzky and Grigg found for 11 of their mongols under 20 years of age. Wallin suggests that the difference may lie in the diagnostic criteria, or possibly on certain educational aspects of the Bancroft School.

In conclusion, over the childhood years to the teenage years the I.Q. of the majority of mongols decreases from often over 70 in the first year to well below 70, and in some cases to below 20 by the middle to late teens.

II.C.2. The adult mongol

Opinions differ about the average adult mongol I.Q. and the range involved. Some early reports (e.g. Down, 1866) suggested that the majority of mongols were idiots or, in present terminology at the low end of the S.S.N. group with I.Q.s less than 20. Other workers (Tredgold, 1908; Shuttleworth, 1909) concluded that the majority were imbeciles or at the upper end of the S.S.N. group with I.Q.s between 20 and 50. More recent work (Brousseau and Brainerd, 1928; Penrose, 1938; Prototzky and Grigg, 1942; Malzberg, 1960; Øster, 1953; Johnson and Barnett, 1961; Nakamura, 1961; Moore, 1973) has tended to favour imbecilic I.Q.s although the distribution tends to be toward the idiot end of the scale rather than the feebleminded end.

Brousseau and Brainerd (1928) reported that of 206 institutionalised mongols 37.8 per cent had I.Q.s in the idiot range, 61.2 per cent in the imbecile range and one per cent in the feebleminded range. Malzberg (1950) reported similar proportions for 880 mongols in New York State schools, although the distribution was more toward the feebleminded range. There were 24.5 per cent of idiots, 71.6 per cent imbeciles, 3.8 per cent feebleminded and 0.1 per cent undetermined. Penrose (1938) reported a mean I.Q. for institutionalised mongols of 22.8, and Nakamura (1961) gives a mean I.Q. of 23.2 for 64 institutionalised mongols with a mean age of 27.9 years range 16 to 63 years.

Another study (Johnson and Barnett, 1961) of 88 institutionalised mongols aged from 6 to 46 years with a mean of 21.1 years, found a mean Stanford Binet I.Q. of 26 with a range of 14 to 40. Moore (1973) reported that of 2,748 institutionalised mongols with a mean age of 22 years and range from one to 65 years, 963 (35 per cent) were idiots, 1,624 (59.1 per cent) fell in the imbecile range, 81 (3 per cent) had I.Q.s in the feebleminded range, and nine (0.3 per cent) had I.Q.s greater than 70. The I.Q.s of 71 mongols (2.6 per cent) were not determined.

Øster (1953) found that of 13 mongols over 19 years in age, 31 per cent

had I.Q.s below 20, and 69 per cent had I.Q.s between 20 and 50. These mongols had a mean I.Q. of 28 points which is higher than in the other reports. The explanation of this difference most likely lies in the fact that these mongols were living at home, and almost all the other reports on adult mongol intelligence have been based on institutionalised mongols. Another study reporting high I.Q.s in the adult mongol is that by Pototzky and Grigg (1942). Ten mongols aged over 20 years had a mean I.Q. of 49.1 with a range from 36 and 71. These mongols were specially selected for a school and this may account for their relatively high I.Q.s.

Thus by adulthood the distribution of I.Q. scores for the mongol population has shifted down towards the bottom end of the scale, from the position in childhood. However for a given group of mongols the range in I.Q. may be more than 50 points. Now that the different karyotypes have been identified some research has studied if there is a relationship between karyotype and I.Q. The evidence, which indicates little or no relationship, is given in Appendix B.
We now turn to the question of whether the fall in a mongol's I.Q. as he gets older represents a true regression in development or not.

II.C.3. Age and Mongol I.Q.

The studies to be reviewed here are concerned with whether the observed decrease in I.Q. with the mongol's increasing age is because his development stops and possibly even regresses, or because he does develop but at a slower rate than the normal child. In other words, is the fall an absolute or a relative one? If the latter is found to be true there is the additional question to consider of whether the rate of development is constant.

It was suggested by Masland, Sarason and Gladwin in 1958 that there was a true regression in development, but more recent research has shown quite clearly that although a mongol's D.Q. may fall his M.A. does increase. Koch, Share, Webb and Graliker (1963) found a significant decrease in the Gesell D.Q.s of 23 mongols from 2 to 48 months. Three of these mongols were in institutions. This decrease however was accompanied by a significant increase in the M.A.s of the same children. For example, the mean M.A. and D.Q. in the first year were 4.91 months and 70.95 respectively. By the fourth year, the mean M.A. was 20.04 months but the mean D.Q. was 45.2.

This sort of finding has often been reported in the literature (e.g. Loeffler and Smith, 1964; Fishler, Graliker and Koch, 1965; Dicks-Mireaux, 1966, 1972; Cornwell and Birch, 1969; Carr, 1970) and so it can be concluded that the decrease in I.Q. is a relative rather than an absolute one.

But does M.A. develop at a constant rate? Koch et al concluded in their study that although the rate of development is steady, it is slow and decelerates after the first 12 months. Two other researchers have looked at this problem in much greater detail (Dicks-Mireaux, 1966, 1972; Carr, 1970).

Dicks-Mireaux reported a faster rate of development between the ages of 3 and 9 months than between 9 and 18 months, whereas Carr found the slowest rate of development between $1\frac{1}{2}$ and 10 months. This discrepancy has already been dealt with in section II A, and will not be gone into again except to say that the faster rate that Dicks-Mireaux found between three and nine months appeared to be an artifact of the simple ratio method which she used to calculate D.Q. Carr found a slight decline in D.Q. from $1\frac{1}{2}$ to 6 months, followed by a more rapid decline up to ten months, after which D.Q. tended to level out with only a gradual decline up to 24 months.

In her 1972 paper, Dicks-Mireaux still using the simple ratio method to calculate D.Q., reported the Gesell D.Q.s of 21 home reared mongols as being essentially constant over the first 12 months and declining from 12 to 18 months. When C.A. and M.A. were plotted against one another, a linear relationship was found for the normal children, whereas the curve for the mongols tended to flatten out particularly after 12 months. Dicks-Mireaux considered two possibilities.

First, that the relationship between the mongol C.A. and M.A. is linear but the slope is less than 45^{o}, i.e. any unit increase in C.A. is associated with a constant increase in M.A. which is less than the unit increase in C.A. Second, that the relationship between mongol C.A. and M.A. is curvilinear, i.e. there is a deceleration in the rate of change of M.A. as C.A. increases. Analysis of her data supported the second hypothesis, that the relationship between mongol C.A. and M.A. is curvilinear.

A problem with the studies by Carr and Dicks-Mireaux is that the children were tested at fairly large C.A. intervals. If the testing ages had been closer,

it would have been possible to see if there were ages when development was particularly slow relative to other ages. This would reflect particular areas of difficulty for the mongol child, and those skills underlying the items which he took relatively long to master could be studied.

However these studies do indicate that the rate of development is not constant, although there is some suggestion of a gradual slowing down of development with age. If there is such a relationship between mongol C.A. and M.A. like the curvilinear one suggested by Dicks-Mireaux, then it should be possible to predict the I.Q. of a mongol at any age from the knowledge of his M.A. at a different age. The next section considers attempts which have been made to predict mongol development.

II.C.4. Prediction and Mongol I.Q.

Knobloch (1959) argues that the Gesell development scales are of greatest value when they are used as a neurological tool, and not as predictors of subsequent development. A similar point is made by Illingworth (1960) when he emphasises their use in establishing mental retardation in early childhood. It is clear from the literature (section II C i) that mongols perform significantly lower than normals on the Bayley Scales from six weeks of age. But is the level at which a particular mongol functions at this age or any other age predictive of his performance at a later age?

Before considering the literature pertinent to the degree of predictiveness of mongol intelligence, the state of the game vis à vis normal intelligence must be surveyed. The position held by Burt (1933) regarding intelligence and its development was that its potential is finite, and that the manifestation of this intelligence increases at a stable rate throughout growth, and undergoes neither qualitative change nor environmental influence. One of the predictions from this is that measures of a person's intelligence at different ages will be highly correlated.

However intelligence scores obtained in the first years of life have been shown to have little if any predictive value for later development (e.g. Bayley, 1933; Lewis and McGurk, 1972). Bayley obtained correlations ranging from -.04 to .09 between scores at 1, 2 and 3 months and scores at 18 to 36 months.

Lewis and McGurk gave the Bayley Mental Scale , in addition to other tests to "approximately" 20 infants at 3, 6, 9, 12, 18 and 24 months. The only significant correlations were between the mental development indices at 3 and 9 months and at 6 and 24 months. Lewis and McGurk conclude that no reliable predictions can be made during the first 24 months, although there is an increase in scores over time.

The fact that the performance in infancy has no predictive value for later development in normal persons does not imply that this will be so for abnormal persons. One might justifiably expect the intelligence of persons, who have in common a genetic abnormality, which retards their mental development, to be predictive of subsequent development.

a) Prediction from mental age

Koch, Share, Webb and Graliker (1963) administered the Gesell Developmental Scales at least once a year for the first three years to 31 mongols. Of the 31 original mongols, 23 were also tested in their fourth year. There was low correlation between the M.A.s and D.Q.s in the first year and those in the second and third years. Performance in the second year was relatively well correlated with that in the third and fourth years, as was performance between the latter two ages.. Significant correlations between M.A.s and D.Q.s in the second and third years for sixteen home reared mongols were also reported in a preliminary study (Share, Webb and Koch, 1961). Koch et al found correlations of 0.78 and 0.77 between Gesell D.Q.s and M.A.s in the second year and Stanford Binet I.Q.s and M.A.s at five years respectively.

In line with Koch et al's findings, Carr (1975) found no significant correlations for a group of mongols between their Bayley Scale M.A.s at six weeks and their M.A.s at later ages. After ten months all of the scores correlated with those at 15 months, two, three and four years. However, although Carr found correlations as high as 0.92, she argues that these are not high enough to allow useful prediction for individual children. She also compared high ahd low scorers at different ages and found that although it was not possible to predict that a child who had a high score at one age would continue to have high scores, it was unlikely that at later ages he would have one of the lowest scores. Despite all this,

she agress with Fishler, Graliker and Koch (1965) that predictions cannot be made with any confidence until at least the age of two years.

An alternative approach to this problem of prediction has been taken by several other researchers. Instead of using M.A. at one age to predict M.A. at a later age, they have attempted to find a relationship between a mongol's M.A. and his C.A. Any such relationship, provided that it was reliable, could then be used to calculate the projected M.A. of a mongol at a later C.A. There have been two different approaches. One relates a mongol's M.A. to a logarithmic function of his C.A. (Zeaman and House, 1962; Silverstein, 1966) and the other relates M.A. to the age at which various developmental landmarks occur (Gibson, 1966; Fields and Gibson, 1971).

b) Prediction from chronological age

Zeaman and House (1962) traced the nature of the change in M.A. and Stanford Binet I.Q. for 97 institutionalised mongols aged from 5,9 to 51,2 years, with a mean age of 18,8 years. The study was semilongitudinal in that although only one measure of I.Q. was obtained from 47 of the mongols, the others were tested on more than one occasion. The mean I.Q. from the first testing was 30,2 with a range from 15 to 59 and with 64 per cent of the I.Q.s falling in the imbecile range. The range for the M.A.s was from 2,0 to 7,11 years with a mean of 3,9 years. The authors found that mongol M.A. was proportional to log C.A. and derived the relationship,

$$\text{Mongol M.A. (in months)} = 18 \log_{10} \text{C.A. (in months)} + c$$

where c is the constant of integration and which was set equal to zero by Zeaman and House.

It was proposed by Zeaman and House that since a mongol's I.Q. changes as he ages, the ratio of M.A./log C.A. might be a more appropriate measure of his relative intelligence.

This approach was taken up by Silverstein (1966) who found a mistake in how Zeaman and House had derived the relationship. The corrected equation was given as $\text{M.A. (in months)} = 18 \log_e \text{C.A. (in years)} - 0.3\ \text{C.A. (in years)} + c$

In his own study, Silverstein obtained a relationship between the M.A.s and C.A.s of 256 institutionalised mongols of whom 101 had been tested more than once on the Stanford Binet. Their age range was from 4,0 to 40,0 years with a mean of 15.3 years. The mean I.Q. was 30.0 and the mean M.A. 3.3 years. It was found that the regression equation which related M.A. to C.A. was

$$\text{M.A.(estimated in months)} = 20.78 \log_{10} \text{C.A.(in months)} - 5.77$$

Despite their differences, these two studies when taken together indicate that mongol M.A. is more closely related to log C.A. than to the actual C.A. There are, however, two problems with this approach. The first, which Silverstein points out, is that the equations predict the same M.A. for mongols of the same C.A., and this is not true even of their own data. The second problem, which is acknowledged in both reports, is that the findings should not be extrapolated to children with C.A.s below those used in the studies. From Silverstein's equation at a C.A. of two years the mongol should have an I.Q. of 100, and at younger ages his I.Q. would be even higher.

This last point was demonstrated in a study by Meindl, Barclay, Lamp and Yater (1971). They obtained a curve representing the mental growth of 185 non-institutionalised mongols aged between 13 months and 16 years. When compared to the curves derived from Zeaman and House (1962) and Silverstein (1966) their mental growth curve began at a lower level and reached a higher asymptote than either of the mathematically derived curves. In other words, the young mongols had lower M.A.s than predicted by the equation, and the older mongols had higher M.A.s than predicted. However these children were not in institutions whereas those from whom the equations were derived were. And so the superior M.A.s of the older mongols over the predicted M.A.s should not come as a surprise in the light of the difference in environments.

This final study points to the main limitation of this first approach of relating a mongol's M.A. to his C.A. The shortcoming is that the relationships that have been derived are limited to populations of mongols who are as similar as possible to those from whom the relationships were derived.

c) Prediction from the chronological age of motor landmarks

The second approach of relating M.A. to C.A. for the mongol population has used the C.A.s of certain developmental landmarks. It is interesting that although Bayley (1955) argues that early developmental landmarks such as the age of the appearance of the first tooth, and the age of walking are not reliable indicators of subsequent intelligence in normal children, others (e.g. McNeill, 1955; Gibson, 1966) have suggested that there might be more direct links between physical and mental maturation in relatively discrete clinical anomalies.

This approach has been taken by Gibson (1966) who applied multiple regression treatment to the age in months when the first tooth appeared, the first unaided steps were taken and the first distinct single words were spoken, for 303 institutionalised mongols aged up to 44 years. He arrived at the equation:

Projected M.A. = 52.46 + 0.07 (C.A. months of first tooth) - 0.57 (C.A. months of first steps) - 0.11 (C.A. months of first word)

A correlation of 0.57 was found between the estimated I.Q.s and the test I.Q.s for 40 of the mongols. The same equation was applied to 22 home reared mongols aged around 20 years by Fields and Gibson (1971). They found a correlation of 0.43 between the estimated M.A.s and the actual M.A.s obtained from the Stanford Binet. Although significant, these correlations are not particularly high, but they do suggest that this approach may be useful.

The advantage of this approach over the previous one of using a logarithmic function is that mongols of the same C.A. will not necessarily have the same M.A. However that is really beside the point, for what is required is an accurate means of prediction. Gibson (1966) found that the M.A.s of the older mongols tended to be overestimated and those of the younger mongols underestimated.

Therefore it seems that all the three approaches to predicting M.A. at a later age either from the present M.A., or from a logarithmic function of the present C.A. or from the C.A. of various developmental landmarks, have serious limitations. None of them is reliable over the first few years of a mongol's life; however at older ages their reliabilities do increase. A problem seems to be the extent to which findings with one group of mongols may be generalized to another

group. The effects of one of the differences which may be present between the two groups, the type of environment, is considered in the next section.

II.C.5. The Environment and Mongol I.Q.

The question with which this section is concerned is whether the environment in which the mongol is reared has any effect on his development. It should be clear from the previous sections on mongol I.Q. that the scores of institutionalised mongols are below those of non-institutionalised mongols. It is not proposed in this section to reiterate what has gone before but merely to discuss several reports which compare the early development of home reared and institution reared mongols.

Stedman and Eichorn (1964) compared ten mongols who were institutionalised between the ages of one month and four and a half months, with ten mongols reared in their own homes. The two groups were matched as nearly as possible for C.A. and sex. The pairs of children were tested once on the Bayley Scales of Mental Development at an age between 17 and 37 months. The home reared mongols were found to be significantly superior to the institution mongols on the Mental Scale.

The conclusions from this study are limited in that there was no normal control group and the children were only tested once. However, these were overcome in a study by Carr (1970). She compared 45 mongols reared in their own homes with nine reared in foster homes or institutions. On the Bayley Scales of Mental Development the home reared and boarded out mongols had essentially the same D.Q.s at one and a half and six months, and these were below the D.Q.s of the normal children. By ten months the boarded out mongols were significantly more backward than those still at home, and this difference remained at 15, 24, 36 and 48 months. Although an improvement over Stedman and Eichorn's study, there is a drawback to this study too, in that at all the testing ages there were fewer boarded out mongols than home reared mongols. For example, at one and a half months there were 4 boarded out and 25 home reared; at six months there were 8 and 34, and at ten months there were 8 and 38 respectively. At the later ages there were six or seven boarded out mongols compared to 39 or 40 home reared mongols. Despite this, Carr interprets the findings as implying that the boarded out mongol "started life with 'normal mongol' abilities" and that his slower development later is due to the adverse environment.

In addition to the I.Q. difference between home reared and institution reared mongols, Francis (1971) has reported difference s in behaviour. She compared 43 home reared mongols with 36 mongols in institutions. All of the children were under four years of age. The institution reared mongols made more diffuse movements of parts of their bodies, more self oriented behaviours such as chewing and rubbing themselves and fewer object oriented behaviours than the home reared mongols. It is interesting to note that the lower developmental level of the institution reared child did not account for the behavioural differences, since there were as many differences between the two groups when they were matched for developmental level as when they were matched for C.A. Francis suggests that aspects of the environment such as the availability of toys, the amount of social contact and the extent of restraint were related to the differences in behaviour.

A number of other studies have looked at the effect on I.Q. of placing a mongol in an institution after he has been reared at home for a number of years. Shotwell and Shipe (1964) reported that 25 mongols reared at home for the first two years before admission to a state hospital performed significantly better on the Kuhlman-Binet or Stanford Binet Form L when tested prior to admission, on the day of admission and 18 months after admission than 17 other mongols reared in a private state-licensed institution before admission. Interestingly the home reared mongols were on average chronologically older at each test age and their I.Q.s were higher than the institution reared. As mongol I.Q. declines with age (section II C iii), one would have expected the home reared to have had lower I.Q.s if age alone was involved. These same children were followed up and the results reported in 1965 (Shipe and Shotwell). Even after three to four years in the state hospital, the previously home reared mongols were still favoured. On the final testing the children were aged between five and ten years, but whereas the mean I.Q. of the home reared children was 26.8 with a range of 14 to 45, the institution children had a mean I.Q. of 20.3 with a range of 8 to 30. The decline in I.Q. over age was greater for the home reared group, falling 26.1 points in 60.6 months, than for the institution reared group whose mean I.Q. fell 21.1 points in 66.4 months. This perhaps reflects the overall higher I.Q. of the home reared mongols which can therefore fall further.

Birch and Belmont (1961) criticised a report by Centerwall and Centerwall (1960) who found essentially the same as Shipe and Shotwell, on the grounds that the non home reared mongols were neurologically inferior initially since they walked later than the home reared mongols. The study found that a group of 32 mongols reared at home until at least the age of two and a half years were superior in I.Q. on the Kuhlman Binet or Stanford Binet Form L to 32 mongols of similar ages who had been reared in foster homes or institutions from birth. At the age of seven years the mean I.Q. of the home reared group was 23, while that of the non home reared group was 16. As in the Shipe and Shotwell studies it was noticed (Birch and Belmont, 1961) that the rate of deterioration in I.Q. was greater in the home reared than in the non home reared mongols.

Although the reports seem fairly conclusive in their findings than an institutional upbringing is more detrimental to a mongol's development than a home upbringing, there is the problem raised by Birch and Belmont of whether the environment is the cause of the difference or whether some other factor is at work.

a) <u>The environment as the cause</u>

One of the main drawbacks to studies which compare the relative capabilities of handicapped children reared in different environments is the possibility of a bias in the selection procedure (Birch and Belmont, 1961). One possibility is that the more intelligent mongols are retained in the parental home. This alone would account for the observed differences in the I.Q. scores.

Several findings argue against this. First, Carr (1970) found no difference between the D.Q.s of home reared and boarded out mongols until ten months of age. Thus the mongols were institutionalised before their D.Q. was different from those who were kept at home. Second, it was concluded in section II C.iv.a that a mongol's D.Q. in the first year or two is not a good predictor of his later development. Therefore even if the mongols who were institutionalised were those who, in the first year, had the lowest D.Q.s this would not mean that they would necessarily have the lowest I.Q.s later on.

However it is possible that there are factors other than D.Q. scores which predict subsequent intellectual ability, and which might be used to selectively place in institutions those mongols who are going to be most retarded. One

possibility is the number of physical signs of mongolism that are present in the child. If the number of signs reflects the level of intellectual functioning such that the larger the number of signs the greater the retardation, then the environmental effect could be due to those children who are physically more mongol being selectively placed in institutions.

The evidence is against this since many studies report little or no significant correlation between I.Q. and the number of characteristic mongol signs (Spuehler, 1929; Fanconi, 1939; Øster, 1953; Liu and Corlett, 1959; Benda, 1960; Dunsdon et al., 1960; Donaldson, 1961; Johnson and Barnett, 1961; Kääriäinen and Dingman, 1961; Domino and Newman, 1965; Shipe et al., 1968; Johnson and Abelson, 1969; and Dicker, 1972). For those that do report a positive correlation between number of signs and I.Q. (Gibson and Gibbins, 1958; Newman, 1960; Shepard, McGreal and Hammer, 1967), it is reported that the greater the number of signs, the higher the I.Q. This is in the opposite direction to that required if the I.Q. inferiority of the institutionalised mongols is to be accounted for by their physical appearance.

There are two other sets of results which indicate that the I.Q. difference between home and non home reared mongols is due to the difference in environment. The first are studies reporting an increased rate of development in institutionalised children when they are given additional stimulation (Lyle, 1960a; Tizard, 1960; Bayley, Rhodes and Gooch, 1966). The second are studies which have found that, for intelligence tests which are subdivided, each subdivision being scored separately, an institutional environment may result in unequal retardation of the subdivisions (Lyle, 1959, 1960b).

These two areas are considered in the following two sections.

b) The effect of additional stimulation on the development of institutionalised mongols

The ten institutionalised and ten home reared mongols that were studied by Stedman and Eichorn (1964) were followed up later by Bayley, Rhodes and Gooch (1966). When these children were at an average age of 61 months with a range from 54 to 71 months, Bayley et al (1966) introduced "an intensive ward programme designed to increase the receptive and expressive language abilities" for the ten institutionalised mongols. This programme was introduced because at the mean age

of 61 months the institutionalised mongols, who had a mean ratio I.Q. of 29.8, seemed to be behind in language development compared to the home reared mongols who at this stage had a significantly higher mean ratio I.Q. of 40.4.

At an average of 13 months later, the mean ratio I.Q. of the institutionalised group was 36.3, and that of the home group 42.5. This difference was not significant. This study supports the contention that it is the relatively unstimulating institutional environment which accounts for the lower I.Q.s of mongol persons reared in such environments.

Similar results were reported by Lyle (1960a) and Tizard (1960). They report the same study in which 16 institutionalised imbeciles aged from five to ten years were matched for C.A., sex and non-verbal and verbal performance on the Minnesota Preschool Scale of Intelligence with 16 other imbeciles from the same institution. Of the 16 pairs, 11 were matched for clinical type, that is mongol with mongol, non mongol with non mongol. Five ad hoc tests were administered to all of the children. These consisted of naming 50 common objects and actions, comprehension of the names, defining words, discriminating and reproducing 80 speech sounds and assessment of the complexity of the language used to describe 20 pictures.

One member of each pair was then transferred from the institution to the Brooklands Residential Family Unit. Here the pattern of education and care was similar to that considered suitable for normal pre-school children in care, and the authors report that there was no specific aim to increase verbal ability, whatever that might mean.

All 32 children were retested 12 and 18 months after the group of 16 had been transferred. Taking the 11 clinically similar pairs first, the Brooklands group were significantly favoured for verbal intelligence, speech sounds and word naming. After the first 12 months, the mean verbal M.A. equivalents of the 11 Brooklands children had increased from 2,0 to 2,8 years, whilst the corresponding increase for the group still in the institution was 1,11 to 2,3 years. For the clinically dissimilar pairs, the mongols improved at a slower rate and this was not cancelled out by the Brooklands' environment. However, in another study (Lyle, 1960b), sex had been found to be unrelated to performance on certain verbal tests, and by

ignoring sex differences it was possible to match all the children for clinical type. After 18 months, the 16 Brooklands children showed more improvement on verbal intelligence and, with the exception of word definition, on all the ad hoc tests compared to the children still in the institution. There was no difference on non verbal intelligence.

Thus, by providing extra stimulation, the development of the institutionalised mongol can be accelerated which argues for the environment being the factor that holds him back more than the home reared mongol.

c) The effect that an institutional environment has on different abilities

Two further studies by Lyle (1959, 1960b) give additional support for the belief that the institutional environment is the cause of the relatively greater retardation of mongols reared in such environment.

In the 1959 study, the performances on the Minnesota Preschool Scale of Intelligence of 77 institutionalised imbecile children aged between $6\frac{1}{2}$ and $13\frac{1}{2}$ years were compared to those of 117 similarly aged day school imbecile children. Of the institutionalised and day school children, 34 and 76 were mongols respectively. There were no differences between the children on non verbal measures. However on verbal I.Q. the institutionalised imbeciles, particularly the mongols, were more retarded than the day school imbeciles.

The same children were compared on a number of verbal tests which were designed to measure various aspects of speech and language (Lyle, 1960b). These tests, which assessed the frequency and clarity of speech, the naming, comprehension and definition of words and actions, the ability to discriminate and reproduce speech sounds, complexity of language and verbal intelligence, all correlated highly with one another yielding a factor termed verbal ability. It was found that the institutionalised children, in particular the mongols, were of lower verbal ability than the day school children.

In the light of the evidence presented in the preceding sections it seems most likely that it is the difference in environment, as opposed to some selection bias, which results in the institution reared mongol being more retarded than the home reared mongol.

II.C.6 Conclusions on Mongol Intelligence

From the studies that have been considered in the preceding sections we may, with confidence, draw the following conclusions.

First, the mongol, although he may start life with a near average level of intelligence, becomes more retarded as he gets older, with his intelligence in early adulthood falling most likely in the imbecile range.

Second, despite this fall in his relative intelligence his mental age does increase, although his rate of development gradually slows down over the years.

Third, this slowing down was reflected in the attempts to predict mongol intelligence by means of a logarithmic function of chronological age. However, as with the various other attempts at prediction, none of them was reliable in the early years, and even later on, their reliability was not particularly outstanding.

Fourth, one aspect which could be predicted, was that an institutional environment was more detrimental to the mongol's development than a home environment. The effect of this showed up within the first year, and it was seen that the mongol who had spent a few years at home before being institutionalised benefited from this in terms of subsequent intelligence.

These conclusions indicate a limitation common to almost all those reports that have been reviewed. Namely, that although they provide an abundance of evidence of the mongol's intellectual ability at different ages, they give little indication as to why he performs at certain levels. Admittedly, the studies on the effects of the environment do not suffer from this limitation to the same extent. But they too often fail to point to those features of the environment which are crucial.

What seems to be missing in these studies is a closer inspection of the mongol's abilities. Only when areas of deficit are identified can we hope to start to understand the particular problems that mongols may have. To have said that this is a failing of the studies reviewed up to this point should not be taken as implying that none of these studies has looked at abilities other than intelligence, just that intelligence is the only measure that has been considered so far. However, we now turn to a consideration of other areas of the mongol's development.

The four areas that will be covered are the motor, verbal, perceptual and social development of the mongol. The first three areas are considered in the following sections and a review of social development is to be found in Appendix C since although it is an important area of development, it is not directly relevant here. The reasons for choosing these particular areas will be outlined in the appropriate sections. However, in general they were selected because they are areas where research has been concentrated and, more importantly, because they do indicate some particular areas of deficit in the mongol person.

II.D. Motor abilities and the mongol

The reason for this review of the motor abilities of the mongol is that there is anatomical evidence which indicates that the cerebellum of the mongol person is small compared to other parts of his brain and to the normal's (Crome, Cowie and Slater, 1966; Crome and Stern, 1967). Since the cerebellum has been implicated as playing a major role in motor performance (Bloomfield and Man, 1970), it seems plausible that one area of particular deficit in the mongol might be his motor abilities.

The literature will be considered in two parts. In the first, the studies which report the motor development of the young mongol will be reviewed to see if his motor development is retarded, and where possible to see if this is different from his level of mental retardation. In the second part, studies which have examined the mongol's performance on tasks designed to assess his motor ability will be reviewed.

II.D.1. General motor development

Two types of evidence will be considered in this section. The first are studies which report the age at which the mongol achieves certain motor landmarks. These data show the mongol to be retarded in his motor development, but from them it is not possible to compare his mental and motor developments. The second source of evidence provides this comparison. This is from studies reporting motor quotients. These are derived in the same way as D.Q.s but from scales designed to assess motor development rather than mental development. Since developmental scales such as the Bayley and Gesell Scales include both

motor and mental scales, the studies which report motor quotients for mongols usually report their D.Q.s and vice versa. Therefore it is possible to directly compare the mongol's mental and motor developments.

a) Evidence from the age of motor landmarks

There is a single study which reports the mongol's motor development to be within normal limits up to the age of six months (Fishler, Share and Koch, 1964). On the other hand there are a number of studies which report delay in the occurrence of motor landmarks which are present in the average child in the first few weeks (Cowie, 1970), at three months (Levinson, Friedman and Stamps, 1955; Carr 1975), and at five months (Erbs and Smith,1962).

The study by Fishler et al (1964) did not include a normal control group, and so the ages at which the mongols first achieved certain motor landmarks were compared to the ages given for the standardized population of the Gesell Scales. Twenty-four mongols could hold up their heads by a mean age of 3.5 months compared with 3 months for the normals. The age range for this landmark in the mongols was one to six months. Rolling over began in 65 mongols at an average age of 5.7 months, range 1 to 15 months, compared with 5 months for normal children. Motor landmarks which occurred after this age were however found to be delayed.

As has been mentioned, these findings of normal motor development in the mongol up to the age of six months have not been substantiated by other research. Cowie (1970) examined a number of early infant reflexes in a mixed group of home and institution reared mongols. Thirty-six children were tested at two weeks of term related age, which is the child's C.A. after adjustment has been made for gestation lengths of other than 40 weeks. None of the mongols showed normal muscle tone, and the normal responses to traction and placing were absent. They all had poor posture in ventral suspension, and although they showed a normal Moro reflex and palmar grasp these took longer to disappear than reported for normal babies.

The results of this study are supported by others who have found retardation at the earliest age the children were tested. The results of the studies to be described are in direct conflict with those of Fishler et al (1964) described

earlier in this section. Levinson et al (1955) found that the age by which 50 mongols were able to hold up their heads varied between 2 and 30 months, and that 50 per cent were able to by 6 months. Carr (1975) tested the same mongols as Cowie (1970), and reports that at six months although 25 out of 29 (86 per cent) held their heads steady while being carried about, only 18 out of 47 (38 per cent) kept their heads balanced when their bodies were tilted. These were in comparison to the average age of the behaviours in normal children of 2.5 and 4.4 months (Bayley, 1969) respectively.

Also against Fishler et al (1964) is the report by Erbs and Smith (1962) that a small number of mongols were able to roll over at a mean age of 7.7 months, with a range from 1 to 36 months.

The weight of this evidence, particularly Cowie's, points to the young mongol being backward in motor development from as near birth as can be tested. This retardation continues. The mean age of sitting unsupported, which is reported for the normal child as 6.6 months (Bayley Scales) and 8.0 months (Gesell Scales), has been reported for the mongol as 11.3 months (Fishler et al, 1964), and 13 months (Erbs and Smith, 1962), and with ranges from 6 to 36 months. Levinson et al (1955) found that 25 out of 50 mongols could sit up by 12 months and Carr (1975) found that 34 out of 47 mongols (72 per cent) could sit by 15 months. A study by Gibson and Pozsonyi (1965) found a difference in the mean ages of sitting for ten translocation and ten trisomic mongols. The translocations sat up at 11 months on average, and the trisomics at 16.6 months. The latter finding is surprising since the age is considerably older than reported in other studies which, although they do not report karyotypes, probably consisted mostly of trisomies as this karyotype accounts for about 95 per cent of mongols.

Crawling was first observed in a group of mongols at a mean age of 12.5 months, range 6 to 28 months, by Fisher et al (1964) compared to the Gesell norm of eight months. Carr (1975) found that 17 out of 46 mongols (37 per cent) could crawl by 15 months and that this increased to 93 per cent by 24 months.

The same picture emerges with the landmarks of standing alone and walking with and without help. On the Gesell Scales the standardised norms of these behaviours are given as 14, 13 and 15 months respectively, although on the Bayley

Scales they are reported at the younger ages of 11, 9.6 and 11.7 months. These discrepancies are most likely due to differences in how the tests were standardised and in the race, culture and socio-economic class structure of the samples. However despite the discrepancies the mongol is clearly retarded in these behaviours. Fishler et al (1964) reported the mean ages at which a group of mongols stood alone as 21.5 months, range 12 to 44 months, walked with help as 22.3 months, range 11 to 48 months, and walked without help as 24.8 months, range 15 to 50 months.

Similar findings to these have been reported by Erbs and Smith (1962) for standing alone. The mean age was reported as 21.8 months, range 9 to 48 months. The same authors also found that the mongols walked with help at an average of 26.8 months, range 16 to 48 months. Levinson et al (1955) found that 50 mongols walked with help at ages ranging from 12 to 54 months, the majority by 24 months. Twenty-seven out of 45 mongols (60 per cent) were able to walk with help by 24 months according to Carr (1975), and at the same age only 13 out of 44 mongols (30 per cent) could walk without help. Gibson and Pozsonyi (1965) observed that walking with help occurred in ten translocation and ten trisomic mongols at mean ages of 25 and 26 months.

A study by Kučera (1969) found that the age of walking of 105 mongols was dependent upon the year in which the child was born. Forty-five mongols born before 1954 walked by an average age of 29.93 months, whereas for 35 born between 1955 and 1960, the corresponding age was 22.31 months, and for 25 born between 1961 and 1966 it was 22.76 months. Kučera argues that this reflects an increasing number of later born mongols being reared in a more stimulating environment, the home, than the earlier born mongols.

The conclusion reached by Kučera is supported by the findings of Centerwall and Centerwall (1960). They compared the age of walking in two groups of mongols who had all been placed in a state hospital at about four years of age. Thirty-two of these mongols, the H group, had been reared at home up until this time, whilst the remaining 32, the P group, had been in foster homes from birth. No mongol in group P walked before two years of age, compared with 14 (44 per cent) of group H. Two (six per cent) of group P walked before three years of age compared with 25 (78 per cent) of group H. By five years, 16 (50 per cent) of

group P were still not walking compared with 5 ($12\frac{1}{2}$ per cent) of group H.

There is further confirmation of this environmental effect from a study by Kugel and Reque (1961). They found that 34 eight year old mongols stood up and walked much earlier than 21 nine year old mongols who had been in an institution since their first year. Of the home reared mongols 50 per cent stood by 15 months and walked by 21 months. The corresponding ages for the institutionalised children were 45 and 60 months. All of the home reared children could stand by 40 months and walk by 63 months. By 78 months, 10 per cent of the institutionalised children could still not stand, and 30 per cent could not walk.

It will also be seen later that a number of studies reporting motor quotients support this environmental effect. It is now to the studies reporting motor quotients that we turn. Up to this point it is clear that the mongol is retarded in his motor development, especially the mongol who is institutionalised, but the question of whether this parallels his mental development or not remains open. This is considered in the next section.

b) Evidence from motor quotients

Of the studies which report motor quotients for mongols, there is one which presents evidence to suggest that the mongol's motor quotient is within normal limits up to three months (Dameron, 1963). Dameron administered the California First Year Mental and Motor Scales to 12 institutionalised mongols at three monthly intervals from 3 to 18 months. Only the data for the mental scale were given, but Dameron reports that the same trend was observed for the motor scale. This argues for motor development following the same course as mental development until the age of 18 months at least, although a direct comparison is impossible because of the absence of the motor data. It was reported that six mongols had a mean mental D.Q. of 94 at three months and since this is within the average range, it is presumed that Dameron is proposing normal motor development up to three months. By six months the mental D.Q. for 11 mongols had fallen to 71. By comparison to the study by Fishler et al (1964), which was the only one of these using motor landmarks to report that the early motor development of the mongol was not retarded, Dameron's is extremely limited. First, the sample was small, and secondly the motor quotients were not actually

reported. Also, as in Fishler et al's study there was no normal control group.

In contrast to Dameron's study there are two others which report below average motor quotients for mongols aged six weeks (Carr, 1970, 1975) and four months (Dicks-Mireaux, 1966, 1972). Carr found that 25 home reared and 4 boarded out mongols had a mean quotient, derived from the Bayley Scales of Motor Development, which was significantly below that of 29 normal controls from six weeks, the earliest age of testing. This study is a considerable improvement over Dameron's in a number of respects. The sample was larger, there was a normal control group and both mental and motor quotients (1970, 1975) and ages (1975) were reported, thus affording a comparison. At six weeks the mean motor age was above the mean mental age, but from six months the mean mental age was greater than the mean motor age and this difference increased at 10, 15 and 24 months. However, by three years the mean motor age was above the mean mental age and this was also found at four years.

Carr suggests that general motor ability is held back at two years by 75 per cent being unable to walk, whereas at three years only 20 per cent could not walk. She also points out that the mean motor quotient of the normal chiidren at 10 and 15 months dropped to below 90. If this is a true fall and the normals are representative of the normal population, the mongol mean motor quotients at these ages should be increased. This would decrease the disparity between their mental and motor scores at these ages, but the difference at two years would remain.

Similar results to Carr's were reported by Dicks-Mireaux (1966, 1972). She gave the Gesell Developmental Scale to 12 (1966) and 21 (1972) mongols within two weeks of 16, 28, 40, 52 and 78 weeks. The later paper also reports the results for 20 different normals seen at each age. In the first paper ratio motor quotients are given, whilst in the second paper motor ages are reported. However, if these ages are converted into quotients, the quotients for the mongols at 16 weeks were 73 (1966) and 74 (1972) and these had dropped to 57 (1966) and 56 (1972) by 78 weeks.

It is also possible in these two papers by Dicks-Mireaux to compare mental and motor quotients. In the earlier paper, they were essentially the same at each age, although at 16 weeks the mean motor quotient was greater than the mean mental quotient. In the 1972 paper the motor ages tended to exceed the mental

ages at 16 and 28 weeks although the reverse was found at 40 and 52 weeks. In all cases the differences were small, and, except for the absence of a difference at 78 weeks, the findings of the 1972 paper are in general agreement with Carr's. That is, compared to mental development, motor development seems slightly more advanced in the first six months and again after two years, but at the ages in between it tends to be more retarded.

Finally in this section we shall consider the question of environment effects on the mongol's motor development. It was seen in the last section that an institutional rearing results in more motor retardation than home rearing (Centerwall and Centerwall, 1960; Kučera, 1969). However we may now ask if the environmental effect on mental and motor development is the same or different.

In support of the findings reported for motor landmarks, Stedman and Eichorn (1964) and Carr (1970) found that the motor quotients of home reared mongols tended to be in advance of those of institution reared mongols. Stedman and Eichorn compared the performances on the Bayley Scale of Motor Development of ten home reared and ten institution reared mongols. The mongols in the two groups were matched for age which varied between 17 and 37 months. The mean motor quotients of the home reared and the institution reared mongols were 51.6 and 45.8 respectively. Although not significant, this difference is at least in the same direction as Centerwall and Centerwall's (1960) finding. When Stedman and Eichorn compared the mental and motor quotients for the two groups, they were similar for the home reared mongols, but for the institution reared mongols the mental quotient was more depressed than the motor quotient.

This last observation is not born out by Carr's 1970 study. She compared boarded out mongols, home reared mongols and normals on the Bayley Scales of Mental and Motor Development at $1\frac{1}{2}$, 6, 10, 15 and 24 months. The motor quotients of the two mongol groups, although not appreciably different from one another until ten months, were below that of the normal group at one and a half months. At ten months and later, the motor quotients for the boarded out mongols were well below those of the home reared, and well below the mental quotients in contrast to Stedman and Eichorn's report. It is not possible to compare the two studies directly, mainly because of the age difference in the mongols. That this age difference is the source of the inconsistency is supported by Carr who found

that whereas at 24 months only 15 per cent of her mongols had motor ages in excess of their mental ages, this had risen to 64 per cent by 36 months.

To conclude, the evidence that has been presented does not show that the mongol's motor development is more retarded than his mental development at all ages, as might have been predicted from the anatomical evidence. However, this is not surprising when the items included in the Scales designed to assess early mental and motor development are considered, since the majority of the items in the mental scale require motor actions. For example, the Bayley Mental Scale includes items such as the child's response to a ring on a string - reaching for it, manipulating it, carrying it to the mouth, pulling the string to secure the ring etc. Other items involve the manipulation of cubes - reaching for them, coordinated reaching, picking them up, holding two cubes, putting them into a cup, building them up into a tower etc. Admittedly there are some items which do not so obviously involve motor actions, such as discriminating strangers, response to a reflection in a mirror and vocalizations, but these are in the minority.

Thus mental ability is assessed on these scales, at least in part, by tasks involving object manipulation. This would act to reduce any real difference between mental and motor abilities measured by these scales.

There are two ways round this problem. The first is to devise developmental scales which provide a clearer distinction between mental and motor abilities. Kohen-Raz (1967) and Yarrow, Rubenstein and Pederson (1975) have attempted to make the Bayley Scales more sensitive by grouping together items which measure similar functions. By means of a Gutman scalogram analysis with 405 Israeli children aged from 1 to 17 months, Kohen-Raz isolated ten areas of functioning. The subdivisions of the mental scale were: Eye-hand, Manipulation, Object-Relation, Imitation-Comprehension and Vocalization-Social Contact-Active Vocabulary. From the motor scale the following subscales were identified: Static Coordination, Body Coordination, Fine Finger Coordination, Arm Coordination and Walking.

Eight clusters of items were developed by Yarrow et al from the performance on the Bayley Scales of 41 black babies aged between five and six months. The clusters were Gross Motor Development, Fine Motor Development, Social Responsiveness, Language, Goal Directedness, Secondary Circular Reactions,

Reaching and Grasping, and Object Permanence. These included items from both mental and motor scales.

Although Kohen-Raz (pers. comm. 1975) has tested a number of young mongol children on the Bayley scales he has not yet analysed his data according to the scalogram. Thus although this approach of distinguishing different areas of functioning seems promising, in that it may indicate particular areas of deficit in the handicapped child, there are no data for the young mongol.

The second way round the problem of distinguishing the motor abilities of the mongol from his mental abilities is to compare his performance on specific motor tasks with the performance of other persons with similar M.A. The results of such comparisons are considered in the next section.

II.D.2 Evidence from the mongol's performance on specific motor tasks

It is intended only to consider in this section studies which directly relate to how the mongol performs on tasks which require motor actions, such as putting pegs into holes, copying a pattern, tapping, or tracking a moving target. Tasks, for example, which require the mongol to discriminate patterns by touch alone or to put blocks into a board whilst blindfolded, will be deferred until the section on perceptual abilities. The reason is that these latter tasks aim to discover any limitations that the mongol might have in how he perceives information through different sense modalities.

At first glance there appear to be a number of studies which indicate that the mongol performs poorly on motor tasks. However closer inspection reveals that the deficit is not so straightforward. It is intended to present first a recent study with evidence for a motor deficit and then to consider some of the older reports to see if their results can be accommodated with the more recent results.

Frith and Frith (1974) set out to define more precisely the type of motor tasks which mongols find difficult. The two tasks they chose were rotary pursuit tracking using a finger, and tapping. There were 17 mongols from a couple of non-residential training centres aged from 9,9 to 26,2 years, mean 17,1 years; 19 autistic children from a special school aged from 5,7 to 17,9 years, with a mean age of 12,5 years, and 23 normal primary school children aged from 4,7

to 7,3 years, with a mean of 5,8 years. The mongol and autistic children were matched for M.A. on the Peabody Picture Vocabulary Test.

It was found that all of the subjects performed at a similar low level initially on the tracking task but whereas the autistic and normal children improved over two sessions, the mongols did not. On the tapping task, the mongols tapped less than the other two groups who both produced a similar number. The authors also assessed the level of visuomotor development from the ability to draw controlled lines. Good drawing was correlated with good tracking for all the groups, particularly the mongols. For the normal and autistic children a high tapping rate was correlated with both good drawing and tracking. For the mongol group, good drawing was correlated with low variability of tapping rate, and a high tapping rate was associated with high variability of rate. On the basis of these findings, Frith and Frith propose that the mongol has difficulty in using long term motor programmes and probably relies to a greater extent on simple feed back processes than normal and autistic children.

We may now look at other research in this area to see if there is any support for the proposal of Frith and Frith.

In a series of studies Berkson (1960a, 1960b, 1960c) investigated the relationship between I.Q. and speed of reaction, or reaction time (abbreviated to R.T.) in persons with low I.Q.s. He found that the lower the I.Q. the slower the R.T., except when seven institutionalised mongols were compared to seven other subnormals of similar C.A., I.Q. and length of stay in the institution. In this comparison the mongols, although of the same I.Q. level as the other subnormals, had slower R.T.s. Berkson argues that it is the actual motor component of the response that was delayed in the low I.Q. person, since he found no relationship between I.Q. and either the time for which the stimulus was exposed or the complexity of the response required.

Also in support of the Friths' proposal is part of a study by Hermelin and O'Connor (1961) who compared the copying abilities of 16 normal children who were matched for M.A. with 16 mongol and non-mongol institutionalised adults. The mongols were inferior to all the others at both copying a figure while it was

displayed and reproducing the same figure after it had been removed. It could be argued that the mongols performed at an inferior level, not because of a motor deficit but because of a visual deficit. However, in the other part of this study the mongols were found to be as capable as the others at visual matching and delayed recognition of the same figures as used in the other tasks.

The mongol has also been shown to be inferior to non mongol retardates and normals of similar M.A., at placing pegs in a board (Zekulin, Gibson, Mosley and Brown, 1974). The M.A.s ranged from 2,4 years to 3,7 years and the C.A.s of the two retarded groups fell between 5,11 and 9,6 years. The children had two minutes to put 25 pegs into the pegboard holes, and it was found that in the first minute the mongols placed significantly fewer than the other children, although in the second minute they placed as many as the others. However, Zekulin et al point out that the mongols may have placed fewer pegs initially not because of a motor deficit but because they were more affected by the unfamiliarity of the task than the other groups.

In contrast to these studies are others which fail to find the mongol as particularly inferior to other matched subnormals on motor tasks. In one such study Clausen (1968) compared 12 mongols aged between 12 and 24 years first with 196 other subnormals in the same age range, and second with 24 non mongols selected from the original 196 so as to match the mongols for I.Q., M.A., C.A., and sex. A large battery of tests were administered, and it was found that when compared to the 196 unmatched non mongols, the 24 mongols were inferior on many motor tasks such as pegboards, R.T.s, tapping rate. This might be taken to support Frith and Frith. However, the mongols had a lower mean I.Q. than these non mongols, and when they were compared to the smaller group of matched non mongols, the majority of the differences disappeared. The mongols still had slower R.T.s to pictures, but there were no other motor differences. There were in fact only six significant differences and given that the subjects were tested on 50 variables, there should have been one difference significant at the two per cent level by chance alone.

Another study to find no difference between mongols and other retarded persons in motor ability was reported by Shurrager, Klebba and Gershbein (1974). A group of 28 mongols was compared to 24 epileptic subnormals, 29 brain injured

non-epileptic subnormals and 49 undifferentiated subnormals at copying the positions of a number of pegs in a board containing 25 holes. The majority were aged between 8 and 21 years, and although no significant differences were found between the groups, they were different in terms of I.Q. Ninety per cent of the mongol group had I.Q.s below 55, compared with 32 to 34 per cent of the other groups. From this I.Q. difference alone, it would have been expected that the mongols would have been inferior, but they were not.

Knights, Atkinson and Hyman (1967) also failed to find any evidence of a significant motor deficit in the mongol. They matched 12 institutionalised mongols with 12 institutionalised non mongols for sex, C.A. and M.A. The C.A. range was from 10 to 20.8 years, with a mean of 14.2 years for both groups. The mean M.A. of the mongols was 3.5 years, range 1.8 to 5.4 years, and for the non mongols the mean was 4.1 years, range 2.6 to 6.1 years. This M.A. difference was nonsignificant. There were six motor tasks, and although there was no significant difference between the groups on any of the tasks, the mongols had a faster tapping rate, and completed a pegboard more rapidly than the non mongols. On the other hand the mongols were worse than the non mongols on a test of hand steadiness, on a dynamometer test and on a simple R.T. task. The sixth test was a maze coordination test, with no tendency for either group to be superior.

Knights et al do not report their data but say that on all but the dynamometer test, the children performed at a level comparable to normal five year olds. The comparable normal age for the dynamometer test was 14 years. The main disagreement between this study and Frith and Frith's is on the tapping test. However in the latter study, the subjects had to tap for 90 seconds and the highest number of taps in any 15 second period was recorded, whereas Knights et al's children had to tap for a number of 10 second trials and the mean number of taps for the three most rapid trials was recorded. Because of these differences it is not possible to compare the two studies directly.

A final study by Nakamura (1965) reports that a group of 64 institutionalised adult mongols, rather than being inferior, were in fact superior on three visuomotor items when compared to 64 undifferentiated retardates matched for C.A., sex and I.Q. The C.A. range for both groups was 16 to 63 years,

mean 27.9 years for the mongols, mean 27.8 years for the others. The I.Q. range for the mongols was 12 to 39 with a mean of 23.2. For the others the I.Q. range was from 10 to 39 and the mean was 23.3. There was no difference in how the two groups performed on 56 out of 60 items which were selected from the Stanford-Binet and Merill Scales. However the mongols were superior at an upright formboard$_2$ building a block bridge and drawing a circle. They were inferior at repeating three digits. The items where there was no difference were not described so it is not possible to see if tasks were included which were equivalent to those used in other studies, such as tapping, R.T.s and maze coordination. Also, as in Clausen's study, the groups could have differed significantly on one of the items by chance alone.:

To conclude, it is difficult to draw any conclusions from these studies because not only have different authors found different results, but they have found them using mongols of various ages who have been matched in several ways with other retardates. The tasks themselves have also varied widely. However despite all these limitations it seems that the careful study by Frith and Frith should not be dismissed because of some studies which report the mongol to be efficient in motor ability. What is necessary are similar studies looking closely at specific tasks rather than studies where a battery of items is administered.

All that may be concluded is that the mongol has been shown to be deficient on certain motor tasks but that the nature of this deficit and the conditions under which it occurs are still unclear.

II. E. Verbal abilities and the mongol

This area has been selected for review because the literature illustrates clearly that the verbal abilities of the adult mongol are inferior to his non-verbal abilities, and that this difference is not found in other subnormals. The approach that will be taken here is not intended to be exhaustive, but to mention some of the large scale studies that have been done. We shall start with the young mongol and follow his language development as he gets older and where possible compare this to the language of other subnormals and normals.

II.E.1. Evidence from the study of sounds which precede language

It has already been pointed out that one of the advantages of studying Down's Syndrome children is that they are identified early in life, often within the first couple of weeks. One result of this is that sounds which precede the emergence of language can be examined. The investigations in this area have focussed on the pain cry (Fisichelli and Karelitz, 1966; Fisichelli, Haber, Davis and Karelitz, 1966; Lind, Vuorenkoski, Rosberg, Partanen and Wasz-Höckert, 1970; Vuorenkoski, Lind, Wasz-Höckert and Partanen, 1971) and on babbling (Dodd, 1972).

a) Evidence from the pain cry

Fisichelli and Karelitz (1966) recorded the pain cries of four mongol and four normal six month olds. The mongols cried less frequently, showed more variation in intensity and less spectral activity than the normals. These findings were extended and confirmed by Fisichelli et al (1966) who compared 21 mongols who were all less than one year old and were in hospital, with 21 normals of the same ages. The mongols, who took longer to cry and cried for less time, made more whimpers and fewer gasps, bursts of vocalizations and sounds than the normals.

The two more recent studies by Lind and his co-workers have extended these findings. Lind et al (1970) recorded the pain cries of 30 standard trisomy mongols and 120 normals, all aged between birth and eight months. Compared with the normals, the mongols took longer to cry, but when they did their cry was longer with a monotonous flat melody form and the pitch was lower than the normal's cry. The mongols cry was often nasal and stuttering and could contain biphonation. It is interesting that five children who were clinically identified as mongols had normal pain cries. However, the karyotypes of these children later showed them to be normal. It may be that the cry can be used as an additional clinical observation. To do this was the aim of Vuorenkoski et al (1971) who by considering 13 cry characteristics were able to differentiate a group of abnormal children which included the mongols of the previous study from a group of normal children. It was also possible to distinguish to some extent between the different abnormalities.

It is clear that there are differences in the crying patterns of young mongols

and other handicapped children and normals. But it is quite likely that crying in response to pain bears no relationship to subsequent language development. Another early behaviour, babbling, seems a more likely precursor of language.

b) Evidence from babbling

Babbling was studied in the mongol by Dodd (1972). The babbling patterns of ten normals and ten mongols aged between 9 and 13 months were analysed. No differences were found in terms of the frequency, length and type of utterance, although on the Bayley Scales of Mental and Motor Development the mongols were significantly retarded. Unfortunately it is unclear from this study how the children were matched and whether the Bayley Scale was administered at the same time as the babbling was recorded.

Thus it appears that there is no difference in how young mongol and normal children of the same C.A. babble. But because of the difference in pain cry it seems possible that the vocal characteristics of mongols might differ from those of the normal person.

II.E.2. Evidence from the study of vocal characteristics

Many reports (Strazzulla, 1953; Schlanger and Gottsleben, 1957; Blanchard, 1964; Lenneberg, Nichols and Rosenberger, 1964) find that the mongol has poor articulation which makes comprehension of his speech difficult. Despite this agreement there is controversy over the fundamental frequency of the mongol's speech. It has been reported that ten and eleven year old mongols have the same speaking fundamental frequencies as normals of the same chronological age (Michel and Carney, 1964; Hollien and Copeland, 1965). In contrast Weinberg and Zlatin (1970) found higher speaking fundamental frequencies for home reared preschool trisomy 21 mongols, and Montague, Brown and Hollien (1974) report higher fundamental frequencies for ten institutionalised mongol boys aged between seven and thirteen years compared with mongol girls of similar ages and normal children of the same age. Goueffic, Vallencien and Leroy-Boisivon (1967) found the fundamental frequency of twenty mongols aged between ten and nineteen years to be lower than that of the normal. From these various studies it seems that there is a change from a relatively high fundamental frequency in the first five years or so of life, to normal

levels at around ten years, and possibly to levels lower than normal by late adolescence.

II.E.3. Evidence of differences between verbal and mental abilities

We now move onto the stage when language has started to emerge in the mongol. Buium, Rynders and Turnure (1974) analysed weekly tape recordings of three 48 month old mongols when playing with their mothers. At the start of the study these children were at the one word stage. Over the 11 months that the recordings were made, the same semantic relational concepts as are found in normal children (Schlesinger, 1971; Bowerman, 1973; Brown, 1973) appeared in the same order but over a slower time course. The same authors examined the content of the mother's language when she was asked to teach her child to play with a toy and set a table (Buium, Rynders and Turnure, 1973). In this study there were five two year normals and six two year old mongols. The mothers of the mongols compared to those of the normals spoke more but shorter utterances and sentences, more grammatically incomplete sentences, imperative sentences and single word responses. They used fewer indefinite pronouns, conjunctions, WH-type questions and certain verb forms. Since this argues that the mother's language to a mongol child is different from that to a normal child, this may well affect the acquisition of language.

A study by Mein and O'Connor (1960) found that as well as language acquisition being delayed in the severely subnormal person, the language that was acquired was different from that acquired by normal persons. It was found that the vocabularies of 80 severely subnormal persons, of whom 19 were mongol, aged between 10 and 30 years and with M.A.s between three and seven years, were similar in size to those reported for normal children of similar M.A. (Burroughs, 1957). The difference was that common words formed one third of the normal's vocabulary, but two thirds of the S.S.N.'s vocabulary. It was found that vocabulary size correlated better with M.A. than with C.A.

In a follow-up study (Mein, 1961) it was discovered that the mongols used more nouns than non mongols in conversation interviews and interviews involving pictures. Although the number of nouns used decreased as M.A. increased, of the words used by the mongol at a M.A. of four and a half years, 31 per cent were

nouns, compared with 19 per cent for a normal child of the same age. The authors suggest that this means that the mongols are functioning at a lower level of language development than the non mongols.

Lyle's studies (1959, 1960b) also seem to support the finding that mongols are more retarded in their language development than would be expected from their M.A. He administered the Minnesota Preschool Scale of Intelligence (Form A) to 77 institutionalised children, of whom 34 were mongol, and to 117 imbeciles at day school, of whom 76 were mongol. There were no differences on the non-verbal part of the scale, but on the verbal scale the mongol children were inferior to the non mongol children and the institution children were inferior to the day school children. In the 1960 paper the same children were tested on a series of tasks which were designed to measure different aspects of speech and language. The mongols were inferior to the non mongols on word definition, speech sounds, complexity of language, clarity of speech, frequency of speech and verbal intelligence. There was no difference between the groups on word naming and comprehension.

Cornwell (1974) looked at the mental ages at which mongols could perform certain verbal, numerical and concept formation tasks. The 38 home reared mongols aged from 5 to 19 years were put into five yearly age groups on the basis of M.A., the lowest being 0,10 to 1,9 years and the highest 5,6 to 5,10 years. All groups were able to recognize names and functions but the ability to give the name or function increased with M.A. When the child had either to select a number of items or to say how many there were, these abilities improved gradually across the ages, but there was no difference between the conditions. This suggests that whereas in verbal tasks there is a difference between comprehension and performance, these are not present in numerical tasks. All the children had great difficulty with the categorizing tasks. It would be nice to see these sorts of task repeated with non mongol imbeciles.

The final study to be discussed in this section is by Ryan (unpublished a, b). Although she used a different approach from Lyle and other workers, there is agreement where there is overlap. Ryan compared the performances on a battery of tests of normals, mongols and other S.S.N.s. The 16 mongols and 15 S.S.N.s

were tested twice, once at the age of seven years, with a range from five to nine years, and second a year later when there were only 13 S.S.N.s. The normals were first tested at the age of three years, range two to three and a half years, and then four and a half months later. Thirteen normals were in the first test, 11 in the second. The M.A.s of all of the children were around three years.

All of the children were better at recognising pictures and objects than naming, and they all improved between test sessions. Compared with the other S.S.N.s the mongols named more body parts on the first test, and on the second test they were better at naming overall.

The normals were superior on tests of prepositions and sentence repetition. Even by the second test the two subnormal groups were still inferior to the normals' performance on sentence repetition on the first test, although their performances had improved. Normals were better at comprehending negatives and affirmatives in pictures especially the former, than either subnormal group. All of the children performed better when comprehension of an affirmative rather than a negative was required. In these three tests of prepositions, sentence repetition and comprehension, there was no difference between the subnormal groups.

The most interesting part of Ryan's study was an analysis of the speech which occurred during several 20 or 30 minute play sessions. The only difference between the two subnormal groups was that on the second test the mongols made shorter utterances. All of the children talked equal amounts and there was little difference in intelligibility, although the mongols tended to be less understandable. The normals made longer utterances which increased between the tests. Also for the normals, their utterance length was greater in the sentence repetition test than in their spontaneous speech. Finally, the normals made more complete utterances than either of the subnormal groups and this increased over tests.

What can be concluded from this study? Ryan concludes that the pattern of verbal abilities of the subnormals is different from that of the normals, rather than that they have a verbal deficit. She found few significant differences between the two subnormal groups, although the non mongol group tended to be superior, but nonsignificantly, to the mongol group whenever the normals were superior to them both.

It is evident from these studies that when the verbal abilities of mongol and non mongol persons of the same level of intelligence are compared, differences emerge, with the mongol being the most deficient. A question which this raises is whether or not the environment plays any part in the mongol's acquisition of language.

II.E.4. The effect of intervention on the mongol's language ability

In line with the research by Buium et al (1973) which was discussed at the beginning of the previous section and found that mothers of mongol children talked differently to their children than mothers of normal children, Rynders and Horrobin (1974) have started a longitudinal early educational programme for mongol infants aimed at maximizing their ability to communicate. There are no details of the educational programme, but the child is stimulated at home from before the age of six months until he is two and a half years old when he enters an experimental preschool. They do report comparisons between stimulated mongols and control mongols. There was no difference in the ability of the children in these two groups to point at named objects at 24 months, but by 30 and 36 months the stimulated mongols performed better than the controls. The Bayley Scales also showed that although the D.Q.s of the two groups did not differ up to 18 months, at 24 and 30 months and on the Cattell at three years, the stimulated mongols had higher D.Q.s than the control mongols.

This study is encouraging and another report (Kolstoe, 1958) gives some support to the suggestion that language may be facilitated by training. Thirty mongols aged from 5 to 14 years were matched in pairs for M.A. and these ranged from 1,6 to 3,9 years. For five and a half months one member of each pair was given daily training which was tailored to his needs, but in general involved getting the child to attend to and use symbols. It was found that the control mongols showed a greater fall in I.Q. and performed worse on the Illinois language test than the experimental mongols, but there were no differences in the complexity of the children's language. There was a greater effect of training on those mongols with the highest M.A.s. Compared with the Rynder's study, the training was over a short time, and the children were five years old at the start.

Another experiment which supports intervention as an aid to language

development is by Lyle (1960a) and Tizard (1960). This was discussed in section II C.v.b when the effect of additional stimulation on development was considered. It was found that the language of a group of institutionalised mongols improved when they were transferred to a unit where the emphasis was on pre-school education, compared to the language of the mongols who remained in the institution.

Finally Jeffree, Weieldall and Mittler (1973) trained two word utterances in two four year old mongol boys. At the beginning of the training these children were at the one word stage, but by the end, the children were producing in play situations two word utterances other than those with which they had been trained. Thus the training on specific two word utterances had generalised.

The evidence that has been reviewed shows that the mongol is retarded in his verbal abilities more than in his mental abilities and that training can facilitate his acquisition of language. Thus there is more to the mongol's make-up than meets the eye when only his intelligence is considered. This is an important step in the right direction. But language and its various problems are a characteristic of the mongol over four years or so. This raises the question of whether there are other abilities in the mongol of less than four years of age which might show deficiencies which one would not expect from the intelligence score alone? As an attempt to find such an area we now look at the research on the perceptual abilities of the mongol person.

II F. Perceptual abilities and the mongol

This review of the perceptual abilities of the mongol person is included because if he is found to perceive the world differently from a normal person this has important implications. One implication is that since the majority of the data in this area are from studies of the adult mongol, any differences which are found can then be investigated in the young mongol. And if the young mongol shows similar deficits in his perceptions, such findings would be of far greater value than D.Q.s or I.Q.s in indicating appropriate ways of educating him.

Two areas of perception will be considered, namely vision and touch.

II.F.1. The visual abilities of the mongol

In this section the concern is with how the mongol perceives his world through the modality of vision. There are two highly related questions. These are whether, in comparison to the normal person, the mongol looks at his world in the same way, and second, whether he sees the world in the same way. There is only one study which relates directly to the first question, since eye movements were recorded (O'Connor and Berkson, 1963). The other studies have used measures of how the mongol looks at his world, but to investigate whether he sees certain aspects of it in the same way as the normal person.

a) Evidence for how the mongol looks at his world

O'Connor and Berkson (1963) studied the eye movements of 14 normal adults, 14 mongols and 14 non mongol imbeciles. They were all of a mean age of about 24 years, and the mongol and non mongol imbeciles had mean I.Q.s of about 32. There were five conditions of light presentation, and regardless of whether there was no light, one light flashing, five lights flashing randomly, one light on continuously or five lights on continuously, the mongols made more eye movements than the others. The lights were positioned 15 inches from the person, and everyone made more eye movements when there were five lights on continuously compared to when there was total darkness or one light or five lights flashed.

This is an interesting study because it suggests that the mongol person may use his eyes in a different way from the normal person and other retarded persons. If he looks at his world differently from the normal person, it seems possible that he sees his world differently. This possibility is considered in the rest of this section.

b) Evidence for what the mongol sees in his world

A number of studies report that the visual ability of the mongol adult is not different from that of the normal child of the same M.A. (Gordon, 1944; Hermelin and O'Connor, 1961; O'Connor and Hermelin, 1961), and the adult non mongol imbecile of the same M.A. (Hermelin and O'Connor, 1961; O'Connor and Hermelin, 1961). In contrast Clausen (1968) found that there were differences in visual ability between mongol and non mongol imbecile adults when their M.A.s were not matched, and that these differences did not disappear when the mongols were compared to

non mongols matched for M.A. On the other hand, when mongol adults and children have been matched for C.A. with normal adults and children respectively differences in visual ability have been found (O'Connor and Hermelin, 1961; Miranda, 1970; Miranda and Fantz, 1973; Miranda and Fantz, 1974; Fantz, Fagan and Miranda, 1975).

The visual abilities of the mongol adult and others of the same mental age

Gordon (1944) compared the performances of six mongol adults with those of six normal children matched for M.A. on the Stanford Binet on a series of tasks. The tests were visual discrimination of size, pattern, three dimensional form, brightness and colour. He also compared the mongols and children on a series of tactile discriminations, but description of these and the results will be deferred until a later section. All of the tasks involved simultaneous rather than successive discrimination. For example, in the three dimensional task the person was given 15 beads which were of five different shapes and he had to put these on a string in order of shape. For each task the score was based on the number of errors made, regardless of the degree of the error.

Unfortunately Gordon neither reports the raw data nor performs analyses on it. Instead he ranked the persons on each test and computed the score for each item from these ranks. The item scores were then averaged to give a visual score. He reported low correlations between performance and Stanford Binet intelligence. However by means of t test he showed, on the basis of the composite visual scores, that the mongol adults were not significantly different from the normal children at visual discrimination.

It is hard to evaluate Gordon's results for a number of reasons. He gave a number of tasks which were extremely different from one another, and yet grouped the results together to arrive at a composite score for so-called visual discrimination. He gives few details of the task instructions and of the materials used. In the pattern discrimination the person had to match 25 cards to 5 standards on which were black line drawings of abstract designs. This could be a task of innumerable levels of difficulty depending on the amount of difference between the designs. A relatively easy task would seem to be stringing beads by shape, but this raises another problem. This task was classified as a visual

discrimination task, but in order to solve it the person had to touch the beads, and therefore discrimination on the basis of tactile cues cannot be ruled out.

Another problem with this study is the small number of mongols and normals. There is one final criticism which concerns the method of analysis. Belmont (1971) re-analysed Gordon's composite data on both the visual and tactile discrimination tasks, using a split-plot analysis of variance with repeated measures. The groups were significantly different from one another, but there was no interaction between the two groups and the two types of discrimination. This argues for the mongols being inferior to the normals on the tasks involving visual discrimination as well as those involving tactile discrimination.

Despite all the shortcomings of Gordon's data, there is other evidence that the mongol adult is not inferior to the normal child of the same M.A. on visual tasks. O'Connor and Hermelin (1961) and Hermelin and O'Connor (1961) compared the performances of mongol adults, non mongol imbecile adults, normal adults and normal children on various visual and tactile tasks. The results of the tactile tasks will be given in a later section. The normal children were matched for M.A. on the Stanford Binet with the adult imbeciles, and the normal adults were matched for C.A. with the imbecile adults.

In the first paper the persons had to recognise visually hardboard shapes which were based on Greek letters. Five shapes were presented one after the other to each person, and this was repeated for the imbeciles and the children. After one minute, the same shapes plus five new ones were presented visually in random order and the person had to choose the five he had seen before. It was found that all of the groups performed similarly except for the normal adults who were superior.

In the second paper the performance on a visual matching task and a delayed recognition task of 16 normal chikdren aged from four and a half to five and a half years and 16 mongol adults and 16 non mongol adults were compared. The adults were matched with the children for M.A. There was no difference between the three groups on the visual matching task, and they all performed badly on the delayed recognition test.

Compared to the preceding studies Clausen (1968) found a group of mongols

to be inferior in visual ability to a group of non mongols even when the M.A.s of the two groups were matched. Twelve mongols aged between 12 and 24 years were compared to 196 other retardates of whom 24 were matched with the mongols for I.Q., C.A., M.A., and sex. A battery of tests was administered and it was found that the mongols were inferior to the total group of non mongols and the smaller matched group on tests of visual acuity and brightness discrimination.

A direct comparison is not possible between this study and the previous ones since Clausen gives few details of the tests employed, and expresses the data with respect to the mean performance of a group of normals. Since this mean was 50 for all of the variables including I.Q. and M.A. the persons in this study cannot even be compared for I.Q. and M.A. levels with those in other studies. However, as Clausen points out, the discrepancies should be taken to indicate that systematic research is required to clarify the particular problems that the mongol has.

The visual abilities of mongol adults and children and normals of the same chronological age.

We now turn to those studies which report differences in the visual abilities of mongol persons and normal persons of similar C.A. It has already been mentioned that O'Connor and Hermelin (1961) found mongol adults to be worse than normal adults at visual recognition of shapes, even though the mongols were given more experience of the shapes to be recognised than the normals.

Differences have also been reported between normal and mongol children of similar C.A. with respect to their visual abilities. One study was published just when the experiments to be described in this thesis were started (Miranda, 1970) and a number of others have been reported since the completion of the experiments, (Miranda and Fantz, 1973; Miranda and Fantz, 1974; Fantz, Fagan and Miranda, 1975). Two techniques have been employed by these experimenters. The first technique, labelled visual preference, involves presenting a pair of patterns which are different from one another. If the child looks at one of the patterns for longer than the other, this is evidence that he can discriminate between the two patterns. However, if no preference is shown it cannot be inferred that the child does not see the patterns as different, since they might be equally preferred. In the second technique, termed recognition memory, the child is first familiarised with a pair of

identical patterns by presenting them usually for a minute. Then, either immediately or after a delay, one of the familiar patterns is presented with a novel pattern normally for ten seconds. Preference for the novel pattern in this test is evidence that the child remembers the familiar pattern and can distinguish it from the novel one.

Evidence from visual preferences

Using the technique of visual preference, Miranda and Fantz (1973) presented 20 mongols and 20 normals all about eight months old with pairs of patterns which differed from one another in various ways. Overall the mongols looked at the patterns for longer than the normals, and they showed fewer preferences in terms of the amount of time spent looking at one pattern rather than at the other. The mongols preferred black and white stripes that were 1/16 inch or 1/32 inch wide to a plain grey card of equivalent luminance. Their only other preference was for a solid as opposed to an outline of a white head. The normal babies, in addition to these preferences also preferred black and white stripes 1/64 inch wide to a grey card, solid objects as opposed to flat objects, circular patterns to straight line patterns, a photograph of a face rather than a schematic face, and the latter was preferred to a face in which all the features were scrambled.

This study found clear differences between the mongol and normal babies of the same C.A., but it does not indicate whether the mongol will show the same patterns of preference as the normal child but at a later age. This was investigated in a longitudinal study of 31 mongols over the first eight months (Fantz and Miranda, in preparation). Between 9 and 21 of the mongols were seen at two weekly intervals and these were approximately matched with 28 normals for gestation, race, number of siblings and parental education. From 8 to 16 of these normals were included in each test. A large number of stimulus pairs were employed, and whereas some of these showed a difference in the preferences displayed by the normal and mongol children, others did not.

There was a difference in the development of a preference for stimuli with circular configurations over those with straight lined configurations. For the normal children this preference occurred at seven weeks and continued throughout the eight months, but in the mongols its onset was delayed by two to four weeks

and decreased after six months. At eight months, therefore, the normals but not the mongols preferred circular to straight lined patterns, thus replicating one of the findings of Miranda and Fantz (1973).

The mongols also developed later preferences than the normals for irregular over regular patterns and for stripes of different widths over a grey card of similar brightness. Another interesting difference was that whereas the normals initially preferred a schematic face over a photograph of a face, but after five months preferred the photograph, the mongols preferred the schematic face throughout the eight months.

On the other hand, there were few differences in the ages at which the normal and mongol children developed preferences for various number versus size combinations. There were three patterns, one composed of four one inch squares, another of four half inch squares and a third of 16 half inch squares. Of the two patterns with four elements, the one with larger elements was initially preferred but this diminished until it was absent in the normals by 9 to 11 weeks and in the mongols by 13 to 15 weeks. For the two patterns with half inch elements, the one with most was initially preferred and this decreased, especially for the normals, and had disappeared by 21 weeks, although the preference reappeared in the mongols from 25 to 29 weeks. Finally the pattern of 16 half inch squares was preferred to that of four one inch squares at all ages except at five weeks by both groups.

Fantz, Fagan and Miranda (1975) interpret their findings as indicating that the emergence of preferences for patterns with more, smaller elements is probably related to the development of elementary visual and neural mechanisms involved pattern perception, and these they consider to be developing as normal in the young mongol. However, the fact that the mongols' visual preferences lag behind that of the normals when the patterns differ in form, is taken by the authors as evidence that these involve higher processes, which are retarded in the mongol. Further support for this comes from their use of the second technique of recognition memory.

Evidence from recognition memory

Miranda (1970) examined the recognition memory for abstract black and white patterns of 16 mongol and 20 normal children all aged between seven and eight months and living at home. It was found that the mongols looked more than the normals during the one minute familiarisation period, and that all of the children looked more at the novel pattern than at the familiar pattern on two ten second trials. From these results Miranda suggested that the mongols may take longer to process the same amount of visual information than normal children, but that both normal and mongol eight month olds show immediate recognition memory of these patterns.

Similar results have also been reported for younger mongols (Fagan, unpublished). Again using abstract black and white patterns, he found that mongols as young as five months recognised the familiar pattern of a pair, as evidenced by a preference for the novel member of the pair. This occurred even when there was a delay of seven minutes between presenting two identical patterns and presenting one of these paired with a novel pattern.

However, when younger normal and mongol children are tested with patterns of differing degrees of discriminability, it has been found that the normal children prefer the novel member of a pair at an earlier age than the mongol children (Miranda and Fantz, 1974). In this study a sample of 28 mongols were matched with 46 normals for C.A., sex, gestation length and to a lesser extent for parental education and number of siblings. They were all living at home and 16 matched pairs of mongols and normals were seen between 8 and 16 weeks, between 17 and 29 weeks, and between 30 and 40 week. The normals showed recognition memory for a pattern at all ages, the mongols only at the two older ages. Recognition of one of two photographs, and of a circular or checkerboard arrangement of squares were demonstrated in the two older normal groups, but only the oldest group of mongols showed recognition of a photograph, and no mongol group showed recognition for the arrangement of squares. Finally, the oldest normal group, but none of the mongols, showed recognition memory for colours. These results suggest that the mongols lag by at least two months behind the normals for recognition memory of these four stimulus variations.

This lag was confirmed in a longitudinal study in which one of two multi-dimensional patterns was presented for familiarisation during intervals between the test sessions of the longitudinal visual preference study described previously (Fantz, Fagan and Miranda, 1975). Significant recognition memory was shown first by the normals at 9 weeks, and by the mongols at 17 weeks. This lag suggests that the mongol's development is similar to the normal's but slower. Also, the fact that the visual preference studies showed that younger mongols could discriminate between more similar patterns than those used in the recognition experiments, is evidence that the lag in the mongol's recognition memory development is related to delayed cognitive development.

Unfortunately the mongol and normal children in these studies reported by Fantz and his colleagues were matched for C.A. rather than for M.A. If a group of normals had been matched with the mongols for M.A., this would have indicated whether the delays found in certain aspects of the mongol's development could be accounted for by his retarded mental development or not.

To conclude, all but one of the studies that have been reviewed in this section lead to the suggestion that the mongol is as capable as other retarded and normal persons on visual tasks, provided that their M.A.s are similar. This is despite the finding that the mongol's eye movements are different. On the other hand, differences appear when normal and mongol persons of similar C.A. are compared on visual tasks. The eye movement finding and the findings in one study of differences between mongol and non mongol imbeciles of the same M.A. suggest that the mongol may not look at the world in the same way as the normal person, and that different tasks may be more sensitive than others in picking up this difference.

II.F.2. The tactile abilities of the mongol

The question which concerns us in this section is whether the perceptions of the mongol person through the modality of touch are the same as those of other persons, retarded and normal. Although different studies have employed different tasks there seems to be general agreement that on tactile discriminations the mongol is inferior to normal children of the same M.A. (Gordon, 1944; O'Connor and Hermelin, 1961) and non mongol imbecile adults whether matched for M.A.

(O'Connor and Hermelin, 1961), I.Q. (Knights, Atkinson and Hyman, 1967) or neither (Knights, Hyman and Wozny, 1965). Clausen (1968) found mongols to be inferior to non mongol imbeciles on a test of stereognosis when their M.A.s were unmatched. On the other hand, he found no difference when their M.A.s were matched.

Gordon (1944) as well as comparing the visual abilities of six mongol adults and six normal children matched for M.A. also tested their tactile discrimination of size, form, three dimensional form and texture. Using the same scoring method as described for the visual tests in the previous section, the mongol adults were found to be inferior to the normal children at tactile discrimination. Although Gordon reports these tasks as measuring tactile discrimination, those of form and three dimensional form may also involve some visual discrimination. This is because the person was handed a shape, which he presumably could see, and had to select the shape which matched it from out of a bag. Because he calculated a single composite score for each person, it is not possible to see if there was any difference between these tasks and the two others which were carried out blindfolded.

However, a tactile deficit is supported by the results of O'Connor and Hermelin (1961). They compared the performances of 12 mongol adults, 12 non mongol imbecile adults, 12 normal children and 12 normal adults on a tactile version of the visual recognition task reported in the last section. The four groups contained different persons from those doing the visual task, but they were matched in the same way. The children were matched with the imbeciles for M.A. and the normal adults were matched with the imbecile adults for C.A. It was found that the mongols performed at a lower level than all of the other groups. One interesting feature to emerge was that the normal and mongol adults were better at visual than tactile recognition, whilst the opposite was found for the non mongol imbecile adults. The normal children performed at a similar level on both tasks.

More support for the mongol being inferior at making tactile discriminations comes from a study by Knights, Atkinson and Hyman (1967). They matched 19 mongols with 19 non mongol retardates for sex, C.A. and I.Q. The mean ages of the mongol and non mongol groups were 14.7 and 15.1 years and their mean

I.Q.s were 41 and 42 respectively. There were five tasks and the first four, which were discrimination of texture, size, weight and shape were carried out blindfolded. The fifth task was a visual-tactile discrimination. The results were that fewer mongols than non mongols were able to perform the tasks at all, and those who could scored lower on the first four tasks, although none of the differences was significant. On the visual-tactile discrimination the mongols performed at a higher level than the non mongols, although again the difference was nonsignificant. Knights et al argue that this last result supports Gordon (1944) and O'Connor and Hermelin (1961) since the mongols only performed better than the non mongols when the task involved some visual discrimination. This seems an unlikely explanation since O'Connor and Hermelin found no difference between normal children, mongol adults and non mongol imbecile adults for visual discrimination, and Gordon found no difference between normal children and mongol adults on his visual tasks. Moreover, the selection of the correct shape in Knights et al's study involves the use of tactile ones and so this alone should have retarded the mongol's performance, if indeed he does have a tactile deficit.

Two studies, one by Knights, Hyman and Wozny (1965) and the other by Clausen (1968) have found mongols to be inferior on a formboard test and a test of stereognosis respectively to non mongols of higher I.Q. Knights et al compared 10 familials, 13 brain damaged persons and 18 mongols who were all aged between 8 and 18 years and living in an institution. The mongols had a mean I.Q. of 40.7 in comparison with 59.33 for nine familials and 58.33 for nine with brain damage. The task was to place eight blocks in the appropriate holes of a formboard whilst blindfolded, using the dominant hand, the non-dominant hand and finally with both hands. The criterion was to position correctly all of the blocks within 15 minutes on two out of three trials. Only four of the mongols reached this criterion compared with nine familials and nine brain damaged persons. This emphasises the particular difficulty that the mongol has on tactile tasks, but since the groups were not matched for I.Q., the lower I.Q. of the mongols cannot be ruled out as a contributing factor. An additional problem for this study, which is also a problem for the other study by Knights et al (1967) and for the tactile discriminations of size and texture in Gordon's (1944) study, is that the children were blindfolded. O'Connor and Berkson (1963) observed that mongols became disturbed when asked

to remain alone in the dark. If they became disturbed when blindfolded this might well have contributed to their failure in these tasks.

The s tudy by Clausen (1968) presents some evidence which is contradictory to the reports of mongols having a tactile deficit when compared to non mongol imbeciles of the same M.A. On a test of stereognosis, 12 mongols were inferior to a group of 196 other retardates. However, the mongols had a lower mean M.A., and when they were compared to 24 of the other retardates who were of similar M.A., the stereognostic difference disappeared. It is difficult to evaluate this study, since the test was not described, and the actual M.A.s of the groups were not reported.

The evidence that has been presented points strongly to the conclusion that the tactile perception of the mongol is inferior to that of other retardates and normal persons.

III. CONCLUSIONS

In this chapter a large area of research has been reviewed with the objective of finding a worthwhile avenue of research on early retardation. The first sections provided the subject population of mongols, since they can be recognised usually at birth on the basis of clinical characteristics, and their chromosome pattern provides confirmation of the syndrome, or not.

Having identified a retarded population who could be studied in early childhood, the aim was then to find an area worth researching. The intelligence of the mongol was examined in some detail, but the main limitations of the studies was that they gave little indication of why the mongol should perform at a particular level. And so aspects of his motor, verbal and perceptual development were considered.

The areas of motor and verbal development produced some evidence of the mongol being more deficient in these areas than expected from his general mental development, but the majority of these differences were found with the older mongol. But one of the exciting prospects of working with the mongol person is that he can now be conclusively identified at birth or shortly afterwards. As far as potential

research on the young mongol is concerned, the most suggestive area was that of visual and tactile perception. Here it was seen that although the mongol adult, in a limited situation, has different eye movements from others, there is little evidence that mongol adults have different visual abilities from others of the same mental age. However, there was much evidence that the adult mongol finds it more difficult than others to make discriminations on the basis of touch.

Therefore, the first question raised by this literature review is whether the visual abilities of young mongol and normal children of the same mental age are similar or different. This question may be asked with respect to the visual discriminations that they make and the strategies by which they make these discriminations.

The second question is whether or not the tactile deficit observed in the adult mongol is also present in the young mongol.

Before describing the experiments which were designed to provide answers to these questions, it is necessary to know how these visual and tactile abilities develop in the normal child. This is the subject of the next chapter.

CHAPTER 2

The Visual and Tactile Perceptions of the Young Normal Child

I. INTRODUCTION

In the last two decades a considerable body of research on the perceptual abilities of the young normal human being has accumulated. It is intended to review only those aspects of this research which are relevant to the subject matter of this thesis.

This chapter will concentrate solely on the visual and tactile perceptions of the developing human, since the conclusions of the previous chapter were that these might be two areas worthy of research in the young mongol. These two areas will be dealt with separately in the two main sections of this chapter.

Although much of the literature that is available up to the time of writing is reviewed, the reader should bear in mind that the experiments to be described later were begun at the end of 1970 and finished by early 1973.

II. VISUAL PERCEPTION AND THE YOUNG NORMAL CHILD

In order to study the visual perception of the young child it is necessary to select an appropriate response that the child is capable of and which can be measured with accuracy. The most available response and therefore the one that has been used in many of the studies to be described is the looking response or visual orientation of the eyes. This visual orientation has been the basis of the majority of experimental methods which have been designed to unravel the problem of how the child views his world. The main methods that have been employed and their limitations will be outlined before the outcomes of the studies which have used these methods are discussed.

II.A. The Methods of Study

II.A.1. Visual Preference

The basic assumption behind this method is that if a child looks at one pattern for a greater length of time than at another, then it can be concluded that the child can perceive some difference between the two patterns. The converse of this is not true. If the child fails to show a visual preference for one pattern over another, it cannot be concluded that he does not notice any difference between the patterns. He may perceive a difference, but this in itself may be insufficient to direct a preference.

The presence of a preference may also be a problem for the experimenter. The problem concerns the basis on which the preference was shown. Clearly, in order to be able to make inferences about the child's visual ability it is essential that all factors that could direct a preference are eliminated, except for the variable or variables under investigation. This particular problem has been a source of much confusion in the literature.

Visual preference has been employed in a number of different paradigms which are described below.

a) Paired Preference

Two patterns are presented simultaneously to the child for a period of time which may be fixed by the experimenter, or depend upon the behaviour of the child. An observer looks at or a camera photographs the child's eyes through a small hole between the patterns. With suitable light a reflection of the patterns can be seen on the child's cornea. The child is judged to be looking at that pattern whose image falls over part of his pupil as seen by the observer or camera. This criterion of fixation was first used by Staples (1932), and has been employed widely since, although there is some recent evidence (Slater and Findlay, 1972a, 1975a) which shows that the centre of the pupil does not represent the line of sight. However the degree of error involved is small compared to the normal angle between the two patterns and so can be ignored. The error only becomes important in techniques which determine exactly where on a pattern the child is looking (section II.A.2).

A number of different measures have been used to test for a preference, the most common one being the total lengths of time that the child spends looking at each of the two patterns. Other measures include the length of the first fixation to each pattern, the average fixation length, which pattern is looked at first and the number of times that each pattern is fixated.

b) Single Preference

This has all the features of the paired preference method, except that two or more patterns are presented to the child successively rather than simultaneously.

c) Familiarization

There are a number of variations of this method, but the basic procedure consists of presenting a pair of identical patterns to the child for a fixed period of time. These patterns, termed the familiarized patterns, are followed either immediately or after a delay by a pair of patterns of which one is the familiar one and one a novel pattern. As in the previous methods the lengths of time that the child looks at the two patterns are compared and a difference is interpreted to mean that the child can perceive a difference between the patterns. A variation of this paradigm is to pair one pattern with a different pattern on each of a number of successive trials.

The familiarization method has a distinct advantage over the paired or single preference method. This is because the child's exposure to the patterns is deliberately manipulated in the familiarization method. By the simple preference methods the child might show no preference although he perceived a difference, but with the same patterns in the familiarization method he might show a preference because one pattern is more novel, and therefore either more or less preferred than the other.

However, there are two disadvantages of familiarization procedures over straight forward preference. The first is that more trials are required in order to familiarize the child. If the design of the experiment involves presenting a number of pairs of patterns to the child, the familiarization method greatly increases the possibility of the child becoming inattentive and upset. The second

disadvantage is that for the child to show a preference in the test phase following familiarization of one pattern, he not only has to be able to perceive the difference between the patterns, but also he has to be able to remember that he has seen one pattern before. However this is only a disadvantage when a negative result is obtained since this could be because the child failed either to perceive the difference or to remember the difference. When a positive preference is demonstrated this method indicates that the difference is both perceived and remembered.

d) Habituation and Dishabituation

This method is really an elaboration of the familiarization technique. A pattern is repeatedly presented to the child on a number of successive trials, and the length of time that the child looks at it on each of these habituation trials is measured. The number of habituation trials may be predetermined by the experimenter or may be dependent on the child's looking behaviour. However after these trials, but with no break in the continuity, a different pattern is presented for one trial. The amount of fixation of this pattern during dishabituation is recorded.

The pattern of the child's fixation over the trials is examined. If a decrease in looking time occurs over the habituation trials, this could be either because the child gets tired or because he becomes aware that the same pattern is being repeated and so looks at it for less and less time. If the decrease was due to fatigue only, no increase in looking time on the dishabituated trial would be expected. But if the decrease occurred because the child noticed that the same pattern was repeated, and perceived the change on the dishabituated trial, then there should be an increase in looking time on this trial.

The disadvantage and advantage of this technique are similar to those of the familiarization method. The disadvantage is that it cannot be concluded from a negative result whether the child does not perceive the pattern or fails to remember it. On the other hand, a positive result not only gives information about what differences a child can perceive and remember, but, by examining the rate at which his looking time decreases over the habituation trials, the experimenter has an insight into the time the child takes to build up a representation of what he perceives.

II.A.2. Visual Scanning

A limitation of the methods employing visual preference is that the measure is of how much a pattern is fixated. There is no information from this technique of how the pattern is looked at. However, the method of visual scanning provides the information.

This method involves photographing the child's eye(s) as he looks at a pattern, using cine film or television. By means of the reflections of suitably positioned infra-red reference lights, it is possible to calculate, after certain calibrations have been made, the successive locations of the child's fixations of the pattern. If the child scans different patterns in distinct ways, this is evidence that at least at the level of his eye movements, the patterns elicit separate responses.

The main drawback to this technique is that it requires elaborate equipment, and as a result it is more costly and likely to break down than the simple preference methods.

II.A.3. Conditioning

A further limitation of the preference technique, in addition to giving no information as to how a pattern is scanned, is that no conclusions can be drawn if neither pattern is preferred. One way around this has been to condition the child to make a response, such as a head turn, to one pattern and to examine the extent to which this response will generalise to other patterns. A pattern which the child does not see as different from the conditioned pattern should be responded to with the same vigour as the conditioned pattern. On the other hand, patterns perceived as different should be responded to less, the strength of the response being related to the degree of the difference. A drawback to this method is that it often takes a considerable length of time to reach the stage when the response that is conditioned to the pattern is stable.

This problem is overcome to some extent by reinforcing different responses to different patterns. In this way, it is not necessary to wait until a response stabilises, since if the discrimination can be learned it can be concluded that the patterns were perceived as different.

Both of these techniques have advantages over the visual preference method, but at the same time they require more of the child than merely perception. In order to show a discrimination, the child must first be able to perceive the pattern, then learn to make a particular response whenever it is presented which involves both learning and memory abilities, and finally he must be able to perceive the difference between one pattern and another.

II.A.4. Physiological Indices

If the child does not show differential visual responses to different patterns, it is possible that some other measure will show such a response. Two of the most popular physiological responses that have been used are heart rate and evoked potentials. However there are two drawbacks to both of these. The first is that their recording involves large amounts of equipment, and second, the stability of both responses and the direction of changes are variable over time.

Other measures which have been employed and that could perhaps also be classified as physiological include smiling, vocalizing, sucking. However, these are not so frequent in occurrence as looking behaviour and so are limited when used alone.

II.A.5. Summary

The visual preference methods stand out as the simplest, and, if used with care, perhaps the most appropriate for the study of the perceptual abilities of very young children. This is not to rule out of hand the other techniques. They can often provide valuable information, but it seems worth exploring capabilities by visual preference before resorting to one or other of the more sophisticated tools.

However, in order to maximise the information we can learn about visual perception from preference studies, it is imperative to remove as many of the limiting features of the technique as possible. One limiting factor that must be considered is the child himself. The next section examines the development of the child's visual system and the factors which may influence his visual behaviour.

II.B. Development of the child's visual system

A prerequisite for pattern perception is that the child can actually resolve the pattern with which he is presented. In order to be capable of this, at a minimum he must have adequate visual acuity, be able to focus the pattern at the distance it is presented, and be able to resolve the contrast between the light and dark areas of the pattern. It is also necessary, particularly when the paired preference method is employed, that the patterns are within the child's visual field. This section, as well as considering these abilities, also examines the extent of binocular fixation, and factors such as medication and posture which may influence visual behaviour. Before discussing these, some of the evidence concerning the physiological maturation of the human visual system will be examined.

II.B.1. The structure and postnatal growth of the visual system

In a recent review of the early growth of the visual system, Bronson (1974) argues that before the second month of age the child's visual perceptions may be mediated by subcortical rather than by cortical mechanisms. These subcortical mechanisms are components of the secondary visual system as distinct from the components of the primary visual system. Bronson proposes that the primary visual system which includes neocortical structures develops rapidly after birth, and within the second or third month is able to support complex pattern perception.

These proposals are supported by physiological evidence of the extent of myelination of the areas involved at different ages (Yakovlev and Le Cours, 1967) and by histological studies of the increasing ramification of neuronal connections within the cortex with age (Conel, 1939, 1941, 1947). As Bronson (1974) points out, lack of myelination does not preclude neuronal activity, although its extent may be taken as a rough indicator of maturation. The second visual system processes peripheral rather than foveal stimulation, and certainly the more peripheral components of the visual system, such as the lateral geniculate and the superior colliculus are myelinated at least in part before birth. On the other hand, the myelination of the temporal lobe areas which form part of the primary visual system does not begin until several months after birth.

The histological data cannot indicate the age at which particular parts of the

visual system begin to function. However in further support of his claim that the development of the secondary visual system is in advance of that of the primary visual system, Bronson (1974) examined a number of behavioural studies. He argues for example that the jerky visual pursuit by newborns when tracking a single moving object (e.g. White, Castle and Held, 1964) and their smooth pursuit of an entire moving field of vertical stripes (e.g. Dayton, Jones, Aiu, Rawson, Steele and Rose, 1964) can be accounted for by the peripheral but not the foveal regions of the retina responding to the movement. Over the first few months the ability to track a single moving object smoothly develops (e.g. White et al., 1964). Bronson (1974) argues that this development reflects the emergence of the primary visual system as controller of visual behaviour.

This review makes it clear that studies of visual perception particularly in the first few months of life must acknowledge the role of maturation as a possible factor influencing the visual response.

II.B.2. The development of visual acuity

Two main techniques have been used to measure the visual acuity of young children. One is the response of optokinetic nystagmus to a field of moving stripes. Using this method Gorman, Cogan and Gellis (1957, 1959) found that all of 100 newborns under four days of age responded when each of the black and white stripes of the moving field subtended 26 minutes of visual angle. A large proportion of these newborns also responded when each stripe only subtended 20 minutes. Even sharper acuity was reported by Dayton, Jones, Aiu, Rawson, Steele and Rose (1964). Using the same technique as Gorman et al., they found that stripes subtending nine minutes of visual angle elicited a response from newborns. However this is in conflict with Gorman et al's finding that none of their newborns responded when the stripes only subtended 12 minutes of arc.

The use of optokinetic nystagmus for the measurement of visual acuity has been criticised by Fantz, Ordy and Udelf (1962), on the grounds that a response to a moving field may be very different from the ability to perceive a stationary pattern. Fantz et al (1962) used the second main method which is to pair a pattern composed of black and white stripes all of a given width with a homogeneous grey surface of the same overall luminance. If the child shows a preference for

the pattern, he is clearly able to resolve the width of line used. With this method Fantz et al (1962) were able to show that children up to the age of two months could resolve lines subtending 40 minutes of visual angle, children between two and four months preferentially fixated a pattern with stripes as narrow as 20 minutes, and those aged between four and six months could resolve lines of ten minutes of visual angle. This study indicates that considerable improvement occurs in visual acuity over the first six months, and, since the adult is able to perceive lines subtending one minute of visual angle, that visual acuity improves further after the age of six months.

In a more recent study Fantz (1965) compared the effects of different levels of illumination on acuity, and found that with an intermediate level of illumination of 20 foot candles, three month olds could resolve lines which only subtended three and a half minutes of visual angle. Therefore it seems that, with optimal lighting conditions, the young child has extremely good visual acuity.

The conditions under which visual acuity is measured thus appear to influence the outcome quite considerably. This is further illustrated by a comparison of pattern resolution such as used in the preference method, and pattern detection where six dark lines of a given width are drawn on a white field. Fantz (in preparation, b) found that one month olds could detect lines subtending 13 minutes of arc, but could only resolve striations of 25 minutes. By four months, lines of three minutes were detected, but lines had to subtend six minutes in order to be resolved in a striped pattern.

It should be clear from these studies that, although the visual acuity of the young child develops over the first six months and probably beyond, he is able, even during these early months, to resolve fairly narrow lines. This ability is influenced by a number of factors, one of which must be the extent to which the child can focus on a pattern. The evidence for this will now be considered.

II.B.3. The development of accommodation of the lens

The extent to which 22 institutionalised children aged from birth to four months could accommodate to different target distances was measured using dynamic retinoscopy by Haynes, White and Held (1965). It was found that in the

first month there was little or no adjustment, and the median focal distance of a group of nine children was 19 cm., with a range from 12 to about 30 cm. The response started to become more flexible by the middle of the second month, and by the fourth month it was comparable to that of a normal adult.

This study is in contrast to the experiment by Fantz et al (1962) on visual acuity. They reported that there was no difference in the ability of the children to resolve patterns presented at 5, 10 or 20 inches. These distances correspond approximately to $12\frac{3}{4}$, $25\frac{1}{2}$ and 51 cm. However since these distances are at the extremes of the range found by Haynes et al (1965) it is likely that Fantz et al (1962) underestimated the visual acuity of the children as all of the patterns may have been out of focus. This criticism does not just apply to the work of Fantz et al (1962) but to all experiments in which the stimuli are not presented at around 19 cm. This means the majority of the studies carried out before Haynes et al's (1965) report.

Thus the clarity of a pattern as seen by a child up to the age of two months is greatly influenced by the distance at which it is presented. After this age, the presentation distance becomes less important.

II.B.4. The development of differential brightness thresholds

Many patterns, such as those used to investigate the visual perception of young children, could be defined as a configuration composed of a number of light-dark boundaries. It is therefore necessary to find out whether there is any limitation to the child's perception of brightness differences across such boundaries.

Two reports of Doris and his colleagues (Doris and Cooper, 1966; Doris, Casper and Poresky, 1967) found that the minimum contrast between the light and dark stripes of a moving field that would induce optokinetic nystagmus was considerably less for children several months old than for children under one week of age.

This development would lead to the prediction that children less than about two months old could only resolve patterns of high contrast, whereas after this age, patterns of low, subtle contrast could be resolved. This prediction is born out in the literature, with children under two months showing a preference for patterns

of high contrast such as a schematic face, whilst older children prefer more subtle contrasts such as a photograph of a face (e.g. Fantz and Nevis, 1967a, b; Wilcox, 1969; Miranda, 1970a; Fantz, Fagan and Miranda, 1975).

II.B.5. Visual field development

The extent of the visual field can be measured by finding the point at which a target which has been introduced into the periphery of the field is noticed. This method has been used successfully with newborns and young children by first presenting a central target, and while the child fixates this, a second target is introduced into the periphery until it is noticed by the child. Tronick (1972) using brightly coloured blocks found that children from two to six weeks old located a peripheral target if it was within 15 to 20 degrees of the midline. From six to ten weeks of age the children located targets up to 40 degrees in the periphery.

In Tronick's study, the central target remained in position when the peripheral target was introduced. This set-up, termed the competing condition, was compared by Harris and MacFarlane (1974) to a noncompeting condition in which the central target was removed when the peripheral target was introduced. In the competing condition, newborns of less than a week old and children of seven weeks both detected targets presented up to 15 degrees off the midline. This argues for smaller visual fields for seven week olds than found by Tronick. However, Tronick employed larger objects which could have been detected more easily, and the trial length was 15 seconds compared to 5 seconds in the Harris and MacFarlane study. In Harris and MacFarlane's noncompeting condition, the newborns responded up to about 27 degrees, and the seven week olds up to 35 degrees.

The finding that peripheral targets are more likely to be located in a non-competing condition than in a competing condition was confirmed with one and two month olds by Aslin and Salapatek (1975). In addition these authors found that the children were better at locating targets introduced along the horizontal or diagonal axis than along the vertical axis. They also confirmed the observation of Tronick and Clanton (1971) that children, at least in the first few months, locate peripheral targets by a series of equal lengthed saccades rather than by the single saccade typical of adults.

It is quite clear from these studies that although the size of the effective visual field increases with age, the likelihood that a peripheral target will be noticed is influenced by its size and by whether or not it is presented alone. Thus care must be taken, particularly when the paired preference method is used, to ensure that the patterns are within the child's visual field.

II.B.6. The development of binocular fixation

The majority of studies that have examined binocular fixation in newborns have concluded that although the newborn's eyes move in a conjugate manner, they show little evidence of binocular fixation (Ling, 1942; Wickelgren, 1967, 1969). The ability to fixate patterns binocularly was thought by these authors to develop by about the age of eight weeks. In contrast to these reports, Slater and Findlay (1975b) argue that the newborn has the ability to fixate binocularly. In an earlier paper (Slater and Findlay, 1972a) they demonstrated that the centre of the pupil does not represent the line of sight, and that when a pattern is viewed binocularly the two eyes may deviate by as much as 17 degrees in the newborn and by 10 degrees in the adult. Therefore the image of the pattern will be reflected in different positions in the two eyes. This difference has been interpreted previously as a lack of binocular fixation, and presumably the observed improvement is due to some decrease in the deviation of the two eyes.

It was found by Slater and Findlay (1975b) that the eyes of children less than nine days old were more divergent when the distance between them and a vertical array of lights was increased. When the array was presented at 10 or 20 inches from the child, it was fixated binocularly provided that the data was corrected for the expected discrepancies between the pupil centre and the line of sight. When the pattern was presented at five inches it tended to be fixated with one eye only.

In the light of this recent evidence, the conclusions of the earlier papers appear unwarranted. It seems that the newborn is capable of binocular fixation of targets presented between 10 and 20 inches away from his eyes.

II.B.7. The effects of medication and posture on visual behaviour

It has been seen that there are a number of features of the oculomotor system itself which may restrict the young child's perceptual ability. It is of

importance for the experimenter to be aware of these, and also of other factors outside the oculomotor system which may also affect the child's visual behaviour. The importance of other factors is illustrated by the two examples of medication during labour, and the child's posture during testing.

It has been found that the more drugs which are administered to the mother, and the closer this is to the child's birth, the less visually attentive the child will be in the first few days of life (Stechler, 1964). Thus, particularly with newborns, it is necessary to know what drugs have been taken and when.

In the early experiments on visual ability, notably by Fantz (e.g. 1958, 1961a,b, 1963), the child was placed in a supine position and patterns were displayed above his eyes. This posture was selected presumably because the position of the child's head can be maintained more easily when he is lying down than if he is held upright. However there is now evidence that the newborn and young child are more responsive to visual stimulation when they are in an upright position than when they are supine (Prechtl cited in Bower, 1971; Fredrickson and Brown, 1975).

II.B.8. Summary

This section has considered a number of factors which influence the child's visual ability. It is apparent that there are certain aspects of the developing visual system which, if ignored, could lead to false conclusions regarding the young child's perceptual ability. It has been demonstrated that the clarity with which a pattern is perceived by a young child, especially one or two months or less, depends upon the distance at which the pattern is presented, its overall size, and the contrast and size of the different parts of the pattern. Medication to the mother and the posture of the child during testing have also been shown to affect the attentiveness of children in the early weeks.

II.C. Perception of two dimensional patterns

At the end of the first chapter (section II.F.1b), a number of studies were described which investigated the visual abilities of young children by means of the visual preference method. These studies were carried out by Fantz and his colleagues (Miranda and Fantz, 1973, 1974; Fantz, Fagan and Miranda, 1975) and if these are compared to some of Fantz's early work (Fantz, 1958, 1961a, 1963) an idea of the increased sophistication of the approach over the intervening years may be obtained.

This sophistication has come about in several ways. In the pioneer work it was often difficult, if not impossible, to identify the basis of the child's preference, because the patterns varied in many ways. Experimenters are now aware that conclusions are unwarranted unless first, the patterns differ systematically from one another, and second, that different aspects of the patterns are not confounded. This increasing awareness is well illustrated by considering some of the vast number of studies which have investigated the effect of contour.

II.C.1. Contour as the determinant of visual fixation

One of the early demonstrations of a visual preference was by Stirnimann (1944) who found that newborns attended more to a pattern of two colours than to either colour alone. This effect was most marked when the two colours contrasted in brightness, which suggests that a contoured pattern is more attractive than a plain coloured card. This preference for patterns over plain colours was confirmed by Fantz with newborns of less than six days old (Fantz, 1963) and with children up to the age of six months (Fantz, 1961a). In both of these studies the children preferred black and white patterns of a schematic face, concentric circles or a section of news print to unpatterned cards coloured white, red or yellow. In an earlier study Fantz (1958) found that at all ages from 1 to 15 weeks children preferred a red and white checkerboard to a plain red card. This preference for patterns has even been employed as a method for testing acuity (Fantz, Ordy and Udelf, 1962).

In recent years two aspects of the contour of a pattern have received considerable attention in the study of visual perception. The first is the amount of contour contained within a pattern, and the second is the form of the contours

of the pattern. The first aspect essentially ignores the shape of the pattern, whereas the second aspect is very much related to the shape.

However, before considering these aspects it seems reasonable to ask how the young child responds to contour and if there are any limitations to this response. Preference studies cannot provide an answer to this question because they give no information as to what aspects of a pattern the child fixates. However there are techniques available which can provide these details and these are discussed in the next section.

a) The attraction of contour evidenced by children's scanning of patterns

It is possible to calculate where on a pattern a child is looking at any given time by photographing his eye or eyes as he looks at the pattern. The technique employs either infra-red television recording (Haith, 1969) or infra-red cine film (Salapatek and Kessen, 1966). Several infra-red reference lights are reflected off the child's cornea and these can be seen on the film. From the relationship between these lights and the pattern it is possible to plot the child's successive fixation points as he views the pattern. This method has, until recently, assumed that the centre of the pupil indicates the person's line of sight. However, this assumption has been found to lead to systematic discrepancies between the derived fixation position and the point actually fixated (Salapatek, Haith, Maurer and Kessen, 1972; Slater and Findlay, 1972a,b, 1975a). In order to overcome this discrepancy it is necessary to calibrate the recorded position of the eyes by getting the person to look towards a number of small discrete points in the area that the pattern will occupy. It is possible to do this with young children by using a number of small light sources.

The majority of the reports to be mentioned in this section have not performed the calibrations outlined above. However, this does not totally invalidate the data, but means that the estimated fixation positions should be displaced relative to the pattern.

The studies on eye movements have shown that children under one week of age do concentrate their fixations on a pattern when one is introduced into their field of vision (Salapatek and Kessen, 1966; Salapatek, 1968; Nelson and Kessen, 1969). When no pattern was presented these children scanned all over the homogenous

field, but with more horizontal than vertical scans. This preponderance of horizontal scans has been used to explain the finding that newborns will orient their eyes towards a vertical edge but not to a horizontal edge (Kessen, Salapatek and Haith, 1972). The explanation is that a vertical but not a horizontal edge will be crossed by the horizontal scans with the result that only the vertical edge is noticed.

With simple geometric patterns such as triangles, it is generally found that newborns' fixations are concentrated on a limited portion of the pattern. On the other hand, Salapatek and Kessen (1973) report that when newborns are presented repeatedly with a geometric triangle for a number of days, although some of them consistently exhibited single feature selection, others were capable of both single and extensive feature scanning. There appeared to be no effect of either age or experience on the extent that the figure was scanned.

However, there is evidence that by two months of age the child scans figures more extensively than has been found for the majority of younger children. Salapatek and Miller (unpublished) found that two month olds scanned outline figures more extensively than one month olds. In addition to this, it has also been shown that two month olds will preferentially inspect the internal features of compound figures such as squares within squares (Salapatek and Maurer, unpublished; Salapatek and Moscovich, unpublished), photographs of faces (Donnee, 1973) and real faces (Bergman, Haith and Mann, 1971; Maurer and Salapatek, 1975). On the other hand, one month olds scan parts of the external contour of compound figures and ignore the internal features. In support of this Salapatek (1975) reports a personal communication from Milewski who habituated sucking in one and four month old children by repeated presentation of a compound figure. Dishabituation occurred in the four month olds, but not in the one month olds when the internal features were altered. However all of the children dishabituated when either the external features or both the internal and external features were changed.

Using a simpler technique Harris (1973) has also examined the extent of young children's examination of patterns. He was not concerned with how a single pattern was scanned, but with how children looked at two patterns that were presented simultaneously. He identified two types of fixations which he termed repetitions and alternations. Repetitions were repeated fixations of the same

pattern, and alternations were changes of fixation from one pattern to the other. When the two patterns were identical the two groups of children who had mean ages of 12 and 26 weeks did not differ with respect to these measures. However, when the two patterns differed in form and colour, the older children made more alternations than the younger children, but there was no age difference for the repetitions. This is in line with the view that with increasing age children scan single patterns more extensively and compare different features of their visual environment more frequently.

In contrast to this study, Ruff (1975) reports that children aged from 9 to 20 weeks, especially the older ones, made more alternations or shifts of fixation between two patterns the greater the similarity between them. She argues that the more similar the two patterns, the harder it is to find differences and as a consequence of this more comparisons are required. In one of her studies supporting this view she presented children with a black and white segmented bull's eye pattern and a pattern of two columns of horizontal black and white stripes. The patterns were of either the same overall size, moderately different in size or very different in size. The most shifts of fixation occurred between patterns of the same size.

There are three main differences between this study and Harris'. First, Ruff (1975) analysed the number of shifts per second calculated by dividing the number of shifts by the length of fixation, whereas Harris (1973) analysed the number of shifts. Ruff argues that the number of shifts are dependent upon the length of fixation but that this relationship is removed by calculating the number of shifts per second. Harris did not find that more looking occurred when the patterns were different rather than identical although there was a tendency in this direction. It is possible that this tendency of which Harris did not take account, might be the source of the difference between the results of these two studies.

The second difference is in the patterns that were used in the two studies. When Harris' patterns were similar they were identical, and were two white cards each with either a black circle or a red cross positioned at the centre. In the different condition a black circle was presented with a red cross. In one of Ruff's (1975) experiments identical patterns were presented in the most similar condition and they were both black and white and either segmented bull's eyes, or

segmented concentric squares or columns of horizontal stripes. It seems likely that more comparisons would be necessary to confirm that two of these patterns were identical than to confirm the similarity of Harris' identical patterns.

A final difference between these two studies is in the time that the patterns were presented for. In Harris' study different children were presented with either two identical patterns or two contrasting patterns for one trial lasting five minutes. In Ruff's experiment, each child performed every condition and each trial lasted 18 seconds. It is possible that the pattern of fixations to two patterns may alter over a long exposure. Therefore the number of shifts which occurred in the first 18 seconds of Harris' trials should be compared to Ruff's results. It is clear that more research is necessary to elucidate the differences between these two studies.

There is however ample evidence that young children, even shortly after birth, will orient their eyes towards a contour, although it appears that their scanning of a pattern does not become extensive until about the age of two months and that of two patterns until after the age of three months. We are now in a position to consider whether the amount of contour in a pattern, or the form of the contour are useful explanations of visual behaviour.

b) Amount of contour

The main proponents of the view that the amount of contour is the primary determinant of visual preferences in young children have been Karmel and his colleagues (Karmel, 1969a,b, 1974; Karmel, Hoffman and Fegy, 1974; Karmel and Maisel, 1975). They argue that the amount of time that a pattern is looked at is a function of the density of the contour within the pattern. The density of the contour refers to the concentration of the contour with the pattern, and therefore takes into account not only the amount of contour but also the area that it occupies. Karmel (1969a,b) proposes that preferences are described best by an inverted U-shaped function of the square root of the amount of contour and that this function shifts towards higher contour densities with increasing chronological age. He argued that a square root transformation of the amount of contour in a pattern reflects the contour density, since contour length increases exponentially with linear change in the visual angle subtended by the pattern containing the contour.

The evidence for this view is that the visual preferences and the maximum amplitude of part of visually evoked potentials shown by children aged between 8 and 20 weeks for random and redundant arrangements of checks of different sizes are predicted by contour density rather than by adults' ratings of their complexity. Also with increasing age the maximum response shifts towards increases in contour density (Karmel, 1969a,b; Karmel et al. 1974).

This emphasis on contour length was supported by McCall and Kagan (1967a) who presented four month olds with a series of nine random straight-edged shapes. These varied in the number of turns and the mean contour length of the sides. When fixation time was measured an interaction between these two variables was observed, but in fact the data were related most simply to an inverted U-shaped function of the total contour length of the shapes. However, the conclusions that can be drawn from this study are limited by the fact that the nine shapes differed from one another in many ways.

In a much improved study, McCall and Melson (1970) varied the contour length and area separately in four patterns each composed of nine regularly arranged outline squares. It was found that the length of the first fixation made by five month olds on each trial was effected by contour length but not by area, whereas both affected the magnitude of heart rate deceleration.

Karmel (1974) attempted to show that the data of Greenberg and O'Donnell (1972), who concluded that 11 week olds preferred more complex patterns than 6 week olds, could also be accounted for in terms of contour density. He equated the patterns used by Greenberg and O'Donnell (1972) for contour so that the sizes of the elements within the patterns and the outer borders of the patterns were equivalent to those used in other studies, and found that 82 per cent of the variance for the 11 week olds' preferences were accounted for by the square root of the contour length. The corresponding percentage for the six week olds was 48 per cent, suggesting that variables other than contour were directing their preferences.

This adjustment of Greenberg and O'Donnell's (1972) data by Karmel (1974) was criticised by Fantz and Fagan (1975) on the grounds that the response levels that were plotted against the corrected contour density values did not correspond to the actual responses that were obtained in the original experiment. In fact,

when the actual responses are plotted against the adjusted contour densities the graphs are barely different from those produced by Greenberg and O'Donnell (1972).

A final criticism of the view that contour density is the main determinant of early visual preferences was raised by Greenberg and Blue (1975). They pointed out that in all of the studies that appear to support this view, the contour density of the pattern has been confounded with the number of elements within the pattern. To test the importance of contour density and number of elements, Greenberg and Blue (1975) designed a series of patterns composed of black dots on a white ground, in which number and contour were varied systematically. When both number and contour varied together, four month olds preferred patterns with more contour and more elements than two month olds. However, when the contour length was varied and the number of dots kept constant and vice versa, there was no evidence for an increasing preference for more contour or number with increasing age.

It is therefore necessary to reject the view that contour density alone can account for early visual preferences. But even if contour density is only one of a number of pattern features which act together in some as yet unclear manner to direct visual attention, this does not rule out the possibility that some other aspect of the contours of a pattern may be of importance. The next section considers the form of the contour.

c) Form of contour

The role of the form of the contours of a pattern in guiding the visual behaviour of young children has received much attention recently, although as early as 1958 Fantz found that up to the age of eight weeks children preferred a pattern of horizontal stripes to a bull's eye. After this age the preference was for the bull's eye. This reversal in the preference for curved and linear contours at around two months has been confirmed since Fantz's early observation, provided that the difference is in the internal contours and not the external contours (Spears, 1964; Fantz and Nevis, 1967a,b; Fantz, 1970, in preparation a;. Ruff and Birch, 1974; Fantz, Fagan and Miranda, 1975).

When the external contours of two patterns also differ in terms of linear and curved contours, children under the age of two months show a preference for the pattern with curved contours, provided that the patterns are not different with

respect to the number of elements and angles within the pattern (Fantz and Miranda, 1975). This finding that until the age of two months patterns with curved contours will be preferred to those with linear contours only if the difference is in the external contours is not surprising, since children of this age tend to scan external contours and ignore the internal contours (section II.C.1a).

The majority of studies in which children have shown a preference for curved over straight contours have used patterns which also vary from one another with respect to other dimensions. These include concentricity, overall configuration, number of elements and angles, contour length, area of light and dark, and orientation of the elements. Two studies (Ruff and Birch, 1974; Fantz, in preparation a) have attempted to isolate the crucial differences which direct this particular preference. Both of these studies provide evidence that although the actual form of the elements is important, the concentricity of the overall pattern cannot be ignored.

Difference in pattern configuration has been suggested by Fantz, Fagan and Miranda (1975) to explain why Hershenson, Munsinger and Kessen (1965) found that newborns preferred patterns with an intermediate number of turns over other patterns with either more or less turns. In support of this finding that newborns do not prefer the least complex pattern, when complexity is defined by the number of turns, Munsinger and Weir (1967) found a preference for increasing levels of complexity, again defined by the number of turns, which was independent of the child's age. In this experiment the patterns had 5, 10, 20 or 40 turns and all possible paired comparisons were presented to the children who were aged from 9 to 41 months.

That the overall configuration of a pattern is possibly as important as the form of the elements themselves is supported by the evidence of preferences for different arrangements and orientations of elements within a pattern (e.g. Fantz, 1965, 1970, in preparation a; Fantz and Nevis, 1967a,b; Fantz, Fagan and Miranda, 1975). It is however difficult to generalise about the attentional value of regular and irregular arrangements of elements since this variable is often confounded with others. The failure in several studies to find preferences for irregular over regular arrangements (Karmel, 1969b; Moffett, 1969; McCall and

Melson, 1970) can be accounted for most likely by an interaction between element arrangement and other factors including the child's age.

Thus once again the conclusion must be that although this particular aspect of a pattern, the form of the contour, is perceived, it cannot alone account for the visual behaviour of young children. It is necessary to acknowledge the role of other pattern attributes in order to give an adequate explanation of the results.

The evidence reviewed in this section indicates that children do respond to contours, but that neither the amount nor the form of contour alone can describe with accuracy the visual preference behaviour of children. The next section considers the outcomes of studies using checkerboard patterns.

II.C.2. Evidence from checkerboard patterns

The number of checks contained in a checkerboard pattern has often been taken as a measure of complexity, with increasing numbers, and therefore decreasing check size, reflecting increasing complexity. In line with this, it has been found that older children prefer more complex checkerboards than younger children (Berlyne, 1958; Hershenson, 1964; Brennan, Ames and Moore, 1966; Harter and Suitt, 1970; Greenberg, 1971; Greenberg and Weizman, 1971; Greenberg and O'Donnell, 1972; Brown, 1974), and that children habituate more slowly to checkerboard patterns of the preferred complexity level compared to other checkerboard patterns (Caron and Caron, 1968, 1969; Caron, Caron and Caldwell, 1971). On the other hand, some studies have failed to find this preference for increasing complexity with age (Horowitz, 1969; Horowitz, Paden, Bhana, Aitchson and Self, 1972; Horowitz, Paden, Bhana and Self, 1972). These negative results may be explained by the finding of a relationship between the habituation rate of 11 week olds and their preferred complexity level (Greenberg, O'Donnell and Crawford, 1973). In this study children who habituated rapidly to a pattern of black dots preferred a more complex checkerboard pattern than either slow or erratic habituators. It is possible that the children in the studies by Horowitz and her colleagues would have been different in terms of habituation rate from those in the studies who found an interaction between age and preferred complexity level. However, as these studies did not investigate habituation rate this explanation cannot be verified.

The results of the studies which reported that older children preferred more complex patterns than younger children have been questioned on different grounds. This is that when the number of checks in a checkerboard pattern is increased, the size of the checks decreases (Miranda and Fantz, 1971; Fantz and Fagan, 1975; Fantz, Fagan and Miranda, 1975). If these two features of size and number are varied independently by using patterns made up of black squares on a white ground, it is found that the check size is the main factor controlling preference in the first few months, after which the number of checks becomes more important.

Size was also shown to be an important determinant of the preferences of six and nine week olds by Ruff and Turkewitz (1975). Children aged 6, 9, 14, 20 and 25 weeks were presented with a pair of patterns. One was a black and white segmented bull's eye and the other consisted of two columns of black and white horizontal stripes. The overall sizes of the patterns varied. The preferences of the six and nine week olds were influenced by the size, with the larger pattern most preferred. On the other hand, the older children preferred the bull's eye pattern irrespective of the size of the two patterns. Ruff and Turkewitz (1975) suggest that size may initially be important because at this age visual behaviour is possibly under the control of the second visual system (Bronson, 1974; section II.B.1). This is characterized by peripheral vision and therefore large patterns may be preferred because they fall on the peripheral regions of the retina, whereas small patterns do not.

The importance of unconfounding the size and number of checks in a pattern has also been made clear in the work of Cohen (Cohen, 1969, 1972; Cohen, De Loache and Rissman, 1975). Cohen and his colleagues propose that visual fixation which occurs in habituation confounds two separate processes. One is attention getting measured by the time to orient towards a pattern. The other is attention holding which is the length of the fixation once the person has oriented to the pattern. In the experiments the attention getting process seemed to reflect the size of the pattern, whilst the attention holding process best reflected the number of checks in the pattern.

The problem of attempting to isolate the crucial factor or factors on which

young children base their preferences is not just confined to those studies which have employed checkerboard patterns. This problem is particularly apparent in investigations which have examined whether young children exhibit any preference for faces or face-like patterns. Some of these studies are considered in the next section.

II.C.3. Evidence for the perception of faces

In 1963, Fantz reported that out of 18 children less than six days old, 11 looked longest at a black and white schematic face, 5 looked longest at a black and white bull's eye, and 2 looked longest at a section of newsprint. No child looked longest at any of three plain coloured cards. This result essentially replicated earlier findings with two to six month olds (Fantz, 1961a). In this study Fantz (1961a) also reported that 49 children aged from four days to six months showed a slight but consistent preference for a black and pink schematic face over the same face in which the features were scrambled. Both of these patterns were preferred to an outline of the face containing the same area of black and pink but concentrated into separate halves of the ovoid.

It is difficult to draw any conclusions from these results since the patterns differed from one another in many ways. However this research marked the beginning of a more careful examination of the extent to which facial characteristics are perceived.

There have been two main lines of research. The first is whether the arrangement of the facial features is important. The majority of these studies have compared preferences for schematic and scrambled faces. The second concerns the importance of particular facial characteristics. These studies have tended to distort or remove particular features of the face to see if the change is noticed.

Since Fantz's pioneer work there has been confirmation that faces, whether photographs or schematic drawings, are preferred to non-face patterns. This was found by Stechler (1964) with newborns, by McCall and Kagan (1967a) with four month olds, and by Lewis, Kagan and Kalafat (1966) with 24 week old girls but not with boys of the same age. In these studies the face-like patterns contain

much more detail than the other patterns, and this alone could account for the preference. Somewhat more illuminating are those studies which have examined preferences amongst regular schematic faces and scrambled faces. Thomas (1965) pointed out that a face in which all the features are scrambled may be more complex than the regular face because the features are no longer symmetrical. As an outcome of this some studies have included a symmetrical scrambled face.

No preference has been found between regular faces and scrambled faces, whether symmetrical or not, for newborns (Fantz, 1965), at 4, 10 and 16 weeks (Wilcox, 1969), at 10 to 11 weeks (Koopman and Ames, 1968), at three to four months (Fantz and Nevis, 1967b), and at four and a half months by premature children (Sigman and Parmelee, 1974).

On the other hand, although Kagan, Henker, Hen-Tov, Levine and Lewis (1966) found no visual preference at four months for a three dimensional regular face over a three dimensional scrambled face, the regular face received more smiles.

There are a number of studies in support of a preference for regular faces over scrambled faces emerging at around four months of age, although Fantz (1966) reports that this preference occurs first at about two to three months. Sigman and Parmelee (1974) found that 19 week old full term children tended to look longer at a regular face than at a scrambled face. The same pattern was found for four month olds by McCall and Kagan (1967a) and at four and a half months by Fantz and Nevis (1967b). Haaf (1974) showed that five and ten week olds, although they looked most at a schematic face, their preferences for other patterns which resembled faces to varying degrees were not ordered according to a preference for faces. By four months, Haaf and Bell (1967) found that the preferences were ordered in terms of the resemblance of each pattern to a face, with the most face-like pattern being the most preferred.

In line with these results Jones-Molfese (1975) presented 43 children aged from 3 to 15 months with photographs of a male face, a regular schematic face and a scrambled face. There were no age differences and 40 out of the 43 children had preference orderings of the three patterns which were transitive. In 67 per cent of these orders the scrambled face was least preferred, and it was never most preferred.

The evidence reviewed so far indicates that schematic faces are preferred to scrambled faces after about the age of four months. But the question still remains as to whether this is due to the development of some facial scheme such as suggested by Lewis (1969) or to some sequence of feature development of facial characteristics as Gibson (1969) suggests, or to some development which is unrelated to the fact that the pattern represents a face.

The effect of the orientation of a face was studied by Watson (1966). He found that 14 week olds smiled more at an upright real face than at an inverted one. On the other hand McGurk (1970) found no visual preference for an upright three dimensional model of a face over an inverted one.

The most interesting aspect of the perception of faces is whether particular facial characteristics are more important than others in indicating that a pattern is a face. Only one study by Caron, Caron, Caldwell and Weiss (1973) has investigated this systematically, although Fantz (1966) reported that after two to three months of age, more children preferred a white ovoid with two correctly positioned eye spots to one with two uncentered eye spots.

In the study by Caron et al (1973), 238 four month olds were habituated to a schematic face which was distorted in one of 16 possible ways. These included various distortions of the eyes, nose and mouth, all the internal features and the hair and outline of the regular schematic face. These four month olds showed dishabituation to a regular schematic face after habituation to most of the distortions except those involving the nose and mouth and one in which the internal features were inverted but the outline and hair remained upright. By five months dishabituation occurred following habituation to these distortions of the nose and mouth and the inversion of the internal features. This suggests that by five months the mouth and nose have become as distinctive as the eyes, and the inner features have become as important as the head outline.

There is therefore evidence that from the age of four months a schematic representation of a face is preferred to a scrambled version of the same face. It has also been found that certain features of the face may have different influence at different ages. From the scanning studies that were reviewed in section II.C.1a, it is clear that up to the age of two months the child's fixation of a face is

confined to the external contours. The possibility that children do not perceive patterns as wholes but only as separate parts is considered in the next section.

II.C.4. Is the pattern responded to as a whole or in terms of its components?

If a child shows a preference for one pattern over another, it has been seen that unless the differences between the patterns are varied systematically, it is difficult to isolate the basis of the preference. It is possible that the child only notices one aspect of the patterns and that his preference is directed by this alone. In this section a number of studies are considered which examine whether children respond to a pattern as a whole or merely to its component parts.

A question that Bower (1967) was concerned with was whether or not one month old children who were conditioned to suck when they were presented with a wire triangle with a rod placed across it, were responding to a complete triangle, or to two halves with unspecified connections. When their sucking rates were stable, they were tested with one of a number of triangles in which the connections between the upper and lower halves varied. The maximum response was elicited by a complete triangle. This suggests that the one month old perceived the original object as a triangle with a bar placed across it. However it is possible that the complete triangle would have elicited more sucking even if the child had not had any prior experience of a triangle with a bar placed across it.

A similar approach has been used by Bower (1966c) to test the law of heterogeneous summation that a whole is equal to the sum of its parts, in comparison to the Gestalt law that the whole is greater than the sum of its parts. Children aged 8, 12, 16 and 20 weeks were conditioned to make a head turn when a pattern consisting of a circle, a cross and two dots was presented. When the response was stable, the generalisation of it to the separate parts was tested. Up to 16 weeks the sum of the responses to the parts did not differ from the number of responses to the whole, but at 20 weeks the whole was responded to more than the sum of the responses to the parts. Bower also tested the converse by conditioning a head turn to the separate parts and comparing the total number of responses elicited by the parts to the number which occurred when the whole was presented. At ten weeks there was no difference between the number of responses to the parts and to the whole, whereas at 20 weeks more responses

occurred to the parts than to the whole. This latter result contradicts the earlier finding and so makes the data inconclusive.

Another approach to the problem of whether or not the child perceives an object as a whole or as its separate components, has been to present a compound pattern for habituation and to examine what changes in the pattern will lead to dishabituation.

Using this method Saayman, Ames and Moffett (1964) found that 12 to 15 week olds only responded more to the novel pattern if it differed in both shape and colour from the familiarized pattern. The result was replicated in four month olds by Cohen, Gelber and Lazar (1971) and Cohen (1973), and indicates that the child attends to both colour and shape and therefore habituates to them both.

The same method was employed by Cornell and Strauss (1973) but they used different shapes rather than shape and colour. Four month olds were habituated separately to two different shapes. Dishabituation did not occur to a compound shape composed of the two habituated shapes, but only to a compound of two different shapes.

There is further evidence that two aspects of the familiar pattern must be altered in order to make it preferred to the familiar pattern. Welch (1974) found that four month olds noticed a change in colour, pattern arrangement and shape provided that at least two of these features were changed.

Another question that has been raised is whether or not the orientation of a pattern is important. McGurk (1970) and McKenzie and Day (1971) found that children aged between one and six months did not show any sign of discriminating different orientations of a striped pattern when the preference method was employed. However, by using familiarization techniques (McGurk, 1970) and conditioning techniques (McKenzie and Day, 1971), it was shown that orientation differences are perceived by children in the first half year of life. In addition to this, McGurk (1972) presents evidence that 6, 9 and 12 month olds, but not 3 month olds, respond to a change in the form of an outline shape at one end of a line, and to a lesser extent to a change in the orientation of the line.

On the basis of McGurk's (1972) work, Cornell (1975) hypothesized that if the child responds to the components of a pattern there may be a hierarchy of dimensions that represents the pattern. A dimension such as orientation might be of low value since this varies, but form, arrangement and colour would be of greater value because they are relatively invariant. An alternative hypothesis offered by Cornell (1975) was that if children are responding to patterns as compounds of dimensions, the study of individual dimensions could result in a misleading impression of the child's perceptions. In an experiment designed to test these two hypotheses, Cornell (1975) found that four to five month olds noticed a change in both element arrangement and pattern orientation whether they were combined together or not, and the preference was for the pattern which was most discrepant relative to the original pattern. This finding that when patterns vary in the amount of discrepancy between them and the original, the magnitude of the response is an increasing function of the degree of discrepancy is in agreement with the results of other studies (McCall and Kagan, 1967b; McCall and Melson, 1969; Miller, 1972; McCall, Hogarty, Hamilton and Vincent, 1973; Salapatek, 1973).

The studies considered in this section indicate that children do not necessarily respond to all aspects of a pattern, and that different aspects may be of different salience to the child. One of the problems with a number of the studies is that they have employed the habituation method to ascertain the child's perceptual ability. It was pointed out earlier in this chapter, in section II.A.1d, that the habituation paradigm not only examines perception but also the ability to remember or recall what has been perceived. Therefore before considering the perception of depth, the next section reviews the evidence concerning the child's ability to remember the features of patterns.

II.C.5. Memory for patterns

The previous sections in this chapter have shown that the young child, even within the first few days of life, is capable of perceiving many of the features which are characteristic of two dimensional patterns. The present section takes this a stage further and considers the child's ability to remember what he has perceived. The relevant studies have concerned themselves with a number of

questions which include the effect of the child's age, the duration of his memory and whether particular patterns are remembered better than others. This section will consider the studies relating to these questions.

a) Memory at different ages

One of the earliest studies was conducted by Fantz (1964) with children aged from 6 to 25 weeks. There were ten successive one minute exposures of two multidimensional patterns, of which one was constant whilst the other was different on each trial. For the children who were over eight weeks old, a preference for the novel pattern gradually emerged over the trials, and this was more marked the older the child. Children of two months or less attended to both patterns equally.

This study indicates that at least after the age of two months the child is able to remember that he has seen one of the two patterns on a previous trial. However the absence of an emerging preference in the younger child does not necessarily mean that he fails to remember the pattern. A second explanation is that he cannot perceive any difference between the patterns. However in view of the evidence reviewed in earlier sections this seems unlikely. A third explanation is that a preference for novel patterns does not develop until after two months of age. Another possible explanation is that the method used by Fantz, involving paired presentation of two patterns of which one did not alter over the trials, was not sensitive to memory capabilities in children aged two months or less.

The third explanation receives some support from Greenberg, Uzgiris and Hunt (1970), Weizmann, Cohen and Pratt (1971) and Wetherford and Cohen (1973). Greenberg et al (1970) found that eight week olds preferred the mobile that they had seen daily for four weeks rather than a novel one, whereas by 10 and 12 weeks the novel one was preferred. Essentially the same was found by Weizmann et al (1971) except that the familiar of two mobiles was preferred at six weeks following two weeks daily exposure to one mobile. The preference for the novel mobile first emerged at eight weeks. Using an habituation paradigm, Wetherford and Cohen (1973) found that when the data was analysed longitudinally, six and eight week olds preferred a familiar pattern, but by 12 weeks the novel one was looked

at longer. When cross-sectional data were analysed, the results were unclear for the six week olds, the eight week olds showed an increasing preference for the familiar pattern, and at ten weeks the novel pattern was preferred.

The failure of Fantz (1964) to find a preference for either the novel or the familiar pattern until after the age of eight weeks may therefore be because he combined the data from six and eight week olds. This may well have obscured the change from a preference for the familiar pattern to a preference for the novel pattern. The more recent results that the familiar pattern is preferred at six weeks is evidence that mobiles and patterns can be remembered at this age when there is no delay (Wetherford and Cohen, 1973) or when there is a twelve hour delay (Weizmann et al, 1971).

The emergence of a novelty preference at two months of age was found by Fagan, Fantz and Miranda (1971) to depend upon the length of gestation. For children born at term the preference occurred first at ten weeks of chronological age, whereas for the premature children it was delayed until 16 weeks. However when the two groups were compared in terms of the age from conception the novelty preference began at about 52 weeks in both groups. This is in contrast to the more recent findings of Sigman and Parmelee (1974). In this study premature and full-term children were tested about 58 weeks after conception, and although a novelty preference was shown by the term children, the premature children looked equally at the familiar and novel checkerboards.

There are several differences between these two studies which may account for this apparent disagreement. First, the premature children in Sigman and Parmelee's (1974) study were more premature with an average gestation length of 33.6 weeks than those in Fagan et al's (1971) study who had an average gestation length of 37.2 weeks. Second, the children in Fagan et al's (1971) study were twins and this is a more parsimonious explanation of their prematurity than some foetal abnormality. On the other hand, since the children in Sigman and Parmelee's (1974) study were singletons, their prematurity may well have been associated with some abnormality. In line with this Sigman (pers. comm.) has found that the absence of a novelty preference in premature children is associated with obstetric complications.

Six weeks has been the earliest age that children have been tested in the studies reported so far in this section. However, Friedman and his colleagues have accumulated a considerable amount of data which indicates that some children of only a few days old habituate to the repeated presentation of a pattern. Provided that the decrement can be shown not to be due to fatigue, this argues for some memory of the pattern. This method differs from that used by Fantz (1964) and the other studies that have been discussed in this section, since only one pattern is presented at a time. Thus these studies provide some support for the fourth explanation that was suggested to account for Fantz's failure to find any evidence for memory in children younger than two months. This was that his procedure might have been insensitive to the memory capabilities of the younger children.

Using this single presentation method females of less than four days old have been found to show more decrement in fixation over eight one minute presentations of a 144 squared black and white checkerboard compared to one of four squares, whereas the converse was true of males (Friedman, Nagy and Carpenter, 1970; Friedman and Carpenter, 1971). In addition, Friedman and Carpenter (1971) found that children over 66 hours old showed greater response decrement compared to others who were less than 48 hours old.

These age and sex differences reported by Friedman and Carpenter (1971) were not replicated by Friedman (1972a). Instead of using a fixed number of trials, Friedman (1972a) presented a checkerboard until the child's fixations on two consecutive one minute trials were at least eight seconds less than his mean fixation on the first two trials. Forty children out of an original sample of 90 reached this criterion, and of these almost three quarters showed response recovery when a new target was introduced. The amount of recovery was related to age, with children over 50 hours showing greater recovery than younger ones. This is similar to the proportion found by Friedman, Carpenter and Nagy (1970) who also found no difference in the effectiveness of 4 and 144 squared checkerboards to produce response recovery. However, Friedman, Bruno and Vietze (1974) found that following habituation to either 4 or 144 squared checkerboards only females showed response recovery when the new pattern was a 16 squared checkerboard, whereas both males and females recovered to a new checkerboard that had either 144 or 4 squares.

The finding that most, but not all, of the children who habituate also show recovery of fixation when a new target is introduced indicates that prior to this recovery their fixation time decreases because they are aware that the same pattern is repeatedly presented. However the results of an experiment by Friedman (1972b) require that this statement is qualified. In this experiment it was found that children less than five days old showed a decrease in visual fixation over ten successive one minute trials even when different non-glossy black and white targets were presented on each trial. Admittedly the decrease was less than if either a 4 or a 144 squared checkerboard was repeatedly presented. However the finding of any decrease does suggest that part of the response decrement to the checkerboards may be due to fatigue or to a general response decrement to patterned targets.

The evidence reviewed in this section indicates that some children are able to remember patterns within the first week of life, and that by six week this is true of the majority. Beyond this age there is much evidence that children can remember what they have seen, although as will become clear in the next section, the occurrence and duration of a memory depends upon what is to be remembered.

b) The duration of memories for different patterns

Due primarily to the detailed studies by Fagan (1970, 1971, 1972, 1973, 1974) much is known about the ability of children in the first half year of life to recognise patterns both immediately and after varying time delays. In many of the experiments, the pattern to be recognised is first familiarized for more than one minute. However Fagan (1974) has shown that five to six month olds will exhibit immediate recognition of certain patterns after considerably shorter familiarization periods. Five seconds was sufficient for recognition of black and white multi-dimensional targets, 20 seconds for targets varying only in the arrangement of a number of black squares, 30 seconds for photographs of faces, whereas even after 40 seconds of familiarization a line drawing of a face was not recognised.

A number of studies have examined the retention of patterns varying in shape and colour. Immediate recognition of such two dimensional patterns has been demonstrated in children from the age of one and a half months (Harris, 1971), three months (Saayman, Ames and Moffett, 1964) and four months (Welch, 1974).

In contrast to these results which all employed a familiarization procedure, Pancratz and Cohen (1970) using the habituation paradigm were able to find immediate recognition for patterns of different shapes and colours only in four month old boys. Girls of the same age failed to habituate and showed no immediate recognition memory. After five minutes delay during which a pattern of a different shape and colour was presented even the boys had forgotten. In support of this forgetting by boys, Miller, Turnure and Cohen (1970) found that boys with an average age of five months failed to recognise a familiar coloured shape after three minutes delay. In contrast to these results, Caron and Caron (1968, 1969) reported that three and a half month old girls habituated faster than boys of the same age to repeated presentations of red and white checkerboards. However, in this study both sexes recognised a familiar pattern after at least a delay of one minute. Using three dimensional patterns varying in shape and colour, Martin (1973, 1975) found that three and a half month old boys and girls looked more on trials when a novel shape was presented than when a coloured three dimensional shape was presented which they had seen for six to nine trials each lasting 30 seconds either several minutes or 24 hours previously.

Turning to black and white patterns, it has been found that if two identical patterns are presented together for two minutes and then one of the patterns is paired with a different pattern and these are presented either immediately or after a delay, children with a mean age of three months show immediate recognition of black and white multidimensional patterns, and there is some indication of retention over 24 hours (Fagan, 1970). By five to six months these multidimensional patterns are remembered over intervals of several minutes (Fagan, 1971), two hours (Fagan, 1970) and 48 hours (Fagan, 1973). Black and white patterns differing only in the spatial arrangement of a number of black squares on a white background have been recognised after no delay by four month olds (Fagan, 1970) and after 48 hours delay by five to six month olds (Fagan, 1973).

In addition to testing the recognition of abstract patterns, Fagan has examined immediate and delayed recognition of various representations of the human face. Four month old singletons exhibited no immediate recognition of upright photographs of faces, although they did recognise an upright photograph from the same photograph inverted (Fagan, 1972). By five to six months of age, twins have

immediate recognition of upright photographs of faces, but not of inverted ones (Fagan, 1972). However, only female singletons of this age show immediate recognition of upright photographs, whilst like the twins, the singletons of both sexes failed to recognise rotated photographs even when there was no delay (Fagan, 1972). These singletons of five to six months old also fail to recognise line drawings of faces when there is no delay (Fagan, 1972).

In contrast to the sex difference found by Fagan (1972), Fagan (1973) found that both male and female singletons aged between five and six months recognised upright photographs of faces after delays up to and including two weeks. Cornell (1974) has extended these findings to other situations. He found that five to five and a half month olds, but not four to four and a half month olds, recognised as novel, both immediately and after a two minute delay, a photograph of a face of a member of the opposite sex from the familiarized face. This was regardless of whether the child was familiarized to the same view of a face, different views of a face or different faces of the same sex.

Fagan has also investigated the early recognition of more face-like patterns, namely three dimensional face masks. Five to six month olds show reliable immediate recognition of face masks provided that they are properly oriented and not inverted (Fagan, 1972), although there is no recognition following a three hour delay (Fagan, 1973).

It seems unlikely that this forgetting over three hours is due to the patterns being three dimensional since Super (1972) reported that four month olds have at least 24 hour retention of solid, coloured, non-social objects. An alternative explanation, that exposure to real faces in the intervening time caused the forgetting, was tested by Fagan (1973). In support of this explanation, it was found that five to six month olds failed to recognise photographs of faces after about a minute delay in which rotated photographs were presented. Properly oriented photographs or inverted line drawings had no effect on retention. This suggests that real faces are of intermediate similarity to three dimensional face masks, and for this reason forgetting occurs. The presenting of rotated photographs was also found to disrupt the recognition of correctly oriented photographs after three hours, provided that they were presented at the beginning rather than at the end of the delay.

Taken together, the studies that have been considered in this section indicate that as the child ages from about two to six months of age, he not only remembers what he has seen, but is also able to remember patterns in greater detail. This latter conclusion is shown by the ability of the youngest children to remember and therefore distinguish patterns varying along several contrasting dimensions, whereas the older child can remember the more subtle features characteristic of a photograph of a face. However, it should not be inferred from this that the availability of a memory is solely a function of the ability to remember. The literature reviewed in earlier sections shows that it must also be dependent upon the ability to perceive.

A number of the studies included in this section have investigated the memory for three dimensional patterns (Greenberg, Uzgiris and Hunt, 1970; Weizmann, Cohen and Pratt, 1971; Fagan, 1972, 1973; Super, 1972; Martin, 1973, 1975). Although this memory does not necessitate memory for depth, this seems a suitable point to ask whether the young child can perceive depth.

II.D. Perception of Depth

Until fairly recently experiments employing the methods of visual preference (Fantz, 1961a,b, 1966, 1967; Fantz and Nevis, 1967b; Jones-Molfese, 1972; Fantz, Fagan and Miranda, 1975), habituation (McKenzie and Day, 1972; Day and McKenzie, 1973), smiling (Polak, Emde and Spitz, 1964a,b), and conditioning (Cruikshank, 1941; Bower, 1964,1965,1966b) which indicated that the young child could respond differently to two and three dimensional forms, were taken as evidence for perception of depth. It is interesting that the studies using preference and smiling showed that there was a changeover at two months, with two dimensional patterns being preferred up to this age, and three dimensional patterns after this age.

The conclusion that these studies provide evidence for perception of depth was questioned by Bower (1966a,b) and more recently by Bower (1970, 1972, 1975), Pick and Pick (1970) and Yonas and Pick (1975). The problem is that the techniques that have been mentioned involve discrimination of two and three dimensional patterns. When such a discrimination is exhibited by a child, it may be

questioned as to whether he is responding on the basis of the difference in depth, or to the difference in the cues which indicate depth. Consider for example, a child who looks at a sphere for longer than a circle of the same diameter. Does he perceive that the sphere, but not the circle, is three dimensional and solid, or that there are pictorial cues and cues of binocular and motion parallax and accommodation changes associated with one pattern but not with the other?

Fortunately there are ways of distinguishing between these two alternatives. One is to use transfer experiments (Bower, 1970; Pick and Pick, 1970; Yonas, 1973). In these a discrimination is established between two patterns which differ in dimensionality on the basis of one or several visual cues. Then, transfer of this discrimination is tested for, using different cues. If the discrimination is transferred it is argued that the child is responding to the difference between the patterns and not merely to the cues that mediate that difference. However this argument is not as strong as it might seem. If the initial discrimination is for the child to respond to a sphere rather than a circle and binocular cues alone are provided, it is quite possible that he could learn to respond to the sphere because it provides more varied stimulation in the form of different input to the two eyes, than the circle. If, in the transfer task, motion parallax cues are provided, the child might show transfer because the sphere again provides more varied stimulation in terms of different views when the head moves. Thus transfer of such a discrimination might simply reflect transfer of a response to the pattern which provided the most stimulation.

An experiment which was based on the idea of transfer, but which was not subject to this criticism, was carried out by Yonas (1973). He habituated young children to a real surface which was either concave or convex. There was uniform lighting so that no part of these surfaces was in shade. Following this habituation he presented each child with two photographs. One was of a disk which was shaded at the top and seen by adults as concave since it is assumed that light comes from above. The other photograph was an inversion of the first, so that the shading was at the bottom and the disk was seen as convex. The children preferentially fixated the photograph of the disk of the opposite apparent curvature from that to which they had habituated.

There are also other ways of examining whether the child is responding to depth per se rather than just to the cues which indicate depth. These involve the use of techniques which measure the appropriateness of the child's behaviour in certain situations. For example, the majority of children of six months and over who will crawl along a board which separates the deep from the shallow side of a visual cliff apparatus, choose the shallow side when the board gets too narrow, even when one eye is covered (Gibson and Walk, 1960; Walk and Gibson, 1961; Walk and Dodge, 1962; Walk, 1966, 1968, 1969). This avoidance of the deep side is associated with the finding that the shallow, but not the deep side, elicits a placing response in children aged between $8\frac{1}{2}$ and 11 months (Walters and Walk, 1974). It has also been shown that children who cannot yet crawl respond differently to the two sides of the visual cliff. In these experiments, when children as young as eight weeks are placed face downwards on the deep side, their heart rate changes more than when they are placed on the shallow side, even when the size of the patterned surfaces are controlled for retinal angle (Campos, Langer and Krowitz, 1970; Campos and Langer, 1971; Schwartz, Campos and Baisel, 1973).

Perception of depth has also been demonstrated by the response to an approaching object. Children from one week of age have been found to react to both real and optical approaches of an object with a complex coordinated movement of their hands and raising of their heads (Bower, Broughton and Moore, 1970a; Ball and Tronick, 1971; Bower, 1971; Yonas, Frankel, Bechtold and Gordon, unpublished study). However heart rate, which usually increases in aversive situations such as impending collision, is found to decrease in two month olds under conditions of optical expansion. On the other hand, six month olds in the same situation respond with a heart rate increase (Hruska and Yonas, 1971). This sort of discrepancy is also found in the visual cliff studies employing heart rate responses, and suggests that the heart rate responses of children less than six months old should not be interpreted in the same way as those for children older than six months.

A number of studies have observed reaching and grasping behaviours as indicators that the young child is able to perceive depth (Cruikshank, 1941; Bower, Broughton and Moore, 1970b,c; Bower, 1971, 1972; Bruner and Koslowski, 1972).

These studies show that children from as early as one week after birth orient their reaching bahaviour towards an object, show different behaviour to objects which are small enough for them to grasp compared to larger objects, and finally become upset when they reach for an object which is a virtual projection of a real three dimensional shape.

From this wide and varied collection of behaviours which indicate that extremely young children are able to perceive depth, it can be argued that the conclusion that this ability is shown by discrimination experiments, is after all valid.

III. TACTILE PERCEPTION AND THE YOUNG NORMAL CHILD

It has been demonstrated in the first part of this chapter that there are many ways in which the visual perceptions of the young child can be investigated. Unfortunately the same is not true for the study of tactile perceptions. It has been seen that the direction of the child's gaze can be utilised to elucidate his visual perceptions, but there is no obvious equivalent system for the testing of the young child's tactile perceptions.

Certain measures, such as the heart rate deceleration which has been found when a newborn is presented with a visual pattern such as a checkerboard (Sameroff, Cashmore and Dykes, 1973), have also been used to examine whether the newborn responds to tactile stimulation. Using this approach, Yang and Douthitt (1974) found that an air puff just sufficient to elicit a motor response from a newborn was accompanied by a heart rate acceleration, whereas there was no heart rate response to a less intense air puff. Similarly, the heart rates of newborns were found to accelerate when the corners of their mouths were touched with a brush, particularly when the right side of the mouth was stimulated (Hammer and Turkewitz, 1974).

These studies of heart rate responses have been mentioned because they indicate that newborns do respond to tactile stimulation. However, they give no indication as to what is perceived by the child. The next two sections attempt to throw some light on the question of what information is apprehended by the child when he touches something. In the first section, literature is presented which

examines how the two modalities of vision and touch affect the young child's visual and tactile inspection of objects. The second section is concerned with whether the young child perceives the tactile and visual versions of an object as equivalent.

III.A. Visual and Tactile Inspection of Objects

In a series of experiments Schaffer and Parry have compared how children aged between five and thirteen months look at and touch three dimensional objects (Schaffer and Parry, 1969, 1972; Parry, 1972, 1973; Schaffer, Greenwood and Parry, 1972). These experiments found that if the same object is presented for a number of trials the total visual fixation time and the length of the first fixation on each trial decrease over the trials. If a new object is presented, there is an increase in visual fixation and this increase is greater the more discrepant the new object is from the previous one. None of these findings is surprising. However, the same pattern of results was not found at all the ages for the main measure that was taken of touch. This was the time that the child took to touch the object for the first time on each trial. Children of less than eight months old touched the object with the same short latency on all of the trials. In contrast to this, older children took much longer to touch the object when it was presented on the first few trials, especially if the object moved towards the child compared to when it was stationary or moved in an arc at a constant distance from the child. Over a number of trials the latency of the older children to manipulate the object decreased. However, these older children showed an increased latency when a new object was introduced, and this increased latency was larger the greater the difference between the novel and the familiar object. Surprisingly, this wariness was greater when the experiment was carried out in an environment familiar to the child compared to one that was unfamiliar.

Thus, prior to the age of eight months novel and familiar objects were found to elicit differential visual behaviour but indiscriminate manipulative behaviour. This was also found when a novel object was paired with one that had been presented alone for two minutes. Children under eight months old fixated the novel object for longer than the familiar one, as did the older children. However, only the older children touched the novel object for longer than the familiar one

(Schaffer and Parry, 1970). In view of the latency difference this last result is rather surprising. If, in accord with the other latency results, the children over eight months old took longer to touch the novel object than the familiar object, it might be expected that they would touch the novel object less and not more than the familiar one. However, in this experiment Schaffer and Parry (1970) do not report latencies and it may be that in a paired presentation these do not reflect the pattern that would be expected from the results where objects are presented singly.

This demonstration by Schaffer and Parry (1970) that it is not until after the age of eight months that children will manipulate novel objects more than familiar ones, was used by Schaffer (1975) to argue against a criticism raised by Rubenstein (1974). Rubenstein found that novel objects were both looked at and manipulated for longer than a familiar object by children who were only six months old. On the basis of these results, she argued that Schaffer and Parry's results were due to their latency measure of manipulation and were not true of manipulation in general. However, she ignored the fact that Schaffer and Parry (1970) did find that the length of manipulation produced similar results to the latency measure. In criticism of Rubenstein's study, Schaffer (1975) points out that she used everyday toys, and more importantly only one toy, a bell, was employed as the familiar object. This failure to randomise which toy was familiar may well account for her results since Schaffer (1971) reports that six month olds will fixate and manipulate for longer the more salient of two objects. If the bell was less salient than the other toys, this would explain Rubenstein's findings.

The finding from Schaffer and Parry's results that there is a change at around the age of eight months in how children visually and tactually explore objects receives some support from Harris (1972). In this study children aged from 6 to $14\frac{1}{2}$ months were familiarized to two objects, only one of which could be touched. Following this familiarization the two objects were presented again, but now both of them could be touched. The children, especially those over nine months old, looked most at the object which they were previously not allowed to touch. Thus it seems that after the age of eight months, not only does visual novelty guide manipulation, but also tactile unfamiliarity may guide visual inspection.

A question which is pertinent to these studies of how children visually and

tactually inspect objects is whether or not there is any transfer of information between these two modalities. The work of Harris (1972) suggests that the two modalities may work in unison in children as young as six months old, since whilst they are looking at an object they tend to touch it more often than would be expected if the two modalities were independent. However this study does not answer the question of transfer of information across modalities. This will be considered in the next section.

III.B. Cross-modal Integration of Information

The question of whether or not children of less than a year old are able to recognise an object as the same when it is presented successively in the two modalities of vision and touch has proved difficult to answer for two reasons. One of the problems is that the ability must be tested in the absence of language since children of this age would not comprehend instructions such as, "show me the object which is the same as the one that you touched".

This particular problem was overcome in a study by Bryant, Jones, Claxton and Perkins (1972). The experiment made use of the observation that children aged from 6 to 12 months are attracted to and will reach for an object which they have heard make a noise. If the majority of children who have held an object which they could not see but which made a noise, subsequently reach for this object when it is presented with another for them to look at, it may be concluded that they recognise the tactile and visual versions of the object as equivalent. Using this procedure Bryant et al (1972) found that children under a year old could select visually which of a pair of three dimensional ellipsoids had emitted a noise whilst they held it. One of these shapes was a complete ellipsoid, and the other had a straight-edge gulley cut out of its top surface. However the children failed to show any evidence of the ability to transfer information from the tactile to the visual modality when a pair of cubes were used, one of which was complete, whilst the other had a gulley.

This failure raises the second problem associated with testing visual-tactile cross-modal recognition in young children. In order to transfer information from one modality to another, the child must be able to discriminate the two objects in each of the two modalities. If he fails the cross-modal task it may be because he

cannot transfer the information or because he cannot discriminate the objects in one or other or both of the modalities. In order to isolate the failure a visual within modal and a tactile within modal task are both necessary (Bryant, 1968).

The visual within modal task is straightforward, and Bryant et al (1972) showed that the children could discriminate visually the members of both the ellipsoid and the cuboid pairs. The problem lies with the tactual within modal task, since this requires that the child selects one of the pair of objects by touch alone. Children of less than a year old will not examine tactually objects that they cannot see. .

From this cross modal study it is clear that children in the first year can discriminate certain shapes both visually and tactually and can transfer the relevant information from the tactile to the visual modality. However with other shapes, although they can visually discriminate them, they fail the cross-modal task and whether this is due to a failure to transfer the information or to a failure to discriminate the shapes tactually is unsettled.

IV. CONCLUSIONS

The literature that has been reviewed in this chapter was selected to build up a picture of how the young normal child examines patterns through the modalities of vision and touch. These were chosen in preparation for studying these abilities in the young mongol child because the conclusion reached at the end of Chapter 1 was that these might be areas of particular deficit.

A number of points can be made. If the perceptual abilities of mongol children are to be studied with respect to normal children, a first necessary step is to discover if mongol children explore their environment and build up representations of what they perceive in a similar way to normal children. The rationale of this is that as normal children get older they scan their immediate environment more extensively in a shorter length of time. If normal and mongol children of the same mental age differ in this respect, this might lead to misjudgement of their perceptual abilities. Experiment I attempted to answer this.

It is clear that normal children are able to perceive three dimensional patterns as real solid objects. This ability is evident at ages when there has

been little opportunity for conscious tactile exploration of objects by the child. However, this is not to deny that touch can affect the way in which such patterns are visually examined, since the data clearly show that touch does have an effect. If the mongol child does have a tactile deficit this might affect how he regards three dimensional patterns, particularly those he can touch. The second experiment in this thesis employed a procedure used to test the tactile-visual transfer of information in normal children, to elucidate whether there is any indication of a tactile deficit in the mongol. The subsequent experiments compared the visual regard of two and three dimensional patterns by normal and mongol children.

Before the experiments are described, the next chapter compares the mongol and normal children who were tested and considers whether the mongol children were a representative sample of the mongol population.

CHAPTER 3

Characteristics of the Experimental Samples

I. INTRODUCTION

There were two groups of children who took part in the experiments to be described in this thesis. One was a group of mongol children whose names were obtained from the Population Genetics Research Unit, Oxford, from Dr. A. Gath of the Park Hospital, Oxford, and from the Area Health Authorities for Oxfordshire and Northamptonshire. Before the parents of these children were approached to ask if they would be willing for their child to take part in some experiments, permission to write to them was obtained from the child's General Practitioner or Paediatrician. The second group consisted of normal children who were contacted through local Child Welfare Clinics.

A total of 50 mongol children were referred and of these 44 took part in the experiments. Eighty-four normal children were contacted and of these 65 were included in the experiments. All of the children, both mongol and normal, were living with their parents, and were tested in their own homes.

Since only 44 mongol children took part in the experiments it was necessary for each mongol to perform in more than one experiment. The next section gives the details of the number of experiments in which each mongol and normal child participated.

The main purpose of this chapter is to consider whether the group of mongol children was a representative sample of the mongol population. To examine this, various aspects of the 44 mongol and 65 normal children who contributed to the experiments are compared to see if the same trends are found as have been reported in the literature for other samples of mongol and normal persons. Three aspects are examined. These are the birth weights of the children, the ages of the parents at the birth of their child, and the birth orders of the children together with the numbers and ages of their siblings.

II. THE ASSIGNMENT OF THE CHILDREN TO EXPERIMENTS

This thesis reports five experiments in which 32, 64, 32, 48 and 32 children respectively took part. Half of these children were mongol and half were normal. In addition to the data collected from these children, those from a number of children had to be discarded for reasons that will be given in the relevant experimental chapters. However, Table 1 gives the numbers of normal and mongol children who took part in, and of those who were discarded from each of the five experiments.

Table 1: The numbers of mongol and normal children whose data were included in or discarded from each experiment

Experiment	Data from Mongol Children			Data from Normal Children		
	Included	Discarded	Total	Included	Discarded	Total
I	16	30	46	16	19	35
II	32	14	46	32	10	42
III	16	20	36	16	12	28
IV	24	6	30	24	6	30
V	16	0	16	16	2	18
Totals	104	70	174	104	49	153

This table shows that data were collected from the mongol children on 174 occasions. The corresponding figure for the normals was 153. These figures are greater than the actual number of children tested because some children were tested more than once. Table 2 gives the number of experiments completed by each mongol and normal child. This table shows that the mongol children tended to take part in more experiments than the normal children. In fact there was a significant X^2 distribution comparing the numbers of mongol and normal children whose data from one or two experiments were included with the numbers whose data contributed to the results of three or more experiments ($X^2 = 5.59$, $df = 1$, $p < .05$).

The reason for this difference was that in some cases a particular test session only involved one experiment and in others more than one. This meant

Table 2: The number of mongol and normal children whose data were included from one or more experiments

a) Data from one experiment

	Experiment					
Group	I	II	III	IV	V	Totals
Mongol	0	7	8	1	1	17
Normal	7	1	16	8	1	33

b) Data from two experiments

	Experiments					
Group	I+II	I+V	II+IV	II+V	III+IV	Totals
Mongol	0	0	3	2	2	7
Normal	1	1	13	10	0	25

c) Data from three experiments

	Experiments					
Group	I+II+IV	I+II+V	II+III+IV	II+III+V	II+IV+V	Totals
Mongol	5	1	1	1	1	9
Normal	3	4	0	0	0	7

d) Data from four experiments

	Experiments			
Group	I+II+III+IV	I+II+IV+V	II+III+IV+V	Totals
Mongol	1	7	1	9
Normal	0	0	0	0

e) Data from all five experiments

	Experiments
Group	I+II+III+IV+V
Mongol	2
Normal	0

that when different experiments were done in different sessions the same mongols could be seen but not the same normals. Experiments I and II were often presented within the same test session together with either experiments III, IV or V. On the other hand, experiments III, IV and V were always presented on different test sessions, and for the children who contributed to more than one of these there was at least six months between experiments. Therefore a mongol who completed experiments III, IV and V would be tested over the course of one year or longer. Each mongol child was matched with a normal child for M.A. Since the mongol's mental development was slower than the normal's, a different normal child had to be matched with the mongol at each of these three test sessions. Table 2 shows that no normal child completed more than one of experiments III, IV and V, whereas 16 mongol children completed at least two of these experiments.

III. BIRTH WEIGHT

III.A. Introduction

Many studies have reported that the mongol has a smaller birth weight than the normal child (Beidleman, 1945; Smith and McKeown, 1955; Hall, 1964; McIntire, Menolascino and Wiley, 1965; Penrose and Smith, 1966). However, when considering the birth weight of a mongol child it is necessary to take into account the length of gestation. This is because a short gestation period is often associated with a low birth weight (e.g. Hockey and Hawks, 1967) and for mongol children the duration of gestation has been reported as shorter than for normal children (Beidleman, 1945; Øster, 1953; Smith and McKeown, 1955; Gustavson, 1964; Penrose and Smith, 1966; Benda, 1969; Lyle, Woodruff and Zuccaro, 1972).

It was reported by Southwick (1939) that the mean birth weight of 108 mongols was 7.08 lbs. which was only slightly below normal. Beidleman (1945) found that 25 per cent of a large group of mongols weighed less than 5.69 lbs. at birth and McIntire, Menolascino and Wiley (1965) reported a median birth weight of 6.62 lbs. for 86 mongols. A difference of almost one pound was found between the mean birth weights of mongol and normal children by Penrose and Smith (1966). The mean birth weights were 6.39 lbs. and 7.24 lbs. respectively. These authors

also reported that the mean gestation length for the mongols was 269.8 days compared to 281.6 days for the normals.

In this last study the possibility that the prematurity of the mongols accounted for their low birth weight cannot be ruled out. On the other hand, there are several reports which indicate that prematurity alone is not sufficient. One such study was by Smith and McKeown (1955). They reported that the mean birth weight and gestation length for 103 mongols were 6.38 lbs. and 268.9 days respectively. For 4,931 controls the corresponding figures were 7.10 lbs and 278.4 days respectively. These means are extremely similar to those reported by Penrose and Smith (1966). In addition Smith and McKeown (1955) examined the birth weights of mongol and control children who had similar gestation lengths. It was found that with short gestations of 30 to 36 weeks, the controls tended to be lighter than the mongols, whereas with 38 weeks of gestation the mongols were consistently lighter than the controls.

In contrast to this report Hall (1964) found that when 51 mongols were matched for gestational age with 185 controls, the mongols had smaller birth weights provided the gestation length was less than 40 weeks. Beyond this point no difference was found between the birth weights of the full term mongol and control children. The observation that premature mongols tend to be smaller at birth in terms of weight than controls is borne out in a study by Hockey and Hawks (1967). Out of a sample of 1,514 mentally retarded children, 29 per cent of the children who were under 6.5 lbs. and had gestation lengths of 36 weeks or more were diagnosed as mongols, and these formed 33 per cent of the 272 mongol children. The corresponding figure for a control population of 1,000 normal children was 15.9 per cent.

A final observation, made by Schutt (1965) was that the low birth weight of the mongol could not be explained by the prevalence of associated congenital defects since these were distributed evenly throughout the birth weight range of 52 mongols.

It appears therefore that the low birth weight which is common in the mongol cannot be accounted for by either the characteristic short gestation length or any accompanying congenital abnormalities.

III.B. The Sample

To examine whether the birth weights of the sample of mongol children were representative of the mongol population, the mothers of the 44 mongol and 65 normal children were asked for the birth weights of their children. At the same time the mothers were asked whether their child had been born on time, or how early or late the birth had been. From their reply the child's gestation length was estimated. However, these may not be accurate since some of the mothers were asked when the child was over one year old, and may not have remembered correctly.

Table 3 gives the means, standard deviations (abbreviated to S.D.) and ranges of the birth weights and gestation lengths for the mongol and normal children.

Table 3: Birth weights (in lbs.) and gestation lengths (in weeks) for the mongol and normal children

Group	Number	Birth weight (in lbs.)			Gestation length (in weeks)		
		Mean	S.D.	Range	Mean	S.D.	Range
Mongol	44	6.30	1.21	2.87 - 8.87	38.84	2.01	32.00 - 42.00
Normal	65	7.26	1.13	4.44 - 9.87	39.43	1.95	32.00 - 43.00

From this table it can be seen that the mongols tend to be almost one pound (lb.) lighter at birth than the normal children. The difference between the means was examined using a significance test for large samples based on the normal distribution (Bailey, 1959, p.35). This confirmed that the mongols had smaller birth weights ($d = 4.137$, $p < .001$, two-tailed). The difference between the mean gestation lengths of the two groups failed to reach significance ($d = 1.515$, n.s., two-tailed) indicating that the mongols did not have shorter gestation periods than the normals.

Although the gestation lengths of the two groups were not significantly different, it is still possible either that the smaller birth weights of the mongols were due to their tendency towards shorter gestation periods, or that the larger birth weights of the normals were due to their tendency towards longer gestation periods.

In order to test this possibility regression analyses were performed (Bailey, 1959, p.95). These showed that the mongols had smaller birth weights than the normals when the gestation length was fixed ($d = 3.628$, $p < .001$). When the birth weight was held constant, the groups did not differ in terms of gestation length ($d = 0.346$, n.s.). Therefore the mongol children had smaller birth weights than the normal children and these were independent of the length of gestation.

The small sample of mongol children used in this study have been shown to be representative of the mongol population in terms of their birth weights being smaller than those of the normal children. This difference was not due to a difference in the length of gestation of the two groups.

IV. THE AGE OF THE PARENTS

IV.A. Introduction

As early as 1909 Shuttleworth remarked that one of the factors often associated with the birth of a mongol child was the advanced age of the mother, although over 30 years before this Mitchell noted this association (Fraser and Mitchell, 1876). Shuttleworth (1909) observed that 41 out of 120 mothers of mongol children (34 per cent) were over 40 years old when the child was born and that only 14 of the mothers (11.6 per cent) were under 30 years. This is in contrast to the figures for the general population where less than five per cent of children are born to mothers over the age of 40 years, and more than 60 per cent are born to mothers who are under 30 years old (e.g. Penrose, 1967; Moric-Petrovic and Kalicanin, 1968; Collmann and Stoller, 1969).

The relationship between maternal age and mongolism has been confirmed in many subsequent studies. For example Brousseau and Brainerd (1928) reported that 38 per cent of mothers of 584 mongol children were over 40 years when the child was born, and Benda (1947) found that 25 per cent of 255 mothers of mongol children gave birth at ages over 40 compared to only three per cent of mothers of other categories of mentally retarded children. Penrose and Smith (1966) summarized the findings from 13 studies of the number of mongol births to mothers of different ages in 11 countries. Taking all of the studies together, 27 per cent

of 9,441 mongols were born to mothers under 30 years and 27 per cent to mothers over 40 years. In a control population the corresponding percentages were 62 and 4 respectively. More recently Carr (1975) reported that 19 per cent of mothers of 54 mongols were under 30 years and 42 per cent were over 40 years compared to over 60 per cent and 1 per cent of the mothers of the control children respectively.

This increase in the maternal age at which mongol children are born is also reflected in the mean ages at which mothers give birth to mongol and normal children. The mean maternal ages when a mongol and normal child are born have been reported as 37.25 and 31.25 years (Penrose, 1933b), 35.1 and 28.7 years (Øster, 1956), 33.7 and 27.9 years (Collmann and Stoller, 1962), 34.43 and 28.17 years (Penrose and Smith, 1966), 30.15 and 25.71 years (Moric-Petrovic and Kalicanin, 1968) and 36.6 and 28.1 years respectively (Carr, 1975).

There is therefore complete agreement that older mothers are more likely to give birth to a mongol child than are younger mothers. However, as Brousseau and Brainerd (1928) pointed out the advanced age of the mother is not a necessary factor since some mongols are born to young mothers. This is reflected in the observation made in a number of studies that there tend to be two peaks in the maternal age distribution curve for mongol births. These occur between 25 to 29 years and 35 to 44 years; in the maternal age distribution for normal births there is a single peak between 25 to 29 years (e.g. Penrose, 1954, 1961, 1967; Collmann and Stoller, 1962; McIntire, Menolascino and Wiley, 1965).

It was suggested as early as 1933 by Jenkins that the factor(s) which resulted in a mongol child being born to a young mother might be different from those involved when the mother was older. In line with this Penrose (1961) has distinguished two classes of mongols termed A and B. Class A includes those mongols whose births are independent of maternal age. For this class the maternal age distribution approximates that for the general population. On the other hand, the class B mongols are influenced by the mother's age and these contribute almost entirely to the second peak in the maternal age distribution curve. Penrose (1961) estimated that 22 per cent of 1,038 mongols were class A type mongols, and the remaining 78 per cent were class B. However estimates based on a larger sample

of 9,441 mongols by Penrose and Smith (1966) revealed that almost 40 per cent of these mongols could belong to class A.

If there is a group of mongols whose births are unrelated to their mothers' age, the problem arises as to whether there is any factor which can account for their occurrence. It was proposed by Penrose and Smith (1966) that this group would include all the hereditary cases such as mongols born to mothers who themselves are mongols, or to phenotypically normal mothers who have a very small proportion of trisomy cells. Another possibility is if one parent who is phenotypically normal but in whom two of the relevant chromosomes have fused, passes on this translocation to a proportion of the offspring who will be mongol. It was also suggested by Penrose and Smith (1966) that one or other of the parents of a class A mongol might carry a gene which disturbs the processes of cell division. Finally they suggested that certain, as yet unidentified, environmental factors might be involved in the incidence of these mongols.

The suggestion that the class A mongols includes those cases in which there is some heritable aspect is supported by the evidence that the maternal age of familial mongols, who are mongols with a mongol relative, is lower than that of non familial mongols (Penrose, 1951, 1954). It should be noted that this finding was not reflected in the study of Richards, Stewart, Sylvester and Jasiewicz (1965) which included 13 familial mongols. However, Richards and his colleagues (Richards, 1967, 1968, 1974; Richards, Stewart, Sylvester and Jasiewicz, 1965) have reported that mongols with the rarer chromosomal aberrations of translocation and to a lesser extent mosaicism tend to be born to younger mothers. It was also reported by Richards (1974) that the mean maternal age at which 15 mosaic mongols gave birth to mongol children was 31.3 years compared to 34.67 years for 15 mongols born to parents with normal karyotypes.

An additional proposition by Penrose (1964) was that the young mothers of mongols whose births were unrelated to maternal age might themselves be partially trisomic, and that this possibility might be increased by a high grandmaternal age. The only data in accord with this hypothesis was reported by Greenberg (1963) who studied all of the mongol children born in Essex between 1953 and 1957. He found that mothers who were less than 35 years old at the time of their child's birth were more likely to produce a mongol if their own mothers had been over 35 years

old when they themselves were born. However Greenberg's data was incomplete and more recent studies (Forssman and Åkesson, 1967; Stoller and Collmann, 1969; Richards, 1974) have failed to find any relationship between old grandmothers, young mothers and mongol births.

If there are two classes of mongol children, one related to maternal age and the second unrelated to maternal age, it follows that the relative proportions of these two groups would be effected by a shift in childbirth towards older or younger mothers. For example, if the shift were towards younger mothers then the proportion of class A mongols should increase and the number of class B mongols should correspondingly decrease. Richards (1967) estimated the proportionate distribution of births at different maternal ages at four yearly intervals from 1940 to 1964. On the basis of this he reached the conclusion that in 1964 the proportion of those mongols whose births were independent of maternal age was increasing. This was attributable to the trend over the intervening years towards more births to younger mothers. The mean maternal age for the general population was reported by Richards (1967) to be 26.7 years in 1964 compared to 28.5 years in 1940.

A similar trend has been reported by Collmann and Stoller (1969) in Australia. Also Moric-Petrovic and Kalicanin (1968) explained their discovery of a higher proportion of mongols born to younger mothers in Serbia than found by Penrose (1951) in England, by noting that the mean maternal age for the general population was lower in Serbia than in England.

It is quite clear from the evidence reviewed so far that the age of the mother is of some importance in determining the likelihood of a mongol child being born. However no mention has been made of the age of the father. Brousseau and Brainerd (1928) found that 23 per cent of 584 mothers and 15 per cent of 457 fathers became parents of a mongol child when they were under 30 years old. The corresponding percentages for parents over 40 at the birth of the mongol were 38 per cent of the mothers and 50 per cent of the fathers. This would suggest that the age of the father is also related to the incidence of mongolism.

However Jenkins (1933) showed that the increase in paternal age was most likely due to the relationship between the ages of husbands and wives. In a more

convincing demonstration Penrose (1933b) using a partial correlation technique and a regression analysis concluded that the ages of the fathers of 154 mongols were an insignificant factor, whereas the mothers' ages were of significant importance. This conclusion is supported by Greenberg (1963) who failed to find any evidence that the father's age had an effect which was independent of the mother's age. He found that in each maternal age group, the distribution of the paternal ages was similar for both mongol and normal children. However he did not compare the distribution of maternal ages in each of the paternal age groups to see if the distributions were different for the mongol and normal children. On the other hand Moric-Petrovic and Kalicanin (1968) reported that although the fathers of 300 mongols were older than the fathers of all of the children born in Serbia in 1957, the age difference was not so pronounced as found for the mothers.

From the evidence that has been considered in this section a number of conclusions may be drawn. First, mongol children tend to be born more often to older mothers than do normal children. Second, there are two classes of mongols, those born primarily to young mothers but whose birth is not related to maternal age, and those born mainly to older mothers whose birth is related to maternal age. Third, any trend towards an earlier age of childbirth in the general population will also be reflected in the mongol population. Finally, it is the age of the mother and not the age of the father that is important.

IV.B. The Sample

In this section the question of the extent to which the ages of the parents of the sample, and the proportions of class A and B mongols in the sample were representative of the mongol population was examined.

The ages of both parents were obtained for 42 of the mongol children, and the maternal ages of another two were also recorded. For the normal group, both parents' ages were known for 63 of the children as well as the maternal ages of the two remaining normals.

The numbers of mongol and normal children born to mothers of different age groups are given in Table 4 together with the numbers expressed as a percentage of each total.

Table 4: The numbers and percentages of mongol and normal children born at different maternal ages

Maternal Age (in years)	Group			
	Mongol		Normal	
	Number	Percentage	Number	Percentage
15 - 19	2	4.5	7	10.8
20 - 24	9	20.5	18	27.7
25 - 29	10	22.7	26	40.0
30 - 34	12	27.3	6	9.2
35 - 39	4	9.1	5	7.7
40 - 44	6	13.6	3	4.6
45+	1	2.3	0	0
Total	44		65	

This table shows that the mongol children tended to be born to older mothers than the normal children. This tendency was also reflected in the mean maternal ages, which for the mongols was 30.36 ± 7.24 years, and for the normals was 26.61 ± 5.82 years. The difference between these means was examined using a significance test based on the normal distribution and found to be significant ($d = 2.866$, $p < .01$, two-tailed).

Although this difference was significant it should be noted that the mean maternal age of both mongol and normal groups was younger than in the majority of the reports that were reviewed in the previous section. This is also seen when the percentages of children born to mothers under 30 and over 40 years are compared. For the mongol children these are 47.7 and 15.9 per cent respectively, and for the normals they are 78.5 and 4.6 per cent respectively.

The fact that the mothers of the children included in my sample tended to be younger than reported in other studies is consistent with a continuation of the shift towards earlier ages of childbearing which was noted by Richards (1967). If this is a real trend it should, for reasons given in the last section, effect the relative proportions of class A and class B mongols by increasing the number of class A mongols.

Table 5 gives the estimated figures of class A and B mongols for the 44 mongols whose maternal ages were known. The sample was small compared to

Table 5: The partition of classes A (age independent) and B (age dependent) mongols

Maternal age (in years)	Number of Mongols		Incidence	
	Class A	Class B	Class A	Class B
15 - 24	11.0	0	0.440	0.000
25 - 34	14.08	7.92	0.440	0.2475
35+	3.52	7.48	0.440	0.935
Total	28.6	15.4		

the groups on which Penrose (1961) and Penrose and Smith (1966) based their estimates, and therefore the data were combined into three maternal age groups. Because of this the estimates may be different from those that would be obtained with a larger sample.

The number of class A mongols was calculated by assuming that in the youngest maternal age group from 15 to 24 years there were no age dependent mongols. From Table 5 it can be seen that approximately 29 out of the 44 mongols (66 per cent) were classified as class A mongols and 15 (34 per cent) as class B. The corresponding figures reported by Penrose and Smith (1966) from studies of 9,441 mongols were 39 and 61 per cent respectively. My figures therefore support the suggestion that the tendency towards mothers having their children at younger ages leads to an increase in the proportion of age independent mongols and a decrease in the age dependent mongols.

The karyotypes of 36 of the 44 mongols were known and these were examined to see if there was any support for the suggestion by Richards (1967, 1968, 1974) that translocation and moasic mongols tend to be born to young mothers. Thirty-five of the mongols were straightforward trisomies. The other mongol was a mosaic trisomy whose mother was 22 years old at the time of the birth. Although there was only one case, the maternal age was consistent with Richards' suggestion. A much larger sample is required to confirm that moasic and translocation mongols tend to have younger mothers than trisomy mongols.

The paternal ages of the groups of normal and mongol children will now be

examined. These ages were known for 42 mongols and 63 normals and Table 6 gives the numbers and percentages of these children who were born to fathers of different age groups.

Table 6: The numbers and percentages of mongol and normal children born at different paternal ages

Paternal Age (in years)	Group			
	Mongol		Normal	
	Number	Percentage	Number	Percentage
15 - 19	1	2.4	0	0
20 - 24	6	14.3	14	22.2
25 - 29	11	26.2	24	38.1
30 - 34	9	21.4	11	17.4
35 - 39	6	14.3	10	15.9
40 - 44	7	16.6	3	4.8
45+	2	4.8	1	1.6
Total	42		63	

It can be seen from this table that at the younger ages the percentages of normals tends to be greater than the corresponding figures for the mongols and that this position is reversed at the older ages. The mean paternal ages also indicate that the mongols were born to older fathers than the normals. For the mongols the mean paternal age was 32.43 ± 7.15 years, and for the normals was 29.43 ± 5.84 years. This difference was significant ($d = 2.258$, $p < .05$, two-tailed).

The mongol children were therefore born to mothers and fathers who were both older at the time of the birth than the parents of the normal children. In order to test whether the maternal age is more important in the incidence of mongolism than the paternal age, a regression analysis was carried out on those cases where the ages of both parents were known. When the maternal age was fixed there was no difference between the paternal ages of the mongol and normal children ($d = 0.017$, n.s.). There was also no significant difference between the

maternal ages of the mongol and normal children when paternal age was fixed (d = 1.582, n.s.).

To this extent my sample differed from that of Penrose's (1933b) who found that maternal age and not paternal age was an important factor in the incidence of mongolism. There are two possible reasons for this difference. The first is that my sample was too small. The second is that the shift towards younger age of childbirth since Penrose's (1933b) study has reduced the effect of maternal age on mongolism. This is supported by the finding that my sample included a greater percentage of age independent class A mongols than found in earlier studies.

The data indicate that the mongol children are representative of the mongol population in terms of older maternal and paternal ages than normal children. On the other hand, the data show that the maternal age of my sample is not an important factor, whereas previous studies have found it to be important. However it is still possible that my sample is representative of the mongol population since the observed trend towards younger childbearing ages may have reduced the effect of maternal age on the incidence of mongolism. This can only be confirmed by a larger sample.

V. BIRTH ORDER OF THE CHILDREN AND THE NUMBERS AND AGES OF THEIR SIBLINGS

V.A. Introduction

Maternal age as well as being associated with paternal age is also correlated with birth order (Penrose and Smith, 1966). Thus children born to older mothers tend to be born into large families and children born to younger mothers tend to be first born. Shuttleworth (1909) as well as believing that the advanced age of the mother at childbirth was an important factor in the occurrence of a mongol child, also suggested that the large size of a family was a characteristic. In these early observations he also noted that mongols tended to be last born children. This last observation was supported by Brousseau and Brainerd's (1928) findings. Out of a group of 583 mongols, 336 (57.6 per cent) were last born, and in a further 99 families (16.98 per cent) the mongol was the only child.

Further support for the suggestion that the mongol is most frequently the

youngest child in a family comes from Benda (1947). He found that in 255 families each with a mongol child, 84 per cent of the other children in these families were born before the mongol and only 16 per cent after. This is in contrast to the figures for 255 families with a mentally retarded child who was not a mongol, which were 54 and 46 per cent respectively.

On the other hand there is little support for Shuttleworth's (1909) proposal that the large size of the family is important. Brousseau and Brainerd (1928) reported that the mongol was first born in 195 out of 800 families (24.37 per cent), second born in 153 families (19.12 per cent), third born in 104 families (14 per cent) and fourth, fifth or sixth born in 165 families (20.6 per cent). It is interesting to note that 104 of the 195 families in which the mongol was first born (53.3 per cent) had more children later.

It seems therefore that the mongol may tend to be born late in the family but not necessarily into a large family. Also the later in the family that the mongol is born the less likely it is that any other children will be born afterwards.

It has already been shown that the incidence of mongolism increases as the mother gets older, and therefore it is necessary to take this into account when considering birth order. This was done by Penrose (1934) and Smith and Record (1955). Penrose compared the actual numbers of mongols at each birth order for a total of 224 mongols to the numbers expected if the probability of a mongol depended only on maternal age. The differences between the two figures for each birth order was nonsignificant, and so Penrose (1934) concluded that the influence of birth order in his study was negligible.

Much the same conclusion was reached by Smith and Record (1955) who compared the birth orders and maternal ages of 217 mongols to those of 1,156 controls. They found that the association of mongolism with maternal age was almost independent of birth order, and that the association with birth order was largely eliminated when the influence of maternal age was removed. However, Smith and Record (1955) did find that more mongols than controls tended to be first born at all maternal ages up to 40 years, and that the reverse was true after this age.

If the mongol child tends to be born late in the family it follows that he

should have more brothers and sisters than the normal child. This was found by Carr (1975) in a comparison of the families of 42 mongol and 42 normal children. She also noted that the siblings of the mongol children tended to be older than those of the normal children.

V.B. The Sample

In the sample the position of birth in the family and the number and ages of siblings were known for 44 mongols and 64 normal children. These data only concern the family size and ages of the siblings at the time of the birth of the mongol or normal child. Thus it cannot be assumed that the families were complete.

Since some of the families were probably incomplete it was not possible to examine whether more mongol than normal children were last born. However if mongol children tend to be last born it might be expected that more normal children than mongol children would be first born. Table 7 gives the birth positions of the children.

Table 7: The numbers of children who were born first, second, third, fourth, fifth and later in the family.

Group	Birth Position					
	First	Second	Third	Fourth	Fifth and later	Total
Mongol	15	15	9	4	1	44
Normal	32	18	6	4	4	64

From this table it can be seen that more of the normal children than of the mongol children tend to be first born. However a X^2 comparing the numbers of first born children to later born children was not significant ($X^2 = 2.077$, df = 1, n.s.). Thus there is no strong evidence in the present sample that the mongol children were born later in their families than the normal children.

Although there appeared to be no effect of birth order, the separate effects of birth order and maternal age were considered in a regression analysis. When maternal age was fixed there was no difference in the birth orders of the two

groups of children (d = 0.787, n.s.). On the other hand, when birth order was held constant, the maternal ages of the two groups were significantly different, the mothers of the mongols being older than those of the normals (d = 2.795, $p < .01$).

The 29 mongol children and 32 normal children who were second or later born in their families had 50 and 59 brothers and sisters respectively. The difference between the mean numbers for the total groups, which were 1.14 ± 1.25 for the 44 mongols and 0.92 ± 1.23 for the 64 normals, was not significant (d = 0.882, n.s., two-tailed). The mean age of the 50 siblings of the 29 mongol children was 8.57 ± 5.80 years, and the mean age of the 59 siblings of the 32 normal children was 7.42 ± 4.64 years. The difference between these two means was not significant (d = 1.131, n.s., two-tailed).

In my sample the position of the mongol children in their families is similar to that of the normal children, whereas other studies have reported mongols to be later born. The mongol and normal children also tended to have a similar number of siblings of about the same age, whereas mongols have been reported as having more older siblings than normals. These differences are probably due to the fact that many of my families were incomplete, and to the finding of a smaller effect of maternal age than in previous studies owing to the change in the age of child-bearing. Since maternal age is correlated with birth order, this could explain the differences.

VI. CONCLUSIONS

The aim of this chapter was to compare the two samples of normal and mongol children who took part in the experiments and to discover if the mongol children were a representative sample of the mongol population.

The sample of mongol children was small and so it was necessary for each mongol child to take part in more experiments than each normal child. The rest of the data presented in this chapter indicated that the mongol children were similar to other groups of mongols in terms of birth weight and parental ages although the effects of maternal age and birth order were smaller than in previous studies.

It seems probable that the shift towards earlier childbearing ages can account for the differences between my sample and other samples, and that therefore my sample is representative of the mongol population.

CHAPTER 4

Experiment I: A Comparison of the Visual Behaviour of Mongol and Normal Children of Similar Mental Age

I. INTRODUCTION

In Chapter I (section II.F.1) a number of studies were discussed which reported that the visual behaviour of young mongol children is different from that of young normal children of the same chronological age (Miranda, 1970; Miranda and Fantz, 1973, 1974; Fantz, Fagan and Miranda, 1975; Fantz and Miranda, in preparation; Fagan, unpublished). However these studies do not indicate whether the differences were due to the mongol's retarded development. The aim of this first experiment was therefore to explore the visual behaviour of mongol and normal children who were of the same mental age, and to discover whether or not the behaviour of these two groups of children were comparable. It was intended that this experiment would serve as a baseline for further experiments.

Two aspects of visual behaviour were considered. These were visual exploration and memory for visual patterns. These were chosen because the evidence reviewed in Chapter 2 (section II.C.1 and section II.C.5) indicated that as the normal child gets older the way in which he scans a pattern and his memory of it become more extensive. We have no evidence to tell us whether or not mongol children scan and remember patterns to the same extent as normal children of the same M.A.

The method that was chosen was based on the experiment reported by Harris (1973) which was described in Chapter 2 (section II.C.1). Harris presented children with either two identical patterns or two different patterns. He reported that at six months but not at three months children made more comparisons between different patterns than between identical patterns. This method was selected because it was a simple way of examining the extent that a child compares two patterns, and because it should indicate whether a child can tell the difference between the two conditions.

Harris' (1973) procedure only involved one trial. In my experiment the

procedure was extended to examine the children's responses to repeated presentations of the same patterns and to a change in the patterns. Harris' one trial of five minutes duration was divided into five trials, each of one minute duration, and these were followed by a sixth trial in which the patterns were altered. This enabled a comparison to be made of the extent of habituation over the first five trials and dishabituation in the sixth trial in the two groups of children.

II. METHOD

II.A. Subjects

There were 32 children in this experiment and their C.A.s ranged from 6 to 37 months. Sixteen of them were mongol and 16 normal. The mongol children were tested before the normal children. This was because each mongol child was to be matched with a normal child for M.A., sex and social class; the M.A.s of the mongol children were not known until they had been tested. The mongol children and their matched normals were assigned to one of two age groups, age I and age II on the basis of the C.A.s of the mongol children. There were eight children in each of the four groups, mongol age I, mongol age II, normal age I and normal age II. The means and standard deviations of the C.A.s of these groups are shown in Table 8.

Table 8: The mean C.A.s of the experimental groups (in months)

	MONGOL		NORMAL			
Age I	Mean	19.27	Mean	10.07	Mean	14.67
	S.D.	4.95	S.D.	2.16	S.D.	6.01
	Range	14.9-27.5	Range	6.5-12.2		
Age II	Mean	26.99	Mean	14.05	Mean	20.52
	S.D.	4.98	S.D.	0.85	S.D.	7.52
	Range	22.1-36.3	Range	12.8-15.6		
	Mean	23.12	Mean	12.06		
	S.D.	6.23	S.D.	2.59		

From this table it can be seen that although the age I children were younger than the age II children there was some overlap in the C.A.s of the age groups. But as will be seen in section II.A.1a, there was fortunately no overlap in the M.A.s of the age I and age II children. Table 8 also shows that the mongol children were almost twice as old as the normal children. The reason for this age difference and the implications of it will be discussed later (section II.A.2).

The next section gives the details of the matching procedures for M.A., sex and social class. This is followed by the section on C.A., and finally there is a section on those children who were discarded from the experiment. Apart from this last section, the next sections contain only the details of those children who completed the experiment.

II.A.1. Matched Aspects of the Mongol and Normal Children

a) Mental Age

The aim of this and later experiments was to examine the perceptual abilities of mongol and normal children who were matched for M.A. It was therefore necessary to use a scale from which a measure of the M.A. of a young child could be obtained. The Bayley Scales of Mental and Motor Development (1969) was chosen for three reasons.

First, tables are provided from which a child's M.A. equivalent can be read off from the number of items which he passes on the mental scale. This is the age at which a child with a D.Q. of 100 would pass the same number of items.

Second, the scale covers a mental age range from birth to 30 months, although the tables do not begin until two months. It was anticipated that the M.A.s of the mongol children would fall within these limits.

The third reason was that the Bayley Scales (Bayley, 1964) had already been used successfully with young mongol children (Carr, 1970, 1975).

The procedure for matching the mongol and normal children for M.A. was as follows. After a mongol child had completed the experiment he was tested on the Bayley Scales and his M.A. obtained. A normal child was then selected who had the same C.A. as the mongol's M.A. Provided that this child also met the other criteria of the matching procedure, which were that he was of the same sex

and social class as the mongol, he took part in the experiment.

When the normal child had completed the experiment his M.A. was calculated using the same scales. This was to ensure that the M.A.s of the two children were well matched. In practice it was more difficult than had been expected to match the children closely. Therefore a criterion of two months was adopted as the maximum difference acceptable between the M.A.s of a mongol and his normal control.

Since it was not possible to match the children as closely as had been hoped the differences were taken account of in the analysis of the data by using analysis of covariance. In this the dependent variable is adjusted so that any differences in the data which are due to uncontrolled variables are removed. As a consequence of this, the results can be interpreted independently of any M.A. differences which existed between the children.

The means, S.D.s and ranges of the M.A.s of the groups are shown in Table 9. It can be seen that at each age level the normals and mongols are well matched overall, and that the age II children are older in terms of M.A. than the age I children.

Table 9: The mean M.A.s of the experimental groups (in months)

		MONGOL		NORMAL		
Age I	Mean	9.84	Mean	9.91	Mean	9.88
	S.D.	2.43	S.D.	2.57	S.D.	2.42
	Range	5.75-12.5	Range	5.4-12.4		
Age II	Mean	14.30	Mean	14.26	Mean	14.28
	S.D.	1.02	S.D.	0.71	S.D.	0.85
	Range	12.9-16.4	Range	12.9-15.3		
	Mean	12.07	Mean	12.09		
	S.D.	2.92	S.D.	2.89		

b) Sex

Of the 16 mongol children, five were female and these were individually matched with five normal females. One female pair was in age I and the four others were in age II. All the remaining mongol and normal children were male.

c) Social Class

The Registrar General's (1960) Classification of Occupations was used to measure social class. This index classifies the father's occupation into one of six social categories. People with professional qualifications are classified in the top two classes. Class I includes doctors, engineers and solicitors. Class II includes authors, actors, social workers and technicians. Semi-skilled people are categorized into either III Non-Manual (abbreivated to IIIN and including clerks, typists, head-waiters) or III Manual (abbreviated to IIIM and including non-managerial butchers, carpenters and tailors). The people in the remaining classes are unskilled. Class IV includes apprentice agricultural workers and machine tool operators. Class V includes lorry drivers' mates, dock labourers and building labourers.

The mothers of the mongol children were asked what their husband's occupation was, and from this information the social class of the family was found using the Registrar General's Index. A normal child was selected whose father's occupation was classified in the same social class.

Table 10: The social classes of the children in the four groups according to the Registrar General's categories

	MONGOL						NORMAL					
	I	II	IIIN	IIIM	IV	V	I	II	IIIN	IIIM	IV	V
Age I	0	4	0	1	2	1	0	4	0	1	2	1
Age II	0	3	4	1	0	0	0	3	4	1	0	0
Total	0	7	4	2	2	1	0	7	4	2	2	1

Table 10 gives the numbers of mongol and normal children who were classified into each of the six social classes. The number is broken down according to the age levels. This table shows that there were the same number of normal children in each social class as there were mongol children.

Thus each mongol child who took part in this experiment was matched with a normal child who was of the same sex, whose father's occupation fell into the same social class and who had approximately the same M.A. as measured by the Bayley Scale of Mental Development.

II.A.2. Unmatched aspect of the Mongol and Normal Children

Chronological Age

Since the normal and the mongol children were individually matched for M.A. it was impossible to match them also on the basis of C.A. This was because the mongol children passed fewer items on the Bayley Scales of Mental Development than would be expected from their C.A.s alone. Therefore their M.A.s were lower than their C.A.s. Each normal child passed the number of items which would be expected by a child of that C.A. Thus, the normals' M.A.s were approximately equal to their C.A.s.

It was seen in Table 8 that the mongol children were almost twice as old as the normals (mean 23.12 months compared to a mean C.A. for the normals of 12.06 months).

The fact that the mongol children are considerably older than the normals is an important unmatched aspect, since if a difference is found in the experiment between the normal and mongol children, it could be due to the C.A. difference rather than due to the children being mongol and normal. As the experiment was designed to compare mongol and normal children it was clearly necessary to be able to test whether any group effect was due to these C.A. differences. The test used to deal with this problem was an analysis of covariance with C.A. as the covariate. In this analysis the dependent variable can be adjusted so as to remove the effects of any unmatched differences between the children, the differences in the present case being C.A.

Thus, although C.A. was not matched across the children it was taken account of in the analysis of the experiments. This means that any significant group effect need not be confounded with C.A. as the effect of the latter can be removed.

II.A.3. Discarded Subjects

Thirty mongol children and 19 normal children were discarded from the experiment for the following reasons.

Two mongols had severe squints, and since the method to be used in the experiment required judging the direction of the child's gaze, these children were discarded. One mongol and one normal child seemed to be frightened of the apparatus and refused to sit in front of it as was required.

In six cases the apparatus failed. Of these, five were during the testing of a mongol child and one during a session with a normal child. Three normals did complete the experiment, but they did not reach the requirements of the M.A. matching procedure. In each case the normal had a M.A. which was different by more than two months from the M.A. of the mongol with whom the normal was being matched.

Twenty-two mongol and 14 normal children refused to complete the experiment and therefore were discarded. There are two likely reasons why so many children behaved in this way. First, the experiment was simple and required little from the children. Second, all but two of these mongols and two normals had already successfully completed a different experiment using the same apparatus. Both of these would contribute to the children becoming bored with the experiment.

The large number of children who refused to complete the experiment and were therefore discarded, is a deficiency of this study. However, the experiment was designed to compare the behaviour of mongol and normal children, and since both mongol and normal children refused to complete the experiment comparisons can still be made between the groups. Obviously it would have been preferable if no children had been discarded for refusing to complete the experiment. However, the spread over both groups of children is more acceptable than a concentration within one group.

II.B. Apparatus

The apparatus consisted of a matt black box which was placed on a table. A four-channel Rustrak event recorder was used to provide a permanent record of the observations. Two push button controls were separately connected to two of the four channels. A clock with a sweeping second hand was used to measure the length of each trial.

The box measured 40 cm. high by 85 cm. wide by 51 cm. deep. One of the long sides of the box was open and this will be referred to as the front. At the front of the box the sides and top extended 20 cm. beyond the bottom of the box, so that a child sitting at the front would not be distracted by other objects in the room.

The box had a false bottom and back which were fixed at right angles to one another and which together pivoted about the horizontal axis at the bottom of the back of the box. The experimenter standing at the back of the box could therefore rotate the back towards her through 90^{o}. This exposed the bottom and the back of the box to the experimenter. From the front the false bottom of the box was now the back of the box.

There was a peephole one cm. in diameter in the back of the box. It was positioned equidistant from the sides and near to the top.

Two white 11 cm. long 4W fluorescent tubes were fixed to the roof of the box. They illuminated the inside of the box and matt-black shades prevented them from being seen from the front.

The stimulus cards on which the patterns were displayed were presented to the children in this box. On each trial two cards were slotted into grooved channels in the back of the box. When in position (Figure 1) there were 31 cm. between the inner edges of the cards. The stimulus cards could be changed by the experimenter rotating the back of the box through 90^{o}. The false bottom which also rotated prevented this change being seen from the front (Figure 2).

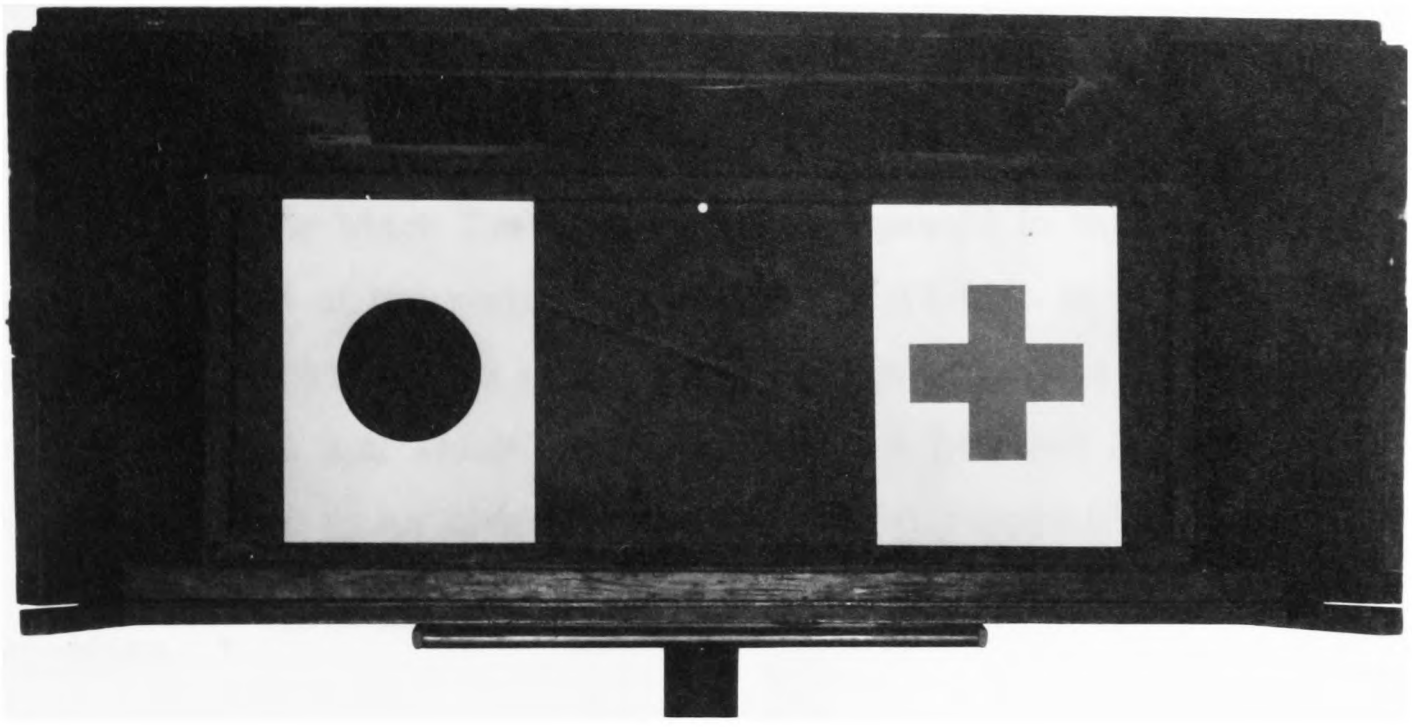


Figure 1: The presentation of the patterns .

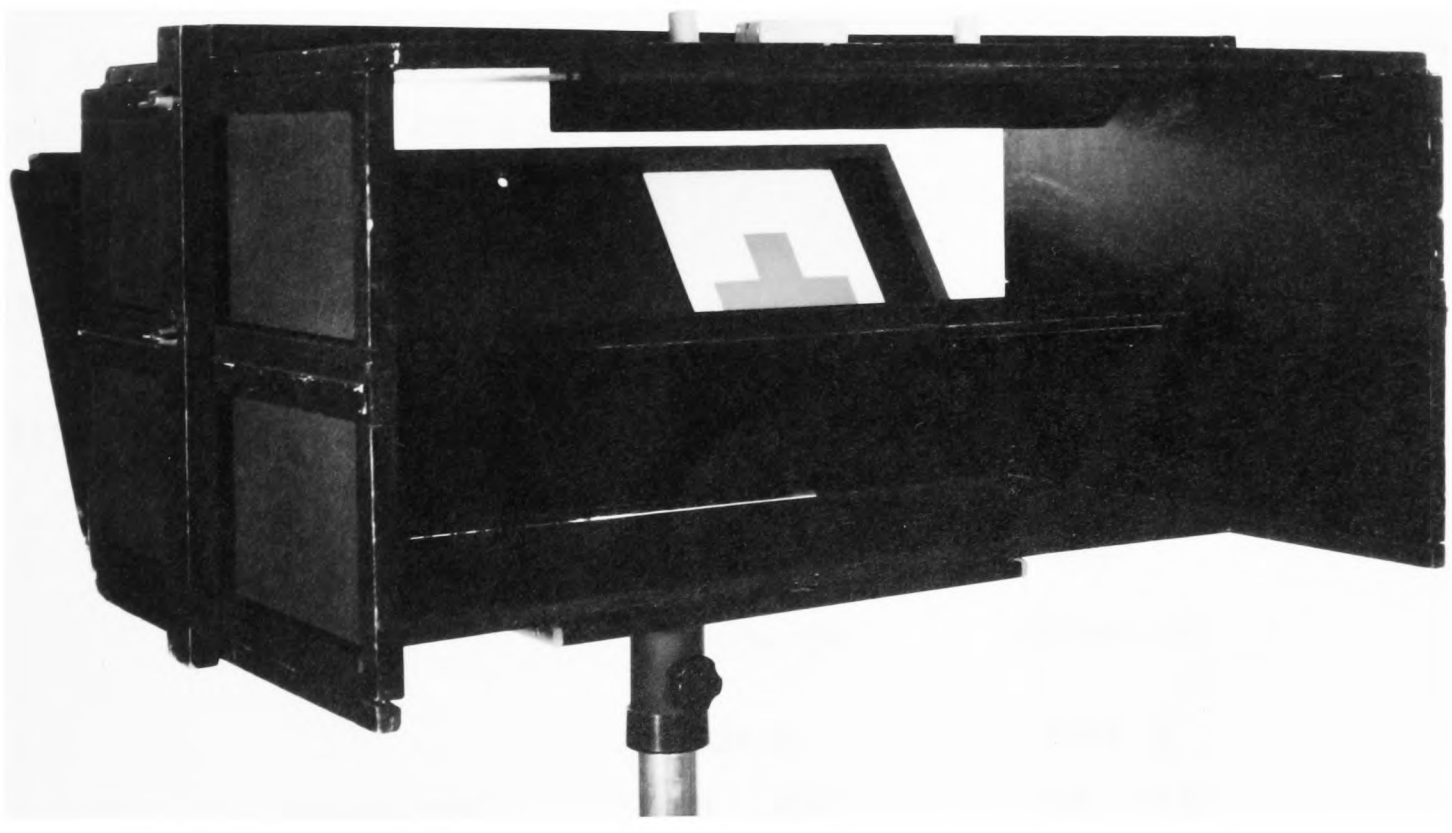


Figure 2: Procedure for changing the patterns

II.C. Stimulus Material

There were four patterns and these are illustrated in Figure 3. Each pattern consisted of a white card which measured 21 cm. wide by 34 cm. high. A shape cut out of red or black Letraset sheet was pasted in the centre of each card. The shape of two of the patterns was a circle 12 cm. in diameter cut out of black Letraset . The shape of the other two patterns was a cross which measured 15 cm. across and which was cut out of red Letraset . These two patterns will be referred to as circle (O) and cross (+) respectively.

II.D. Procedure

II.D.1. Counterbalancing

There were two experimental conditions which were completed by all of the children. Both conditions consisted of six trials, and on each trial two patterns were presented side by side. In one condition, called Condition Same, the patterns were identical to one another. In the other condition, Condition Different, the patterns were different from one another.

In each condition the patterns which were presented on the first trial were also presented for the next four trials. On the sixth trial the patterns were altered. In Condition Same another pair of identical patterns was presented. In Condition Different the left-right positions of the patterns which were presented on the previous trials were reversed.

There were four pairs of patterns and these are shown in Table 11.

Table 11: The four pairs of patterns

		Pattern on the child's right	
		Circle (O)	Cross (+)
Pattern on the child's left	Circle (O)	Pair A (O O)	Pair C (O +)
	Cross (+)	Pair B (+ O)	Pair D (+ +)

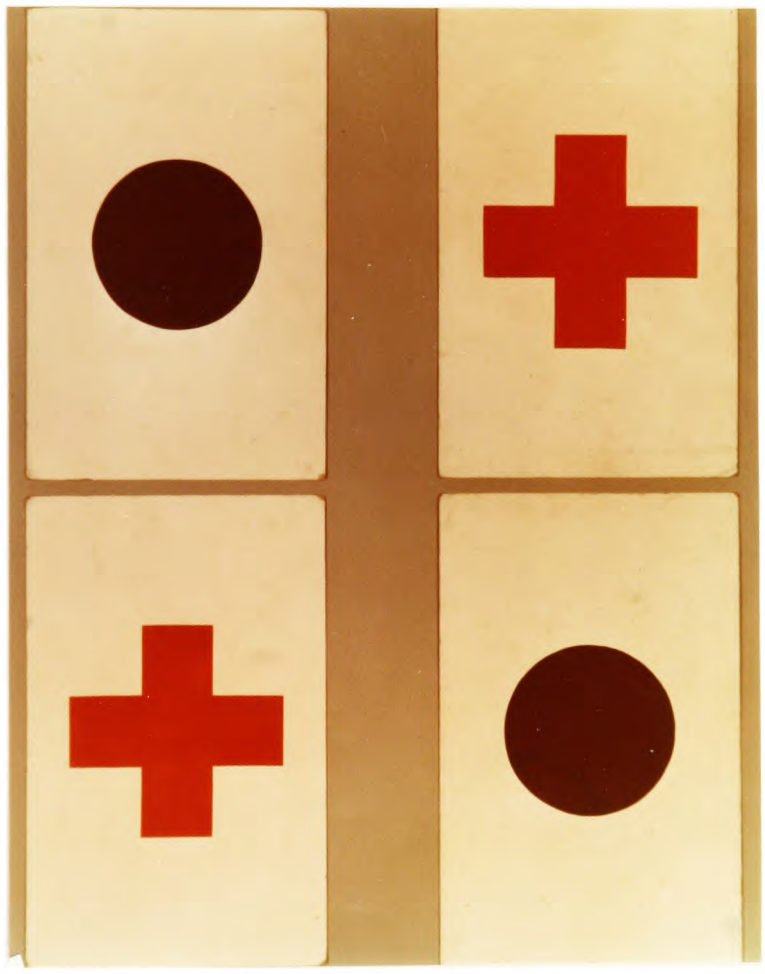


Figure 3: The patterns

Pairs A and D were used for the trials in Condition Same, and pairs B and C for the trials in Condition Different.

Three variables were balanced across the eight children in each of the four groups. These are summarized in Table 12 A. They are (1) the order

Table 12: The counterbalancing of the subjects

A: Summary of the randomization procedures

(1) Order of presentation of conditions

Order	First 6 Trials	Second 6 Trials
i	Condition Same	Condition Different
ii	Condition Different	Condition Same

(2) Order of presentation of the pairs of patterns in Condition Same

Order	Trials 1-5	Trial 6
a	Pair A (O O)	Pair D (+ +)
b	Pair D (+ +)	Pair A (O O)

(3) Order of presentation of the pairs of patterns in Condition Different

Order	Trials 1-5	Trial 6
p	Pair B (+ O)	Pair C (O +)
q	Pair C (O +)	Pair B (+ O)

B: Assignment of subjects

	Order	Trials on First Session		Trials on Second Session	
		1-5	6	1-5	6
Subject 1	i a p	O O	+ +	+ O	O +
Subject 2	i a q	O O	+ +	O +	+ O
Subject 3	i b p	+ +	O O	+ O	O +
Subject 4	i b q	+ +	O O	O +	+ O
Subject 5	ii a p	+ O	O +	O O	+ +
Subject 6	ii a q	O +	+ O	O O	+ +
Subject 7	ii b p	+ O	O +	+ +	O O
Subject 8	ii b q	O +	+ O	+ +	O O

of presentation of the two conditions; (2) whether pair A or pair D was presented on the first five trials of Condition Same, and (3) whether pair B or pair C was presented on the first five trials of Condition Different. If pair A was presented on the first five trials of Condition Same, then pair D was presented on the sixth trial and vice versa. The same procedure was followed with pairs B and C in Condition Different.

Table 12 B shows how these three variables were balanced across the eight children in each group. Four of the children (Subjects 1 to 4) received Condition Same first. Of these four, two were presented with pair A on the first five trials of Condition Same (Subjects 1 and 2). The other two (Subjects 3 and 4) were given pair D for the first five trials of Condition Same. One child who received pair A (Subject 1) and one who received pair D (Subject 3) on trials one to five of Condition Same were shown pair B for the first five trials of Condition Different. The other two children (Subjects 2 and 4) were shown pair C for the first five trials of Condition Different. The remaining four children were treated similarly, except that Condition Different was presented before Condition Same.

Each normal child was treated exactly the same as the mongol child with whom he was matched.

II.D.2. The Method of Presentation

Each child was tested on two occasions. There were more than three days and less than eight days between these two test sessions. Each session took place in the child's home and on each visit only one of the two conditions was presented. The procedure was the same on both occasions.

After the apparatus had been assembled the room was darkened as much as possible and all possible distractions were removed.

Before the experiment began the mother was shown the patterns. She then sat in front of the matt black box with the child on her lap. She was asked to sit quietly and to look straight ahead. If her child turned around she was told to smile and to reassure him. This procedure was found to be more satisfactory than the child sitting alone in a high chair.

It was checked that the child was sitting centrally and at a suitable height so

that he would be able to see the patterns. In this position he was approximately 40 cm. in front of the back of the box. From where the child was sitting there was an angle of about 42^{o} between the cards.

The first five trials each lasted one minute. The sixth trial only lasted a quarter of a minute, since this was sufficient time to see whether the child had noticed that the patterns had been altered.

The experimenter stood behind the box and held a push button control in each hand. These were separately connected to two channels of the event recorder. Each trial was initiated by the experimenter rotating the back and base of the box towards the child. This movement attracted the child's attention and as soon as the child was visible through the peephole the clock was started and the two push button controls were pressed simultaneously. Since the back and base of the box were fixed at right angles to one another, and the peephole was in line with the top edge of the stimulus cards, the clock was started just before the child was able to see the patterns.

A trial was terminated by the experimenter rotating the back and the base of the box away from the child after one minute or a quarter of a minute as indicated on the clock. Both stimulus cards were removed, and the same cards or new cards put in position for the next trial. The cards were removed between trials to ensure that the interval between trials 5 and 6 was not different from intervals between other adjacent trials. The intertrial interval was 20 seconds.

After the experiment was finished the Bayley Scales of Mental and Motor Development were administered as directed in the manual. The mothers of the mongol children were then asked for the child's birth weight, the number and ages of any other children, her husband's occupation and age, and her own age. The mothers of the normal children were also asked the same questions but they were asked for their husband's occupation before the experiment was started. This was to check that the normal was of the same social class as the mongol with whom he was matched.

II.D.3. The Scoring of the Experimental Observations

This section describes how the data were collected and how different measures were scored from the raw data.

a) Data Collection

The data were collected by recording where the child was looking when he was presented with two patterns in the box. The child was judged to be fixating a pattern when its reflection was seen to be superimposed over part of the pupil of the child's left eye by the experimenter through the peephole. This criterion of fixation was adopted from Fantz (1956) although the same method was also used by Staples (1932). Since the visual angle between the stimulus cards was 42^{o} a change in which pattern the child was fixating was also accompanied by a noticeable head movement.

During each trial the push button in the experimenter's left hand was pressed while the child was looking at the pattern on his right. The other push button was pressed whenever the child looked at the pattern on his left. A permanent record was kept on the chart paper of the event recorder.

b) Measurements taken from the raw data

Before any measurements were taken from the chart paper of the event recorder, a line was drawn across the two channels to indicate the duration of one minute from the beginning of each of the first five trials, and the duration of a quarter of a minute from the start of the sixth trial in both conditions. The chart paper moved at a constant rate of five inches per minute, and so the distance that it moved in one minute or in a quarter of a minute could be calculated easily. The converse of this calculation was used whenever the duration of an event was required, since this was represented on the chart paper by a measurable distance.

Five measures were scored from the raw data. The first four measures were taken from the first five trials of both conditions. The data from the sixth trial of both conditions were not included in these measures. This was because the patterns were altered on this trial in order to investigate dishabituation which was considered in the fifth measure. The last measure therefore was the only measure to include the data from the sixth trial.

Total Visual Fixation. This was the sum of the amount of time in seconds that a child looked at the two patterns presented on each of the five one minute trials in both conditions. The maximum for each trial was sixty seconds.

The measure of total visual fixation was taken for two reasons. First to see whether the mongol children looked at the patterns for approximately the same length of time as the normal children. Second, to discover whether the mongol and normal children habituated to repeated presentations of the same pair of patterns.

Number of Fixations. This was the number of times that the child looked at the two patterns which were presented on each of the first five trials in both conditions.

This measure was taken to discover whether the mongol and normal children would make more fixations when the patterns were different compared with when they were identical. If this difference was found the fixations could then be divided up into those which were alternations of fixations and those which were repetitions of fixation to examine whether the difference was found for the alternations but not for the repetitions.

Alternations. This was the number of times on each of the first five trials in the two conditions that the child looked from one pattern to the other pattern.

This measure was scored to discover if the mongol and normal children compared the patterns, and in particular whether or not they looked from one to the other more when the patterns were different than when they were identical.

Repetitions. This was the number of times on the first five trials in the two conditions that the children made repeated looks at the same pattern without looking at the other pattern.

This measure was included because it was the main measure apart from alternations that Harris (1973) took, and it would provide more details about the visual scanning of the two groups of children.

Dishabituated Fixation. This was the amount of visual fixation which occurred in the first fifteen seconds of the fifth trial and the amount of visual fixation which occurred in the fifteen seconds of the sixth trial.

This measure was taken to examine whether or not both groups of children would exhibit dishabituation when the patterns were altered. If they do, this is

evidence that they notice the change and that any decrease in total visual fixation which occurred over the first five trials was due to habituation and not to fatigue.

III. RESULTS

The method of analysing the data was essentially the same for the five different measures. It is described in the next section before the results are discussed.

III.A. General Method of Analysis

III.A.1. Transformation of the Raw Data

Before the raw data for each measure were analysed, a check was run to see if there was a relationship between the means and the variances of the treatment levels. The most appropriate transformation is that one which tends to make the variances more homogeneous. The three types of transformation that were used in this and following experiments were square root, logarithmic and reciprocal.

The most appropriate transformation was selected by following the procedure given in Kirk (1968). This entails applying each transformation to the largest and the smallest score in each treatment level. The difference between these is determined and the ratio of the largest to the smallest range is calculated. The transformation which results in the smallest ratio is selected. This is because a transformation which tends to make the ranges of the treatment levels more uniform will also tend to make the variances more uniform.

A square root transformation of each of the raw scores is usually most appropriate when the treatment means and variances tend to be proportional. If any of the scores are less than 10, a more appropriate transformation is $\sqrt{(X + 0.5)}$ where X is the raw score.

If the treatment means and standard deviations tend to be proportional a logarithmic transformation is normally the most appropriate. If any of the raw scores are 0 or very small, the transformation $\log_{10} (X + 1)$ is used.

Finally, a reciprocal transformation is appropriate when the square of the treatment means and the standard deviations are proportional. If any of the raw

scores are less than 1, the transformation of $1/(X + 1)$ is applied to the data.

If it was necessary to transform the data, all of the analyses were carried out on the transformed data, and all inferences concerning the treatment effects were made with respect to the transformed data.

III.A.2. Analysis of Variance

Each measure was analysed using a four-way split-plot analysis of variance. A split-plot repeated measures design as used in this experiment, in which a subject receives all levels of some treatments but only one level of other treatments is sometimes referred to as a mixed design.

For each measure there were two between subject variables and two within subject variables. The between subject variables were Groups (Mongol vs. Normal) and Ages (I vs. II). For the measures of total visual fixation, number of fixations, alternations and repetitions, the within subject variables were Conditions (Same vs. Different) and Trials (1 vs. 2 vs. 3 vs. 4 vs. 5). For the measure of dishabituated fixation the within subject variables were Conditions (Same vs. Different) and Pattern (Repeated vs. Altered).

III.A.3. Analysis of Covariance

In addition to, and quite separate from the analysis of variance, two analyses of covariance were performed on the data. For one the covariate was C.A. and the rationale for this was given in section II.A.2. For the second the covariate was M.A. and the rationale for this was given in section II.A.1.a. The design for each measure was the same as outlined for the analysis of variance.

Briefly these analyses of covariance were carried out to check that any significant effect of the between subject variables was not due to differences in the C.A.s and M.A.s of the four groups of children. Conversely, any effect which was masked by the age differences would appear in these analyses.

In an analysis of covariance the dependent variable is adjusted so as to remove the effects of the uncontrolled source of variation. By this analysis it is possible to distinguish between whether an effect is a real effect or is due to an uncontrolled variable. This is because, if the effect is real, it will still be present when the data are adjusted and analysed, whereas if the effect is due to

the uncontrolled variable, it will disappear when the data are adjusted. In the present experiment the dependent variables were total visual fixation, number of fixations, alternations, repetitions and dishabituated fixation. C.A. and to a lesser extent M.A. were uncontrolled sources of variation between the four groups of children.

III.A.4. Post-Hoc Tests

If the analysis of variance or either analysis of covariance for a particular measure indicated that a main effect which had more than two levels was significant, or that an interaction between two or three factors was significant, the data were tested to find the source of the effect.

Tukey's HSD method (1953) was used for all pairwise comparisons, i.e. comparisons between two means in a main effect or in an interaction. If the main effect has five levels there are ten possible pairwise comparisons. These are level 1 with levels 2, 3, 4 and 5; level 2 with levels 3, 4 and 5; level 3 with levels 4 and 5; and level 4 with level 5.

For an interaction between two factors each with two levels there are four comparisons which can be interpreted. If the two levels of one factor are designated a_1 and a_2 and the two levels of the other factor b_1 and b_2, the four means contributing to an interaction between these two factors will be a_1b_1, a_1b_2, a_2b_1, and a_2b_2. The meaningful comparisons are a_1b_1 with a_1b_2; a_1b_1 with a_2b_1; a_2b_1 with a_2b_2; and a_1b_2 with a_2b_2. The other two comparisons, i.e. a_1b_1 with a_2b_2, and a_1b_2 with a_2b_1 are not meaningful because in order for a comparison to be meaningful it is necessary to keep one factor constant whilst the second is varied.

Scheffé's S method (1953) was used for all non-pairwise comparisons, i.e. comparisons involving more than two means. This is best illustrated by a couple of examples. For a main effect with five levels, level 1 could be compared with the mean of levels 2, 3, 4 and 5 combined. Alternatively, the mean of levels 1 and 2 could be compared to the mean of levels 3, 4 and 5.

III.B. Measures

For each measure there is a table of the means and standard deviations for each cell. These are given for the raw data or the transformed data if a transformation was necessary. This is followed by a summary table of the analysis of variance which also gives the adjusted F ratios (abbreviated to ADJ.F) for the between subject variables from the two analyses of covariance. The levels of significance for the F ratios are indicated by x for $p < .05$, xx for $p < .025$, xxx for $p < .01$ and xxxx for $p < .001$.

III.B.1. Total Visual Fixation

This was the amount of time that the patterns presented on each of the five one minute trials in both conditions were looked at.

When these data were tested for transformations the most suitable one was square root, and since some of the scores were less than 10 the transformation $\sqrt{(X + 0.5)}$ was applied where X is the raw data.

Table 13 gives the means and standard deviations for each cell of the transformed data. Several aspects of this table are worth noticing.

First, the four groups of children have similar total visual fixation times. The main exception is the group mongol age I who fixate the displays for a greater length of time compared with the other groups, particularly in Condition Different.

Second, the total visual fixation in Condition Different seems to be greater than in Condition Same for all the groups although the difference is slight for the group normal age I.

Third, all of the groups appear to show a decrease in total visual fixation over the five one minute trials.

The analyses are summarised in Table 14 and these essentially confirm the observations made from the table of means. The group effect was nonsignificant ($F = 0.0$, df 1/28, n.s.), but the two main effects of Conditions and Trials were highly significant ($F = 12.5$, df 1/256, $p < .001$; and $F = 29.3$, df 4/256, $p < .001$ respectively).

The Conditions term confirmed that all of the children looked more at the

Table 13: Means and Standard Deviations for Total Visual Fixation. The raw data have been transformed $\sqrt{(X + 0.5)}$

Condition Same

Group	Mongol				Normal				
Age	I		II		I		II		Means of
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	Totals
1	5.08	1.21	3.91	0.57	4.49	0.91	4.77	0.62	4.56
2	4.30	1.00	3.56	0.86	3.86	1.04	4.00	0.91	3.93
3	3.89	0.94	3.37	1.27	3.62	1.06	3.08	0.91	3.49 3.74
4	3.77	2.04	2.37	0.70	3.61	0.91	3.44	0.73	3.30
5	3.70	1.40	2.93	0.68	3.44	0.74	3.55	0.65	3.41
Means of Totals	4.15		3.23		3.80		3.77		
	3.69				3.79				

Condition Different

Group	Mongol				Normal				
Age	I		II		I		II		Means of
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	Totals
1	5.30	1.37	4.68	0.88	5.03	0.67	5.11	0.47	5.03
2	4.23	1.27	4.02	1.07	3.88	0.92	4.30	0.95	4.11
3	4.13	1.33	3.19	0.63	3.19	1.06	4.04	1.47	3.64 4.05
4	4.47	1.78	3.46	0.67	3.58	0.94	3.68	0.56	3.80
5	4.46	1.07	3.35	1.13	3.44	1.36	3.54	0.69	3.70
Means of Totals	4.52		3.74		3.82		4.13		
	4.13				3.98				

Table 14: Analysis of variance for total visual fixation (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ. F (M.A.)
Groups (G)	1	0.06	0.0	2.3	0.0
Ages (A)	1	10.02	2.0	0.0	0.5
GxA	1	19.38	3.8	2.2	3.7
S.W.G.	28	5.09			
Total subjects	31				
Conditions (C)	1	8.02	12.5^{xxxx}		
Trials (T)	4	18.82	29.3^{xxxx}		
GxC	1	1.23	1.9		
GxT	4	0.21	0.3		
AxC	1	1.17	1.8		
AxT	4	0.57	0.9		
CxT	4	0.42	0.7		
GxAxC	1	0.21	0.3		
GxAxT	4	0.10	0.2		
GxCxT	4	0.73	1.1		
AxCxT	4	0.27	0.4		
Final Residual	256	0.64			
Grand Total	319				

patterns in Condition Different than in Condition Same. Since the Condition term did not interact significantly with either the group or the age variables, the observations made from the table of means about differences between the groups of children were not supported.

Since the Trials term had five levels, post-hoc tests were carried out to find the source of the effect. Tukey's HSD test showed that the amount of total visual fixation which occurred in Trial 1 was greater ($p < .01$), than in Trial 2, Trial 3, Trial 4 and Trial 5. The total visual fixation in Trial 2 was greater ($p < .05$) than in Trial 3, Trial 4 and Trial 5.

In summary, the length of time that the mongol children looked at the patterns was not different from the time spent by the normal children. Secondly, both the mongol and the normal children showed similar decreases in fixation of the patterns over the five trials. Whether this was due to habituation or fatigue will be answered by the final measure of dishabituated fixation.

The remaining result was that the children looked more at the patterns when they were different than when they were identical. This indicates that the children discriminated between the two conditions since two different patterns attracted more visual fixation than the identical patterns. This is in contrast to the children in Harris' experiment who looked for as long at two identical patterns as at two different patterns. Because of this similarity in looking times, Harris was able to conclude that his finding that the six month old children made more fixations, and in particular more alternations of fixation, between two different patterns than between two identical patterns, was independent of how long they spent looking at the patterns. However, in my experiment, if the children are found to make more fixations to two different patterns than to two identical patterns, this could be because they looked longer at two different patterns than at two identical patterns. Fortunately there is a way around this difficulty. This is to use an analysis of covariance to adjust the dependent variable, whether it is number of fixations (section III.B.2), number of alternations (section III.B.3) or number of repetitions (section III.B.4), for the amount of visual fixation which occurred on each trial. The results of the analyses can then be interpreted as though there were no differences in total visual fixation.

III.B.2. Number of Fixations

This measure was the number of times that the child looked at the patterns which were presented on each of the five one minute trials in both conditions.

The data were tested to see if a transformation was necessary and the most appropriate one was found to be $\sqrt{(X + 0.5)}$. Table 15 gives the means and standard deviations for each cell of the transformed data.

It can be seen from this table that more fixations seem to occur to two different patterns (Condition Different) than to two identical patterns (Condition Same). However when the four groups of children are considered separately it can be seen that the mongol age I, the mongol age II and the normal age II children all tend to make more fixations to two different patterns than to two identical ones. The normal age I children tend to make more fixations when the patterns are identical than when they are different. Finally, more fixations tend to occur in the first two trials than in the last three trials.

It was pointed out at the end of the previous section that if a difference is found in the number of fixations in the two conditions an analysis of covariance with total visual fixation transformed ($\sqrt{(X + 0.5)}$) as the covariate could be carried out. This would show whether or not the difference in the number of fixations for the two conditions is accounted for by the difference in total visual fixation. For the present measure, and also the measures of alternations and repetitions, the data were analysed in this way. A summary of the analyses performed on the number of fixations is presented in Table 16.

No difference was found in the number of fixations made by the age I and age II children unless total visual fixation was covaried out. Then it was found that the age II children made more fixations than the age I children ($F = 4.3$, df 1/27, $p < .05$). This was presumably because the age II children tended to make slightly more fixations and also tended to have shorter visual fixation times than the age I children.

In the analysis of variance the Conditions term was significant ($F = 10.7$, df 1/256, $p < .01$) indicating that more fixations occurred to two different patterns than to two identical ones. However, the Conditions term became nonsignificant

Table 15: Means and Standard Deviations for Number of Fixations. The data were transformed $\sqrt{(X + 0.5)}$

Condition Same

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
1	3.80	0.88	3.95	0.75	4.31	0.56	4.48	0.44	4.14
2	3.01	0.62	3.06	0.84	3.32	0.62	3.52	0.93	3.23
3	2.95	0.72	3.19	0.88	3.35	0.70	2.68	0.70	3.04 3.23
4	2.81	1.20	2.29	0.77	3.13	0.61	3.04	0.54	2.82
5	2.81	0.62	2.81	0.84	3.05	0.49	3.00	0.41	2.92
Means of Totals	3.07		3.06		3.43		3.34		
	3.07				3.39				

Condition Different

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
1	4.16	0.89	4.57	0.87	4.66	0.48	4.78	0.59	4.54
2	3.31	1.11	3.59	1.05	3.24	0.84	3.62	0.86	3.44
3	3.09	0.89	3.00	0.64	2.69	1.00	3.43	1.14	3.05 3.43
4	2.98	0.85	3.27	0.48	2.93	0.70	3.20	0.55	3.09
5	3.12	0.57	2.90	0.62	2.92	0.92	3.16	0.55	3.02
Means of Totals	3.33		3.47		3.29		3.64		
	3.40				3.46				

Table 16: Analysis of variance for number of fixations (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed $\sqrt{(X + 0.5)}$), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	2.95	0.9	2.2	0.1	0.9
Ages (A)	1	0.73	0.2	4.3^{X}	0.2	0.3
GxA	1	0.10	0.0	2.8	0.0	0.0
S.W.G.	28	3.22				
Total subjects	31					
Conditions (C)	1	3.28	10.7^{XXX}	0.9		
Trials (T)	4	21.88	71.6^{XXXX}	32.1^{XXXX}		
GxC	1	13.14	4.3^{XXX}	2.4		
GxT	4	0.45	1.5	1.6		
AxC	1	1.73	5.7^{XX}	4.2^{X}		
AxT	4	0.22	0.7	0.7		
CxT	4	0.36	1.2	1.2		
GxAxC	1	0.42	1.4	1.2		
GxAxT	4	0.09	0.3	0.8		
GxCxT	4	0.26	0.8	1.0		
AxCxT	4	0.25	0.8	0.9		
Final Residual	256	0.31				
Grand Total	319					

when total visual fixation was covaried out ($F = 0.9$, 1/255, n.s.). This shows that the difference in the number of fixations which occurred in the two conditions was accounted for by the corresponding difference in total visual fixation.

There was a significant Trials effect ($F = 71.6$, df 4/256, $p < .001$) which still existed when total visual fixation was covaried out ($F = 32.1$, df 4/255, $p < .001$). Tukey's HSD test was used to find the source of the effect. It was found, whether the data were adjusted or not for differences in total visual fixation, that more fixations ($p < .01$) occurred on trial 1 than on trials 2, 3, 4 and 5. Also, more fixations occurred on trial 2 than on trial 3 ($p < .05$), trial 4 ($p < .01$) and trial 5 ($p < .01$) but only when the data were not adjusted for total visual fixation. Therefore, the number of fixations decreased over the five trials, and the finding that more fixations occurred on trial 1 than on later trials cannot be accounted for by the drop in total visual fixation which also occurred over the five trials.

When total visual fixation was not covaried out there was a significant interaction between Groups and Conditions ($F = 4.3$, df 1/256, $p < .05$). Tukey's HSD test showed that the mongol children made more fixations when the patterns were different than when they were identical ($p < .01$). The difference in the number of fixations that were made by the normal children to two identical patterns and to two different patterns was not significant. Finally, when the patterns were identical the normal children made more fixations than the mongol children ($p < .01$). This interaction became nonsignificant when total visual fixation was covaried out ($F = 2.4$, df 1/255, n.s.). Therefore the differences that were noted above were accounted for entirely by the differences in total visual fixation. In neither analysis was there a significant interaction between Groups, Ages and Conditions as had been suggested when the means were looked at.

The remaining significant F ratio in both analyses was for the interaction between Ages and Conditions. For the analysis of variance, $F = 5.7$, df 1/256, $p < .025$; and when total visual fixation was covaried out, $F = 4.2$, df 1/255, $p < .05$. Tukey's HSD test was once again used to find the source of the interactions. When total visual fixation was not covaried out the age II children were found to make more fixations to two different patterns than to two identical patterns ($p < .01$).

This difference was not significant when the data were adjusted for total visual fixation. When the patterns were different the age II children made more fixations than the age I children, both when the data were not adjusted for total visual fixation ($p < .05$) and when the data were adjusted ($p < .01$). Finally, but only when the data were adjusted for total visual fixation, the age II children made more fixations to two identical patterns than the age I children ($p < .01$).

Thus the effect of covarying out total visual fixation, on the interaction between Ages and Conditions, was to increase the number of fixations made by the age II children to two identical patterns. This was because the age II children tended to look for a shorter time at these patterns than at different patterns, and also for less time than the age I children looked at both different and identical patterns. The results of this adjustment were that the difference in the number of fixations that the age II children made to different and to identical patterns became nonsignificant, and that the age II children now made more fixations to the identical patterns than the age I children.

How may these results be summarized? It is perhaps easiest to take first the question of whether the mongol and normal children make more fixations to different patterns than to identical patterns. It has been shown that the finding that the mongol children and the age II normal children make more fixations to different than to identical patterns is due to these children looking for longer at two different than at two identical patterns. The answer to the question once total looking time is controlled is that none of the children made more fixations when the patterns were different compared with when they were identical.

It has also been found that when differences in total visual fixation are covaried out the age II children make more fixations than the age I children, and more fixations occur on the first trials than on later trials.

We may now look to see if when the fixations are separated into those which are alternations and those which are repetitions, the results are similar or different.

III.B.3. Alternations

The treatment means and variances of this measure tended to be proportional and so the data was transformed $\sqrt{(X + 0.5)}$.

Table 17 shows the means and standard deviations of each cell of the transformed data.

All of the mongol children and the normal age II children tend to make more alternations of fixation when the patterns are different (Condition Different) compared with when they are identical (Condition Same). The normal age I children tend to make fewer alternations when the patterns are different than when they are identical.

When the five trials are considered, all of the children seem to make more alternations in Condition Different than in Condition Same on the first two trials. However there seems to be little difference between the conditions on the last three trials.

The data were analysed in the same way as described for the number of fixations. In addition to the analysis of variance and the analysis of covariance in which C.A. and M.A. were covariates, there was a further analysis of covariance in which the covariate was total visual fixation transformed ($\sqrt{(X + 0.5)}$). The outcomes of these analyses are summarized in Table 18.

The Conditions term was significant when total visual fixation was not taken into account ($F = 6.3$, df 1/256, $p < .025$), showing that more alternations occurred when the patterns were different compared with when they were identical. As was found when the data were the number of fixations, this effect became nonsignificant when total visual fixation was covaried out ($F = 0.3$, df 1/255, n.s.). This means that the difference in the number of alternations in the two conditions could be accounted for by the differences in total visual fixation.

The Trials effect was significant both when total visual fixation times were ignored ($F = 53.1$, df 4/256, $p < .001$) and when they were taken into account in the analysis of covariance ($F = 19.1$, df 4/255, $p < .001$). Post-hoc tests showed that whether the data were adjusted or not for total visual fixation, more alternations ($p < .01$) occurred on trial 1 than on trials 2, 3, 4 and 5. It was also

Table 17: Means and Standard Deviations for Alternations. The data were transformed $\sqrt{(X + 0.5)}$

Condition Same

Group	Mongol				Normal				
Age	I		II		I		II		Means of
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	Totals
1	2.91	0.78	3.11	0.81	3.40	0.78	3.33	0.54	3.19
2	2.37	0.55	2.28	0.88	2.34	0.66	2.41	1.03	2.35
3	2.14	0.79	2.54	0.89	2.48	0.62	2.16	0.81	2.33 2.45
4	2.30	0.89	1.66	0.52	2.41	0.61	2.29	0.67	2.17
5	1.97	0.83	2.22	1.11	2.33	0.45	2.27	0.33	2.20
Means of Totals	2.34		2.36		2.59		2.49		
	2.35				2.54				

Condition Different

Group	Mongol				Normal				
Age	I		II		I		II		Means of
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	Totals
1	3.40	0.79	3.87	1.01	3.83	0.24	3.78	0.45	3.72
2	2.68	0.97	2.96	0.99	2.53	0.62	2.75	0.88	2.73
3	2.55	0.74	2.22	0.82	1.91	1.07	2.58	1.05	2.32 2.61
4	2.30	0.80	2.58	0.71	1.71	0.90	2.22	0.47	2.20
5	2.25	0.79	2.14	0.80	2.13	0.97	1.85	0.72	2.09
Means of Totals	2.64		2.75		2.42		2.64		
	2.69				2.53				

Table 18: Analysis of variance for alternations (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed $\sqrt{(X + 0.5)}$), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.02	0.0	0.0	0.1	0.0
Ages (A)	1	0.32	0.1	2.7	0.0	0.6
GxA	1	0.00	0.0	2.9	0.0	0.0
S.W.G.	28	3.06				
Total subjects	31					
Conditions (C)	1	2.20	6.3^{XX}	0.3		
Trials (T)	4	18.69	53.1^{XXXX}	19.1^{XXXX}		
GxC	1	2.60	7.4^{XXX}	5.4^{XX}		
GxT	4	0.33	0.9	1.0		
AxC	1	0.84	2.4	0.9		
AxT	4	0.11	0.3	0.3		
CxT	4	1.22	3.5^{XXX}	4.9^{XXX}		
GxAxC	1	0.25	0.7	0.4		
GxAxT	4	0.38	1.1	1.7		
GxCxT	4	0.34	1.0	0.4		
AxCxT	4	0.58	1.7	1.8		
Final Residual	256	0.35				
Grand Total	319					

found, but only when the data were not adjusted for total visual fixation, that more alternations ($p < .01$) occurred on trial 2 than on trials 4 and 5. Thus, again the number of alternations show the same pattern as the number of fixations; even when the data are adjusted for the observed decrease in total visual fixation over the five trials, it is still found that more alternations occur on the first trial than on the subsequent trials.

In both analyses there was a significant interaction between Groups and Conditions. For the analysis of variance, $F = 7.4$, df 1/256, $p < .01$, and for the analysis of covariance with total visual fixation as the covariate, $F = 5.4$, df 1/255, $p < .025$. Tukey's HSD test was employed to find the source of these interactions. When the number of alternations that were made were not adjusted for the amount of total visual fixation, it was found that the mongol children made more alternations in Condition Different than in Condition Same ($p < .01$). However this difference, although still present, was not significant when the data were adjusted for total visual fixation. There were no other significant differences between the means of the Groups by Conditions interaction either when total visual fixation was taken into account or not. Thus, in both analyses the interaction was due to the mongol children comparing different patterns more often than identical patterns, but this difference was only significant when total visual fixation was ignored.

The final significant interaction was between Conditions and Trials. In the analysis of variance $F = 3.5$, df 4/256, $p < .01$, and when total visual fixation was covaried out, $F = 4.9$, df 4/255, $p < .01$. Tukey's HSD test on the means both before and after the data were adjusted for total visual fixation showed that in both conditions, more alternations ($p < .01$) occurred on trial 1 than on trial 2, trial 3 (although in Condition Same, and when the data were adjusted, this particular difference only reached the 5% level), trial 4 and trial 5. Also, for both unadjusted and adjusted data, more alternations occurred on trial 2 than on trial 4 ($p < .05$) and on trial 5 ($p < .01$). The only difference between adjusting the data for total visual fixation and not doing so, was that when total visual fixation was ignored, on trial 1 more alternations occurred in Condition Different than in Condition Same ($p < .05$), but that when total visual fixation was covaried out, this difference was nonsignificant.

What may we conclude from these results? It will be recalled that the number of alternations was scored to provide an answer to the question of whether or not the mongol and normal children would make more alternations between two different patterns than between two identical patterns. It has been shown that all of the differences which were found in the number of alternations in the two conditions are accounted for by differences in the lengths of time that the patterns in the two conditions were fixated. The only finding that was not entirely accounted for by differences in total visual fixation was that more alternations occurred on the first trial than on later trials.

III.B.4. Repetitions

A square root transformation was selected as that most appropriate for this measure, and since some of the raw scores were less than 10, the transformation ($\sqrt{(X + 0.5)}$) was used.

Table 19 gives the means and standard deviations for each cell of the transformed data.

Only two observations can be made of the data. First, at both ages and in both conditions the normal children tend to make more repetitions than the mongol children. Second, more repetitions appear to be made by all of the children on the first trial compared with later trials.

The data were analysed by an analysis of variance and three analyses of covariance in which total visual fixation transformed $\sqrt{(X + 0.5)}$, C.A. and M.A. were the covariates respectively. These analyses are summarized in Table 20.

The analysis of variance confirms that the normal children made more repetitions than the mongol children ($F = 5.9$, df 1/28, $p < .025$). This difference was still significant when total visual fixation was covaried out ($F = 9.3$, df 1/27, $p < .01$). From these two results it may be concluded that the difference between the two groups in terms of the number of repetitions could not be accounted for by a difference in total visual fixation. However, when C.A. was the covariate the group factor became nonsignificant ($F = 0.1$, df 1/27, n.s.). Therefore the difference in the number of repetitions made by the two groups of children can be accounted for by differences in their C.A.s.

Table 19: Means and Standard Deviations for Repetitions which were transformed $\sqrt{(X + 0.5)}$

Condition Same

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
1	2.29	0.65	2.30	0.32	2.45	0.53	2.88	0.25	2.48
2	1.95	0.46	2.10	0.51	2.43	0.32	2.57	0.56	2.26
3	2.09	0.38	2.00	0.53	2.32	0.55	1.64	0.46	2.01 2.12
4	1.78	0.73	1.68	0.69	2.08	0.46	2.02	0.60	1.89
5	2.04	0.29	1.69	0.42	2.05	0.47	2.06	0.39	1.96
Means of Totals	2.03		1.95		2.26		2.23		
	1.99				2.25				

Condition Different

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Trial	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
1	2.25	0.58	2.17	0.70	2.48	0.75	2.81	0.62	2.43
2	2.03	0.67	2.09	0.65	2.13	0.64	2.34	0.78	2.15
3	1.85	0.61	2.03	0.54	1.85	0.83	2.31	0.70	2.01 2.19
4	1.97	0.51	2.02	0.46	2.40	0.33	2.36	0.58	2.19
5	2.12	0.67	1.97	0.51	2.05	0.46	2.56	0.63	2.17
Means of Totals	2.04		2.06		2.18		2.47		
	2.05				2.33				

Table 20: Analysis of variance for repetitions (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed $\sqrt{(X + 0.5)}$), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	5.70	5.9^{xx}	9.3^{xxx}	0.1	5.7^{xx}
Ages (A)	1	0.20	0.2	2.3	1.6	0.0
GxA	1	0.55	0.6	0.2	0.2	0.6
S.W.G.	28	0.97				
Total subjects	31					
Conditions (C)	1	0.37	1.5	0.2		
Trials (T)	4	2.15	8.9^{xxxx}	0.4		
GxC	1	0.01	0.0	0.8		
GxT	4	0.34	1.4	1.1		
AxC	1	0.87	3.6	2.0		
AxT	4	0.16	0.6	0.5		
CxT	4	0.52	2.1	2.2		
GxAxC	1	0.28	1.1	0.8		
GxAxT	4	0.33	1.4	1.6		
GxCxT	4	0.15	0.6	1.1		
AxCxT	4	0.42	1.7	2.2		
Final Residual	256	0.24				
Grand Total	319					

The trials effect was significant when total visual fixation was not taken into account ($F = 8.9$, df 4/256, $p < .001$), but became nonsignificant when total visual fixation was covaried out ($F = 0.4$, df 4/255, n.s.). Tukey's HSD test was used to test the differences between the unadjusted means in order to find the source of the effect in the analysis of variance. It was found that significantly more repetitions ($p < .01$) occurred on trial 1 than on trial 2, trial 3, trial 4 and trial 5. Thus, although there was a decrease in the number of repetitions from the first trial to subsequent trials, this could be accounted for by the corresponding decrease in total visual fixation.

III.B.5. Dishabituated Fixation

This was a comparison of the amount of visual fixation which occurred in the first 15 seconds of the fifth trial with that in the 15 seconds of the sixth trial. An increase in the sixth trial was taken as an index of dishabituation.

The means and standard deviations appeared to be unrelated and so the raw data were analysed.

Table 21 gives the means and standard deviations for this measure. These indicate that all of the four groups of children showed an increase in visual fixation when the patterns were altered.

The analysis of variance confirmed this observation and is summarized together with the two analyses of covariance in Table 22. The Pattern effect was highly significant ($F = 107.3$, df 1/85, $p < .001$) indicating that there was an increase in the visual fixation from the first fifteen seconds of the fifth trial to the fifteen seconds of the sixth trial.

The only other significant result was for the Group term when C.A. differences between the two groups were covaried out ($F = 4.3$, df 1/27, $p < .05$). This showed that the mongol children looked longer than did the normal children.

These results show that both the mongol and the normal children responded to a change in the patterns by an increase in visual fixation. This indicates that the decrease in visual fixation that was shown by all of the children over the first five trials was due to habituation and not to fatigue. If the decrease had been due to fatigue no increase in visual fixation would have occurred when the patterns were altered.

Table 21: Means and Standard Deviations for Dishabituated Fixation. The data were not transformed

Condition Same

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Pattern	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
Repeated	3.313	3.469	2.937	1.746	2.719	1.467	3.938	2.275	3.23	5.98
Altered	9.063	3.020	6.719	2.226	10.000	2.946	9.125	2.703	8.73	
Means of Totals	6.19		4.83		6.36		6.53			
	5.51				6.45					

Condition Different

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Pattern	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
Repeated	5.969	4.695	2.063	2.267	2.719	2.644	2.844	2.478	3.40	5.46
Altered	7.688	3.127	6.875	3.399	7.844	1.827	7.688	2.542	7.52	
Means of Totals	6.83		4.47		5.28		5.27			
	5.65				5.27					

Table 22: Analysis of variance for dishabituation fixation (raw data) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	2.53	0.2	4.3^{x}	0.2
Ages (A)	1	25.38	2.5	0.2	1.1
GxA	1	30.00	2.9	1.3	2.8
S.W.G.	28	10.20			
Total subjects	31				
Conditions (C)	1	8.51	1.2		
Patterns (P)	1	741.13	107.3^{xxxx}		
GxC	1	13.78	2.0		
GxP	1	20.32	2.9		
AxC	1	2.82	0.4		
AxP	1	0.78	0.1		
CxP	1	15.13	2.2		
GxAxC	1	1.32	0.2		
GxAxP	1	6.13	0.9		
GxCxP	1	0.13	0.0		
AxCxP	1	23.63	3.4		
Final Residual	85	6.91			
Grand Total	127				

IV. DISCUSSION

The most outstanding feature of this experiment was the similarity in the way the mongol and normal children looked at the patterns. Although this conclusion is necessarily confined to the patterns that were used and to the way in which they were presented, it is a useful starting point. In one situation mongol children have been shown to react in terms of total visual fixation time, number of fixations, alternations and repetitions and habituation and dishabituation in much the same way as normal children of the same M.A. If this situation is modified and the reactions of the two groups of children are found to be different, this difference would most probably be due to the modifications. We thus have an effective baseline for looking at visual perception in mongol children.

The experiment was designed to compare the extent to which mongol and normal children of similar mental development compared two patterns and showed habituation and dishabituation. There were no major group differences but it is worth noticing that when the amounts of visual fixation were controlled, the measure of alternations failed to show that two different patterns were compared more often than two identical patterns. This is contrary to Harris' (1973) finding with normal children. However, a more recent study by Ruff (1975) which was discussed in Chapter 2 (section II.C.1) reported that when looking time was taken into account, more alternations occurred between patterns which were extremely similar than between more different patterns. It may be that the children in my experiment made as many alternations when the patterns were identical as when they were different because they were looking for differences between the identical patterns and were comparing the different patterns. It should be noted that the children were older than those in Harris' and Ruff's experiments.

Given that there is now an experimental baseline for studying the visual perception of mongol children, we can turn our attention to possible ways in which the visual perception of mongol and normal children of similar mental age may be different.

One possibility concerns the influence of tactile perception. A question which was raised at the end of Chapter 1 was whether the tactile deficit which has been found in the adult mongol is present in the young mongol. If the mongol child is

inferior to the normal child at tactile discriminations the question arises as to whether this would effect how the young mongol would visually inspect a three-dimensional object which he could touch.

The argument is somewhat complex since it involves two possibilities. The first is that there are tactile differences between the two groups and the second that these affect the visual perception of three dimensional objects. The next experiment deals with the first possibility by looking for evidence of a tactile deficit in mongol children.

CHAPTER 5

Experiment 2: The Recognition of Shapes Across Modalities by Normal and Mongol Children of Similar Mental Age

I. INTRODUCTION

The previous experiment established that the visual behaviour of normal and mongol children at the same level of development was similar when they were presented with two dimensional patterns. The aim of this next experiment was twofold. The first aim was to discover whether there is any support for the proposal that the tactile deficit which has been found in adult mongol persons (Chapter 1, section II.F.2) is also present in the young mongol. The second aim was to extend the findings of the first experiment by comparing the visual reactions of normal and mongol children to patterns which are solid and three dimensional.

It was pointed out in Chapter 2 when the tactile abilities of the young normal child were considered (section III) that although there are many methods which can be used to investigate visual perception in the young child this is not true for tactile perception. There is only one experiment in the literature which has explored the tactile abilities of young normal children of less than one year old and this employed a cross-modal procedure. The experiment, which was by Bryant et al (1972), was discussed in Chapter 2, section III.B. The procedure relies on the observation that young children are attracted to and will reach for an object which makes a noise.

The experiment involved two tasks. One was a visual within modal task in which children were first shown an object which made a noise. Six to 12 month old children reached significantly more than expected by chance for this object when it was later presented with a different object. In the tactile-visual cross-modal task the child first held an object but could not see it whilst it made a noise. The children reached more than expected by chance for the object which they had held when it was one of a pair of ellipsoids. However the children performed at chance level on the tactile-visual cross-modal task with a pair of cuboid objects.

There is one significant disadvantage to using this experimental procedure and also one added advantage. The disadvantage is that although a positive result with the tactile-visual cross-modal task indicates that the children are capable of tactile discrimination, a negative result does not necessarily imply that they are incapable of tactile discrimination. The failure may be one either of tactile discrimination, or of visual discrimination or of integration of information across the modalities. A tactile within-modal and visual within-modal task are necessary to isolate the failure. The visual within-modal task is straightforward and was included by Bryant et al (1972).

On the other hand the tactile within-modal task does not appear to be viable since it requires that the child tactually inspects two objects which he cannot see and selects one of them. There is evidence that children up to the age of seven months will not reach for an object which has been completely hidden by an opaque cloth (Gratch, 1972). Between 9 to 12 months the child will search for an object which he sees being hidden in front of him (e.g. Miller, Cohen and Hill, 1970). However, there is no report in the literature as to whether or not a young child will tactually explore an object he cannot see.

A pilot study was therefore carried out to examine this. Mongol and normal children with mental ages of less than two years old were required to feel two objects which were fixed inside a box. The child could put one or both hands through a hole in the side of the box. The children became upset when they discovered that they could not see the objects and refused to touch them. The outcome of this pilot study eliminated the possibility of including a tactile within-modal task with the mongol and normal children.

Therefore if a child performs at chance level on the tactile-visual cross-modal task and above chance level on the visual within-modal task, it may be concluded that touch is implicated in some way but that it is unclear in exactly what way. We will not know whether it is a pure tactile failure or a failure of integration of information across the modalities.

The additional advantage of using the procedure devised by Bryant et al (1972) is that it provides an opportunity to extend the findings from the first experiment with two dimensional patterns to a situation in which the patterns are solid and

three dimensional. If the mongol and normal children perform at the same level on the visual within-modal task this would indicate that their visual abilities are comparable when the objects are three dimensional. However, if it is found that the visual abilities of the mongol and normal children are different this could be because the patterns are three dimensional whereas in experiment I, when there were no differences in the visual behaviours of the two groups, the patterns were two dimensional. except that no discrimination was in each.

II. METHOD

II.A. Subjects

There were 32 mongol children and 32 normal children in this experiment, and their C.A.s ranged from 7 to 46 months.

As in the first experiment the mongol children were tested before the normal children. This was because the mongol and normal children were to be matched for M.A., sex and social class, and each mongol's M.A. was not assessed until after he had completed the experiment. The resulting matched pairs of normal and mongol children were put into one of two age groups, age I or age II, depending on the C.A. of the mongol. In each of these four groups, mongol age I, mongol age II, normal age I and normal age II, there were 16 children. Table 23 gives the means, standard deviations and ranges in months of the C.A.s of these groups.

Table 23: Chronological Ages of the groups (in months)

	MONGOL		NORMAL			
AGE I	Mean	19.81	Mean	11.95	Mean	15.88
	S.D.	4.33	S.D.	2.3	S.D.	5.26
	Range	12.0-25.1	Range	7.9-15.2		
AGE II	Mean	31.37	Mean	16.01	Mean	23.7
	S.D.	5.71	S.D.	3.09	S.D.	9.01
	Range	22.2-45.2	Range	11.2-22.1		
	Mean	25.6	Mean	13.98		
	S.D.	7.7	S.D.	3.38		

It can be seen from this table that the age I children were younger than the age II children although there was some overlap. This table also shows that the mongol children were approximately twice the age of the normal children. This was because the C.A.s of the mongol children were greater than their M.A.s, whilst the C.A.s and M.A.s of the normal children were similar. Therefore the difference in the C.A.s of the mongol and normal children was a direct result of their being matched for M.A.

II.A.1. Matched aspects of the Mongol and Normal Children

a) Mental Age

The means, standard deviations and ranges in months of the M.A.s of the four groups of children are shown in Table 24.

Table 24: Mental Ages of the groups (in months)

	MONGOL		NORMAL			
AGE I	Mean	11.98	Mean	12.59	Mean	12.28
	S.D.	2.48	S.D.	2.66	S.D.	2.55
	Range	8.1-15.4	Range	8.4-16.2		
AGE II	Mean	16.90	Mean	15.87	Mean	16.39
	S.D.	3.27	S.D.	3.17	S.D.	3.21
	Range	11.0-21.8	Range	10.2-23.0		
	Mean	14.44	Mean	14.23		
	S.D.	3.8	S.D.	3.32		

This table shows that the mongol and normal children, within each of the two age groups, were fairly well matched, and that the age II children had larger M.A.s than the age I children.

b) Sex

Eight of the 16 mongol age I children and six of the 16 mongol age II children were female. Each of these children was matched with a normal child who was also female. All of the other children were male.

c) Social Class

The Registrar General's Index was used to assess the social class of each mongol child who was then matched with a normal child of the same class.

The numbers of mongol and normal children at each age level who were classified into each of the six categories are shown in Table 25. It can be seen that in each class there were the same number of mongol children as there were normal children.

Table 25: The Social Classes of the children in the groups as classified by the Registrar General's Index.

	MONGOL						NORMAL					
	I	II	IIIN	IIIM	IV	V	I	II	IIIN	IIIM	IV	V
AGE I	2	8	3	2	1	0	2	8	3	2	1	0
AGE II	3	3	5	2	1	2	3	3	5	2	1	2
Total	5	11	8	4	2	2	5	11	8	4	2	2

Thus every mongol child taking part in this experiment was individually matched with a normal child for M.A. as measured by the Bayley Scales of Mental Development, sex and social class as given by the Registrar General's Index.

II.A.2. Discarded Subjects

Fourteen mongol children and ten normal children were discarded from this experiment for the following reasons.

One normal child was frightened of the stimulus material which was used, in particular the noise which was emitted from the objects which were presented to the child during the experiment. This noise was an essential part of the experiment, and the mechanism which produced it failed to work during the testing of six mongol children and five normal children. They therefore had to be discarded.

The response that was scored was which of two objects the child first reached towards; this response was not scorable for eight mongols and three normals either because the child reached for both objects simultaneously (three mongols and one normal) or because he failed to reach for an object (five mongols and two

normals). Finally, one normal child was discarded because there were more than two months between his M.A. and his C.A.; he was thus considered to be inadequate as a control.

II.B. Stimulus Material

Four hollow objects made of fibre glass and painted red were used. These are illustrated in Figure 4. Each object contained an electronic device such that when the object was tilted a mercury switch completed a circuit activating a 'bleeper'. Two of the objects (Pair E) were ellipsoids $4\frac{1}{2}$ cm. high and 4 cm. wide, but one had a gulley 1 cm. wide and deep cut out of its upper surface. The latter object will be referred to as the incomplete ellipsoid (abbreviated to E^I) and the other as the complete ellipsoid (abbreviated to E^C). The other objects (Pair C) were cubes 4 cm. high by $3\frac{1}{2}$ cm. by 3cm. One of the cubes had a similar gulley to the incomplete ellipsoid and will be referred to as the incomplete cube (abbreviated to C^I). The fourth object will be referred to as the complete cube (abbreviated to C^C).

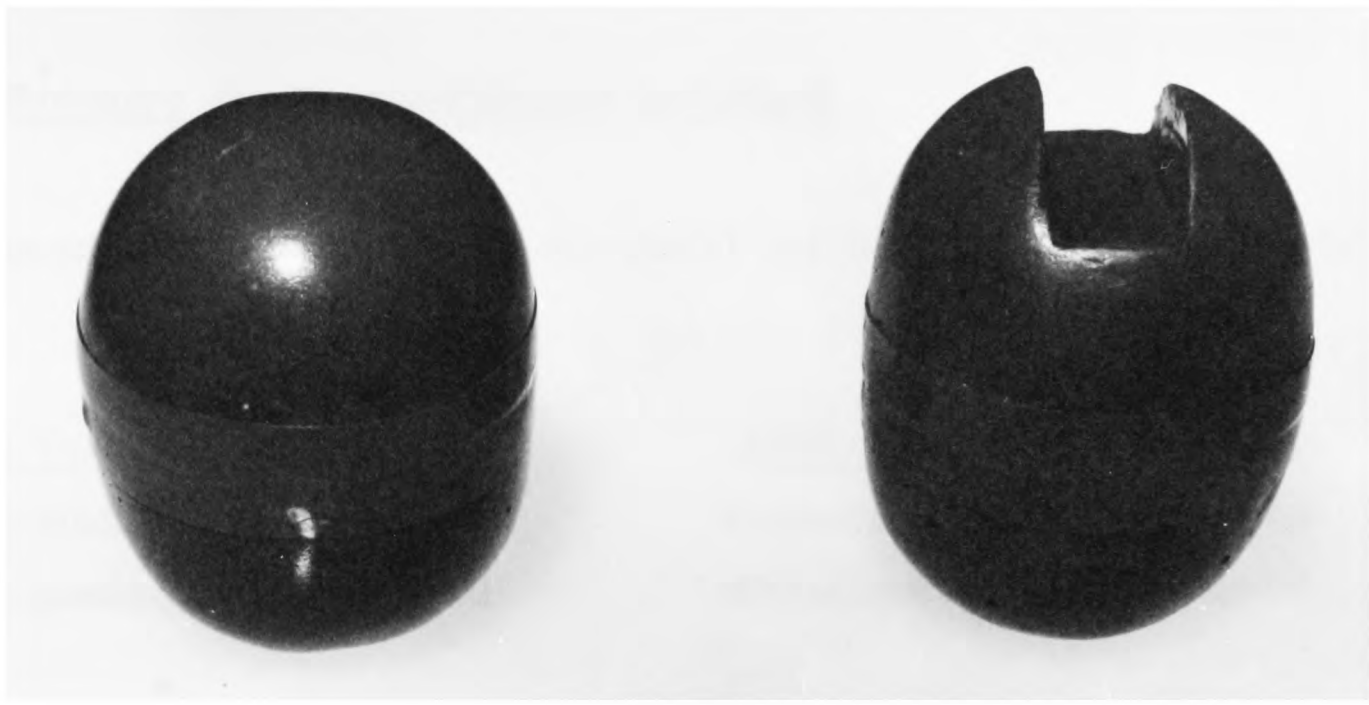
II.C. Procedure

II.C.1. Counterbalancing

Each of the 64 children completed two visual within-modal tasks and two tactile-visual cross-modal tasks. One of each type of task was presented during two different visits. Each task consisted of three stages involving one pair of objects. In stages 1 and 3 two objects were placed side by side in front of the child. In stage 2 of each visual within-modal task one of the objects was held in front of the child so that he could see it but not touch it. In stage 2 of each tactile-visual cross-modal task one of the objects was placed in the child's hand so that he could touch it but could not see it.

Three variables were randomized as far as possible across the 16 children in each group. These are summarized in Table 26. The first variable was whether the first of the tasks on the two visits was within-modal or cross-modal. For half of the children in each group the first task on the first visit and the second task on the second visit were within-modal, and the other tasks were cross-modal. The other children received the opposite orders.

Pair E



Pair C

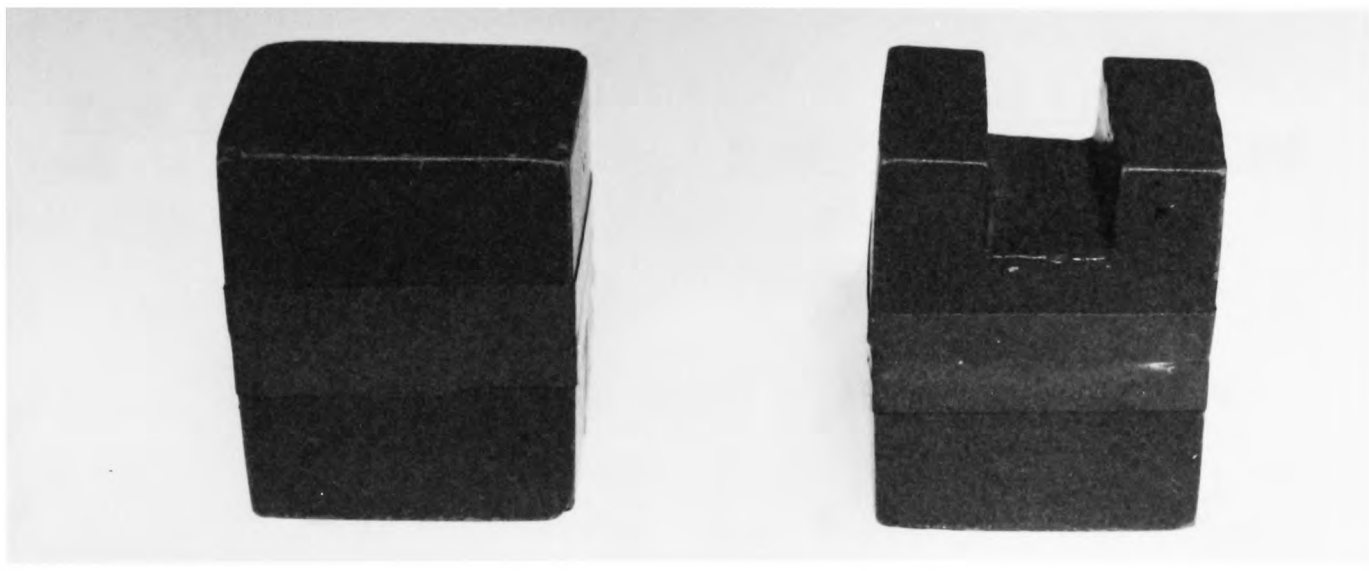


Figure 4: The two pairs of objects

Table 26: Summary of the randomization procedure

1) Order of presentation of the visual within-modal and tactile-visual cross-modal tasks

Order	First Visit		Second Visit	
	First Task	Second Task	First Task	Second Task
a	Within-modal	Cross-modal	Cross-modal	Within-modal
b	Cross-modal	Within-modal	Within-modal	Cross-modal

2) Order of the pairs of objects (C or E) and the object (c or I) presented in stage 2

Order	First Visit		Second Visit	
	First Task	Second Task	First Task	Second Task
i	C^I	E^c	C^c	E^I
ii	C^c	E^I	C^I	E^c
iii	E^c	C^I	E^I	C^c
iv	E^I	C^c	E^c	C^I

3) Order of the position of the stage 2 object in stage 1 and stage 3 relative to to the other member of the pair.
The letters R and L stand for right and left respectively as seen by the child.

Order	First Visit				Second Visit			
	First Task		Second Task		First Task		Second Task	
	Stage 1	Stage 3	Stage 1	Stage 3	Stage 1	Stage 3	Stage 1	Stage 3
p	L	R	R	L	L	L	R	R
q	L	L	R	R	L	R	R	L
r	R	R	L	L	R	L	L	R
s	R	L	L	R	R	R	L	L

The second variable to be balanced was which pair of objects, the cubes (Pair C) or the ellipsoids (Pair E) was used for each task and in particular whether the incomplete (I) or the complete (c) member of the pair was presented in stage 2. Every child received both pairs on each visit. Half of the children in each group were presented with Pair C on the first task of the first and second visit and Pair E on the second task of each visit. The two pairs were presented in the opposite order for the other children.

The order of the pairs was the same for the two visits, so that each child completed a within-modal and a cross-modal task with each pair. For half of the children who received each order of the two pairs of objects, the incomplete member of the pair was presented in stage 2 of the first task on the first visit, and the complete member of the pair was given in stage 2 of the second task on the same visit. On the next visit the complete object was used in stage 2 of the first task and the incomplete object was presented in stage 2 of the second task. The other children received the opposite order.

The final variable was the left-right positions of the two objects which were presented in stages 1 and 3 of each task. It was not feasible to randomize this completely because of the number of children, and so four of the possible orders were selected. These were selected so that for each child the stage 2 object was presented in stages 1 and 3 as often to the child's right as to his left.

The variables were combined so that all possible combinations of the first two variables occurred and as many as possible with the third variable. It was ensured that all of the different orders were represented equally often, and that each of the 16 children in a group received a different combination. The same 16 combinations were used for all the children in each of the four groups.

II.C.2. The Method of Presentation

The experiment was carried out in the child's home on two visits which were separated by more than three days and less than eight days. On each visit there were two tasks and these were presented one after the other. During the experiment the child sat on his mother's lap in front of a table. The experimenter stood on the opposite side of the table. The mother was asked to remain quiet and not to point at the objects which were presented.

In stage 1 of both the within-modal and the cross-modal tasks, two objects were placed side by side on the table about eight inches apart and out of the child's reach. When he had looked at them both they were removed. In stage 2 of the tactile-visual cross-modal task the experimenter walked round the table to the child's right hand side, and keeping the objects out of sight from the child and the mother, placed the child's hand on one of the objects. The experimenter then tilted the object so that it produced a noise and drew the child's attention to the noise. The object was then removed, again ensuring that it was not visible to either the mother or the child. In stage 2 of the visual within-modal task one of the objects was held in front of the child out of his reach, and when he was looking at it, it was tilted so that it produced a noise. The object was then removed. In stage 3 the two objects were placed on the table as in stage 1, and when the child had looked at both of them, the experimenter pushed them towards the child until they were within his reach. The object which the child first reached for and made contact with was noted.

When the two tasks had been completed on the first visit, the child was assessed on the Bayley Scales of Mental and Motor Development.

II.C.3. The Scoring of the Experimental Observation

The measure was the number of children in each group who, in stage 3, reached for and made contact with the object which had been presented in stage 2. This was selected because if the number is more than expected by chance this is evidence that the object was recognised. Each group had separate scores for both the visual within-modal and the tactile-visual cross-modal tasks with the ellipsoids and the cubes.

III. RESULTS

The results of this experiment are shown in Table 27.

The binomial distribution model was used to test whether, for each score, the number of children who reached for the stage 2 object was significantly greater than would be expected by chance.

Overall the results for the normal children confirm the findings of Bryant et al

Table 27: Number of children in each group who, in stage 3, reached for the stage 2 object out of the total number of children in the group. The results are given separately for each type of task with each pair of objects.

1) Visual within-modal task with ellipsoids

	MONGOL	NORMAL	
AGE I	10/16 p > .10, n.s.	12/16 p < .02	22/32 p < .02
AGE II	13/16 p < .005	13/16 p < .005	26/32 p < .0002
	23/32 p < .006	25/32 p < .0007	

2) Visual within-modal task with cubes

	MONGOL	NORMAL	
AGE I	8/16 p > .10, n.s.	13/16 p < .005	21/32 p < .04
AGE II	9/16 p > .10, n.s.	12/16 p < .02	21/32 p < .04
	17/32 p > .10, n.s.	25/32 p < .0007	

3) Tactile-visual cross-modal task with ellipsoids

	MONGOL	NORMAL	
AGE I	10/16 p > .10, n.s.	12/16 p < .02	22/32 p < .02
AGE II	9/16 p > .10, n.s.	14/16 p < .001	23/32 p < .006
	19/32 p > .10, n.s.	26/32 p < .0002	

4) Tactile-visual cross-modal task with cubes

	MONGOL	NORMAL	
AGE I	7/16 p > .10, n.s.	7/16 p > .10, n.s.	14/32 p > .10, n.s.
AGE II	10/16 p > .10, n.s.	12/16 p < .02	22/32 p < .02
	17/32 p > .10, n.s.	19/32 p > .10, n.s.	

(1972). In the visual within-modal task more normal children reached in stage 3 for the object which they had seen in stage 2 than for the other object. The numbers were significantly greater than could be expected by chance for both the ellipsoids ($p < .0007$) and the cubes ($p < .0007$) and this was true for both age groups.

In the cross-modal task, although the majority of normal children reached for the object which they had felt in stage 2 this was only significantly greater than chance for the ellipsoids ($p < .0002$). However when the two age groups were considered separately it was found that the older normal children did reach significantly more often than expected by chance for the stage 2 object when the objects were cubes ($p < .02$).

The mongol children on the other hand performed significantly better than chance in only the visual within-modal task when the objects were ellipsoids ($p < .006$). In fact in this task it is only the older mongol children who reach more than expected by chance ($p < .005$). The older mongol children performed at chance level in the visual within-modal task with the cubes ($p > .10$, n.s.) and in both tactile-visual cross-modal tasks (both $p > .10$, n.s.). The younger mongol children performed at chance level in all of the four tasks (all $p > .10$, n.s.).

Comparisons were also made between the performances of the mongol and normal children on each task using the X^2 test. On the visual within-modal tasks there was no difference between the groups for the ellipsoids ($X^2 = 0.08$, df = 1, n.s., one tailed), but with the cubes the mongols were inferior to the normals ($X^2 = 3.39$, df = 1, $p < .05$, one tailed). On the tactile-visual cross-modal tasks with the ellipsoids the mongols were inferior to the normals ($X^2 = 2.69$, df = 1, $p < .06$, one tailed) but there was no difference with the cubes ($X^2 = 0.06$, df = 1, n.s., one tailed), since on this task the normals performed as badly as the mongols.

IV. DISCUSSION

This experiment had two aims. The first was to discover whether there was any evidence that the young mongol has a tactile deficit. The second aim was to compare the visual responses of normal and mongol children to objects which were solid and three dimensional.

Taking the second aim first, the results of this experiment indicate quite clearly that mongol children are less able than normal children of similar mental age at discriminating three dimensional objects visually. All of the normal children performed above chance level on the visual within-modal tasks with the cubes and ellipsoids. On the other hand, only the age II mongols performed above chance level on a visual within-modal task and then only with the ellipsoids. The fact that a difference in the visual abilities of the mongol and normal children has been found in this experiment, but was not found in experiment I, may be because three dimensional objects were used in this experiment whereas in experiment I the patterns were two dimensional. There are of course other differences between these two experiments, such as the method of presentation, which could also be the source of the difference.

With respect to the first aim, it was pointed out in the Introduction to this experiment that a tactile deficit can only be implicated if the children perform at chance level on the tactile-visual cross-modal task. None of the mongol children performed above chance level on these tasks with either the cubes or the ellipsoids. In contrast both age groups of normal children succeeded with the ellipsoids and the older normal children also performed above chance level with the cubes. Since the younger mongol children responded at chance level in both visual within-modal tasks, this visual failure alone would account for their failure on the tactile-visual cross-modal tasks. However, the older mongols responded at a level above chance in the visual within-modal task with the ellipsoids and therefore a difficulty with visual discrimination cannot account for their failure on the cross-modal task with this pair of objects. In this task at least a tactile deficit in the young mongol is implicated although not proven.

No measure was taken of how the mongol and normal children visually inspected these three dimensional objects. Therefore the possibility cannot be ruled out that although their visual behaviours are similar when patterns are two dimensional as demonstrated in experiment I, their visual behaviours are different when they view three dimensional objects. This possibility was examined in the next experiment.

CHAPTER 6

Experiment 3: A Comparison of the Visual Behaviour of Mongol and Normal Children to Two Dimensional Patterns and Three Dimensional Objects

I. INTRODUCTION

In experiment 1 the looking behaviour of normal and mongol children of the same mental age was similar when they were presented with simple two dimensional patterns. On the other hand the results of the second experiment indicated that this may not be so if the children are presented with three dimensional objects to look at.

The suggestion that young normal and mongol children look in different ways at solid (though not at flat) objects raises some interesting possibilities. One of these is that solid objects normally can be handled and flat objects usually cannot. Since the second experiment has provided evidence that the mongol's tactile perceptual system in some way differs from that of the normal's, the way in which mongols perceive three dimensional objects visually and the way in which they handle them may be connected.

However there were many other methodological differences between experiments 1 and 2 besides the fact that one used two dimensional patterns and the other three dimensional objects. Therefore the purpose of this third experiment was to compare directly the visual responses of normal and mongol children to two dimensional patterns which they could look at and to three dimensional objects which they could look at and touch. I decided to let the children touch the three dimensional objects but not the two dimensional patterns because I was interested in the possibility that touch might in some way be related to the visual response to three dimensional objects. If differences are found in the ways in which mongol and normal children look at two dimensional patterns and three dimensional objects, the role of touch can be explored in a subsequent experiment.

Thus if the differences in the results of the first two experiments are due to the mongol and the normal children responding visually in a similar way to two dimensional patterns and in different ways to the three dimensional objects, this

should occur in this third experiment. However if the visual responses of the two groups of children are similar to two dimensional patterns and three dimensional objects, the difference in the results of the first two experiments must have been due to some other methodological difference.

II. METHOD

II.A. Subjects

A total of 32 children aged between 3 and 37 months took part in this experiment. Of these, 16 were mongol and 16 were normal.

Each mongol child was individually matched with a normal child for M.A., sex and social class. There were two age groups, age I and age II. The eight chronologically youngest mongols and their normal controls were assigned to age I, whilst the eight oldest mongols and their normals were assigned to age II. There were thus four groups of children, mongol age I, mongol age II, normal age I and normal age II, and there were eight children in each of these groups. Table 28 gives the details of the C.A.s of the groups of children.

Table 28: Chronological Ages of the Groups (in months)

	MONGOL		NORMAL			
	Mean	9.94	Mean	6.87	Mean	8.42
AGE I	S.D.	4.02	S.D.	3.83	S.D.	4.1
	Range	5.9-15.1	Range	3.1-14.2		
	Mean	29.68	Mean	13.0	Mean	21.34
AGE II	S.D.	7.21	S.D.	4.29	S.D.	10.34
	Range	20.0-36.5	Range	9.7-22.5		
	Mean	19.78	Mean	9.94		
	S.D.	11.64	S.D.	4.96		

From this table it can be seen that the mongol children were considerably older than the normal children, and that the age II children were older than the age I children. The reason for the difference in C.A. between the mongol and normal children and the way in which this was taken into account in the analysis of the data were the same as discussed in Chapter 4 (section II.A.2).

The reader is also referred to Chapter 4 (sections II.A.1.a,b,c) for details of how the children were matched.

II.A.1. Matched Aspects of the Mongol and Normal Children

a) Mental Age

Table 29 gives the means, standard deviations and range in months of the M.A.s of the four groups of children.

Table 29: Mental Ages of the Groups (in months)

	MONGOL		NORMAL			
	Mean	6.48	Mean	6.65	Mean	6.56
AGE I	S.D.	3.64	S.D.	3.94	S.D.	3.66
	Range	3.2-13.4	Range	3.2-14.6		
	Mean	13.14	Mean	13.1	Mean	13.12
AGE II	S.D.	4.2	S.D.	3.65	S.D.	3.8
	Range	9.1-22.0	Range	10.4-20.5		
	Mean	9.97	Mean	9.97		
	S.D.	5.18	S.D.	4.91		

From this table it can be seen that when the group means are considered, the normals and mongols are well matched for M.A. It is also clear that the age II children both mongol and normal, have higher M.A.s than the age I children, although there is an overlap of about four months.

b) Sex

Five of the 16 mongol children were female and these were each matched for M.A. and social class with a normal female. Three of the mongol females and their controls were in age I, and two were in age II. All of the remaining mongol and normal children were male.

c) Social Class

The social class of each mongol child was found using the Registrar General's Index and a normal child selected whose father's occupation was classified in the same class.

Table 30: The Social Classes of the Children in the Groups as given by the Registrar General's Index

	MONGOL						NORMAL					
	I	II	IIIN	IIIM	IV	V	I	II	IIIN	IIIM	IV	V
AGE I	2	2	2	1	1	0	2	2	2	1	1	0
AGE II	1	0	3	4	0	0	1	0	3	4	0	0
Total	3	2	5	5	1	0	3	2	5	5	1	0

Table 30 gives the number of mongol and normal children at each age who were classified into each of the six social classes. From this it can be seen that the numbers of mongol and normal children in each class were identical.

Thus each mongol child who completed this experiment was matched with a normal child who had a similar M.A., was of the same sex and whose father's occupation was classified in the same social class.

II.A.2. Discarded Subjects

In order to obtain the final sample of 16 mongol and 16 normal children, a total of 36 mongols and 28 normals were seen. The 20 mongols and 12 normals were discarded for the following reasons.

Four mongols had severe squints and since the method to be used in the experiment required the experimenter to judge the direction of the child's gaze they were discarded. Two of the mongols seemed to be frightened of the apparatus that was used, and no amount of encouragement would get them to participate.

The recording apparatus developed faults whilst the testing of two mongols and three normals was in progress and so their data had to be discarded. One mongol and three normals became upset during the course of the experiment and so it was terminated before the end.

Eleven mongols and six normals did complete the experiment but their data had to be discarded. The mongols had been assigned to the wrong treatment groups and the normals did not meet the requirements of the M.A. matching procedure. There was more than a two months' difference between the M.A. of

each of these normals and the M.A.s of the mongols with whom they were being matched and so these normals were not considered to be adequate as controls.

II.B. Apparatus

The basic apparatus which was used in experiment I was also used in this experiment. The reader is therefore referred to section II.B. in Chapter 4 for details. The only difference was that the black box was modified so that the three dimensional objects (abbreviated below to 3 D objects) could be presented to the children. These modifications are described below.

As in the first experiment, the two dimensional stimulus cards slotted into the back of the box (Figure 5). When they were in position there were 46 cm. between the two dimensional patterns (abbreviated below to 2 D patterns) which were pasted on each card.

The 3 D objects fitted into two platforms in the base of the box. These were 20 cm. in front of the back of the box and 26 cm. apart (Figure 6). A peg in the base of each object fitted into a hole in the platform. The object was held firmly in place by a rod which was screwed against the peg from the side of the base of the box. The platforms were designed so that if the object was touched a second platform beneath the visible platform tilted. This tilt activated microswitches arranged between the two platforms. These microswitches formed a break in a circuit between each platform and a channel on the event recorder. Therefore whenever an object was touched, the lower platform tilted which activated a microswitch and caused an event to be registered on the event recorder. When the 2 D patterns were presented a cap was fitted over the holes in the two platforms.

II.C. Stimulus Material

In experiment 1 the children were presented with a pair of white cards in a black box, and on each card either a black circle or a red cross was pasted. To be able to compare the results obtained with these 2 D patterns with those to be obtained with 3 D objects, 3 D crosses and spheres of the same colours and measurements would have to have been presented in the same way as before. But this was not practical for several reasons. First, the 3 D objects would

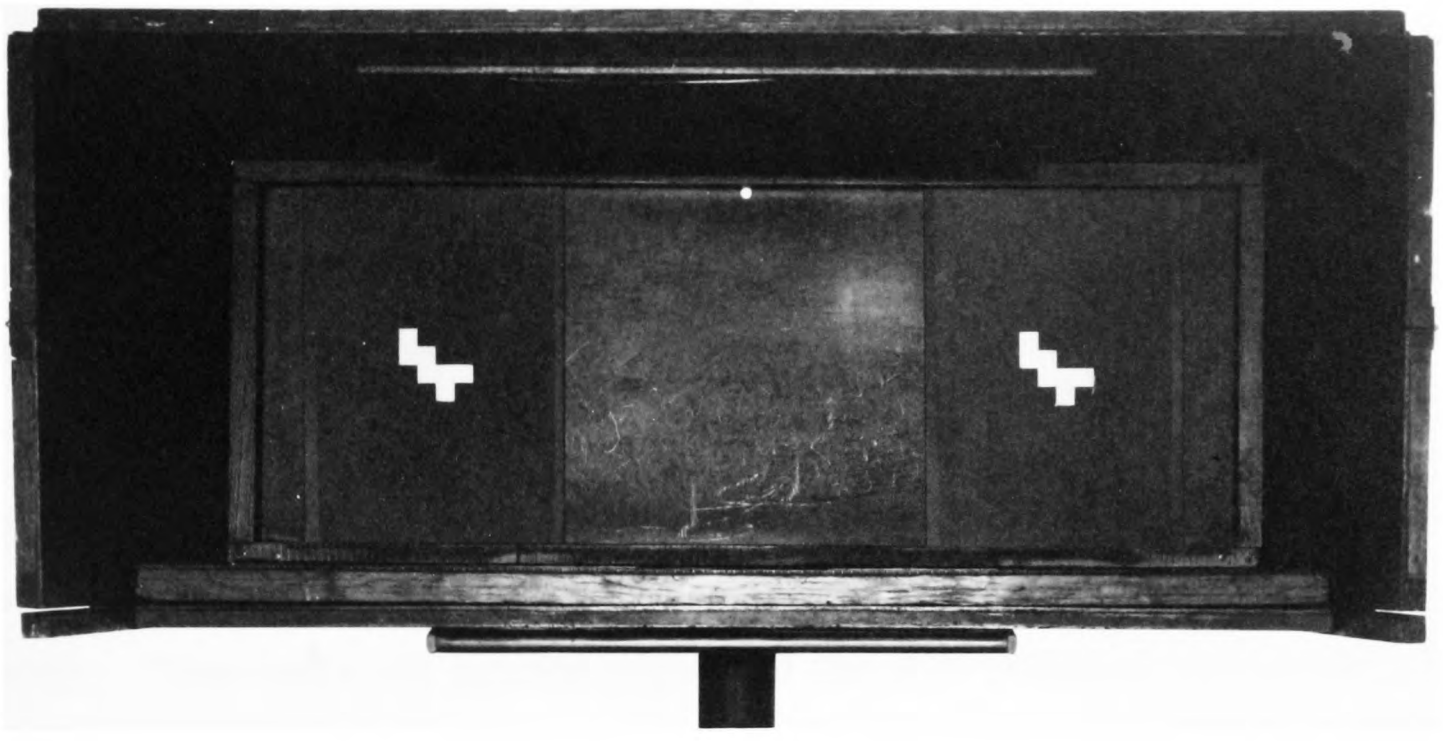


Figure 5: The presentation of the 2 D patterns

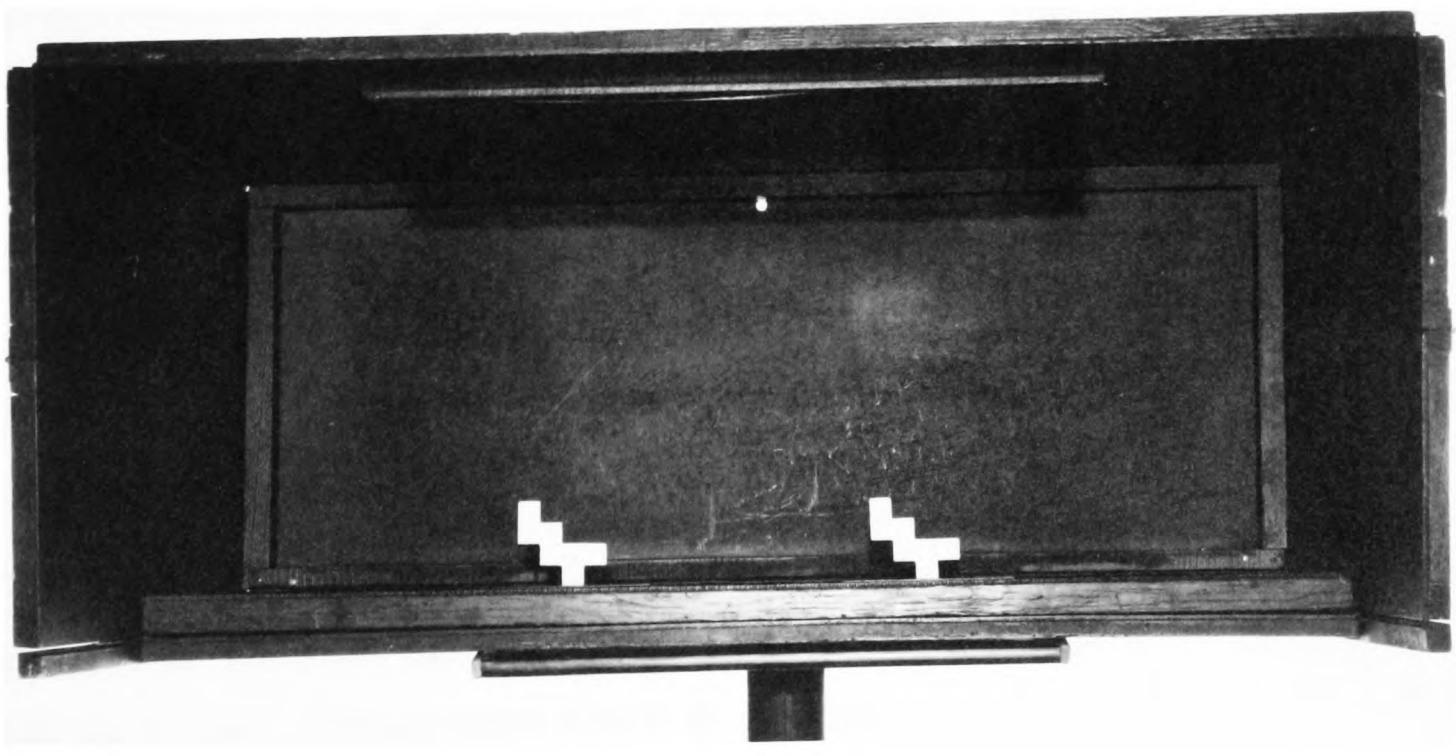


Figure 6: The presentation of the 3 D objects

have been extremely large relative to the child's hand; the sphere corresponding to the black circle which had an area of 113 sq. cm. would have occupied more than 900 cu. cm. Second, the 2 D patterns in experiment 1 were pasted onto white cards which were then presented to the child in a black box; it would not have been possible to present the 3 D objects so that they were surrounded by a similar white border.

To overcome these difficulties the children were presented with 2 D and 3 D versions of shapes whose area and volume were 20.5 sq. cm. and 307.5 cu. cm. respectively. They were all painted white and the 2 D versions were pasted on black cards and these 2 D cards and the 3 D objects were presented in a black box

There were two identical sets of stimulus material each consisting of eight different patterns. One of these sets is illustrated in Figure 7 and is described below.

The overall extent of all of the shapes both horizontally and vertically was 6 cm. and the contour length was 24 cm.

There were four different shapes. Two contained eight right angled corners and will be referred to as patterns 8A and 8B. The 8 indicates the number of corners and the letters are used arbitrarily to distinguish the shapes. The two other shapes each contained 14 right angled corners and for similar reasons are labelled 14A and 14B.

Each of the four shapes was cut out of both white cardboard and $1\frac{1}{2}$ cm. thick plywood. The cardboard shapes were each pasted centrally on a black card which measured 21 cm. wide by 34 cm. high. These were the 2 D patterns.

The plywood shapes were painted white and a metal peg 2 cm. long and $\frac{1}{2}$ cm. in diameter was inserted into the base of each. When in position the peg protruded by 1 cm. These were the 3 D objects.

In summary, there were two identical sets of stimulus material each composed of eight different patterns. Four of the patterns in each set were 2 D and four were 3 D. Each of these four patterns differed from one another in shape.

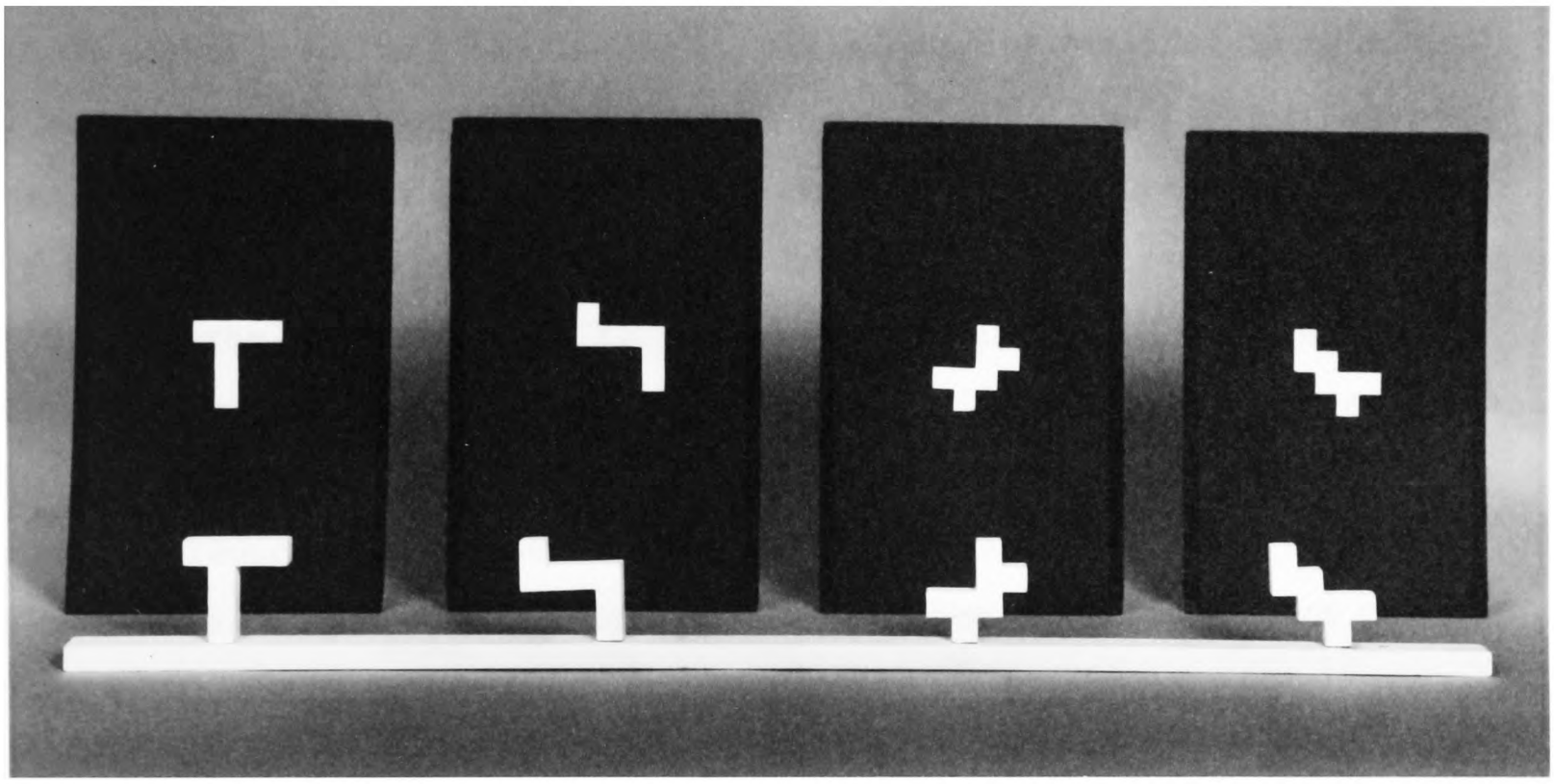


Figure 7: One set of the stimulus material.
The 2 D patterns are above the 3 D patterns
and the patterns are in the order 8A, 8B,
14A, 14B, read from left to right.

II.D. Procedure

In experiment 1 each child was tested twice; on one occasion two identical 2 D patterns were presented for five one minute trials, and one quarter minute trial; on the other occasion two different 2 D patterns were presented for the same number of trials. However in the present experiment it was decided not to use the same procedure because double the number of trials would be required since both 2 D and 3 D patterns were to be presented. The solution was to present the children with each pair of patterns for one trial lasting one minute rather than for five one minute trials, and to omit the sixth trial in each condition when the patterns were altered. This seemed a reasonable solution since these additional trials were only adopted so that habituation and dishabituation could be studied and these were not the concern of the present experiment. This substantially reduced the number of trials and so it became possible to present each child with two pairs of identical patterns and two pairs of different patterns for both 2 D and 3 D patterns.

II.D.1. Counterbalancing

Each child completed eight trials and on each trial two patterns were presented side by side. On four consecutive trials the patterns were both 2 D and on the other four consecutive trials the patterns were 3 D. With each type of pattern there were four conditions (8-8, 14-14, 14-8 and 8-14).

The patterns which could be presented for each condition are shown in Table 31. In Condition 8-8 two identical patterns each with eight right angled

Table 31: The eight possible stimulus presentations for the four different conditions

		Pattern on the child's right			
		8A	8B	14A	14B
Pattern on the child's left	8A	CONDITION 8-8		CONDITION 8-14	
	8B		CONDITION 8-8		CONDITION 8-14
	14A	CONDITION 14-8		CONDITION 14-14	
	14B		CONDITION 14-8		CONDITION 14-14

corners were presented. In Condition 14-14 the patterns were identical and each had 14 corners. In Condition 14-8 a pattern with eight corners was presented to the child's right and a pattern with 14 corners to his left. In Condition 8-14 the left-right positions of the patterns presented in Condition 14-8 were reversed.

It can also be seen from Table 31 that patterns labelled A were never paired with patterns labelled B and vice versa. The pairs with the label A will be referred to as patterns from series A, whilst those with the label B will be referred to as patterns from series B.

There were therefore two pairs for each condition, one pair from series A and one from series B. Each child was presented with 2 D patterns from one series and 3 D patterns from the other series.

Three variables were balanced as far as possible across the eight children in each of the four groups. These are summarised in Table 32 A. The first was 1) the order of presentation of the 2 D and 3 D patterns. Four children in each group received 2 D patterns on the first four trials and 3 D patterns on the second four trials. The order was reversed for the other children. The second variable was 2) the order of presentation of patterns from series A and B. Four children in each group were presented with patterns from series A on the first four trials and from series B on the second four trials. This order was reversed for the other four children.

These two variables of patterns and series were combined so that two children in each group had 2 D patterns from series A on the first four trials and 3 D patterns from series B on the second four trials. This order was reversed for two further children. Two other children were presented, on the first four trials, with 2 D patterns from series B and on the second four trials with 3 D patterns from series A. This order was reversed for the remaining two children in each group.

The final variable to be balanced was 3) the order of presentation of the four stimulus conditions. For each child the order of presentation of the conditions was identical in the two blocks of four trials. Four orders of presentation of the four conditions were obtained using a randomised Latin Square. Two children from each group were assigned to each presentation order.

Table 32 A: Summary of the variables which were counterbalanced

1) Order of presentation of the 2 D and 3 D patterns

Order	First four trials	Second four trials
a	2 D	3 D
b	3 D	2 D

2) Order of presentation of patterns from series A and series B

Order	First four trials	Second four trials
i	Series A	Series B
ii	Series B	Series A

3) Order of presentation of the stimulus conditions

Order	First Trial	Second Trial	Third Trial	Fourth Trial
p	14-8	14-14	8-14	8-8
q	8-14	8-8	14-14	14-8
r	8-8	8-14	14-8	14-14
s	14-14	14-8	8-8	8-14

Table 32 B: Assignment of mongol subjects

							First four trials		Second four trials	
Age	Subject	Order	Order of Conditions				Pattern	Series	Pattern	Series
I	1	a i p	14-8	14-14	8-14	8-8	2 D	A	3 D	B
I	2	a i s	14-14	14-8	8-8	8-14	2 D	A	3 D	B
I	3	a ii r	8-8	8-14	14-8	14-14	2 D	B	3 D	A
I	4	a ii s	14-14	14-8	8-8	8-14	2 D	B	3 D	A
I	5	b i p	14-8	14-14	8-14	8-8	3 D	A	2 D	B
I	6	b i q	8-14	8-8	14-14	14-8	3 D	A	2 D	B
I	7	b ii q	8-14	8-8	14-14	14-8	3 D	B	2 D	A
I	8	b ii r	8-8	8-14	14-8	14-14	3 D	B	2 D	A
II	1	a i q	8-14	8-8	14-14	14-8	2 D	A	3 D	B
II	2	a i r	8-8	8-14	14-8	14-14	2 D	A	3 D	B
II	3	a ii p	14-8	14-14	8-14	8-8	2 D	B	3 D	A
II	4	a ii q	8-14	8-8	14-14	14-8	2 D	B	3 D	A
II	5	b i r	8-8	8-14	14-8	14-14	3 D	A	2 D	B
II	6	b i s	14-14	14-8	8-8	8-14	3 D	A	2 D	B
II	7	b iip	14-8	14-14	8-14	8-8	3 D	B	2 D	A
II	8	b ii s	14-14	14-8	8-8	8-14	3 D	B	2 D	A

Table 32 B shows, for all of the mongol children, how these three variables were combined. Each normal child was treated in exactly the same way as the mongol child with whom he was matched.

In summary, the variables that were counterbalanced across the children were the orders of presenting 1) the 2 D and 3 D patterns; 2) the two series A and B, and 3) the four different conditions.

II.D.2. The Method of Presentation

The presentation of this experiment was essentially the same as described for experiment 1 in Chapter 4 (section II.D.2). The reader is referred back to that section for the relevant details.

The main differences were that there was only one testing session and all of the trials lasted one minute, provided that at the end of each one minute trial the child was not looking at one of the patterns. If he was fixating a pattern the trial was not terminated until he looked away from that pattern. The reason for this was so that the average length of a fixation for each trial could be calculated. This will be elaborated when the measurements are described (section II.D.3,b).

As before in experiment 1, the child sat approximately 40 cm. in front of the back of the box where the 2 D patterns were presented. Therefore he was 20 cm. from the 3 D patterns. When he was in this position there were 30^{o} of visual angle between the edges of both the 2 D and 3 D patterns.

II.D.3. The Scoring of the Experimental Observations

a) Data Collection

The data consisted of a record of which pattern the child was looking at during the eight trials. This was collected as described in section II.D.3,a for experiment 1.

In addition, on those trials when the patterns were 3 D, the amount of time that the child spent touching either or both objects was recorded. This was done automatically as described in section II.B.

b) Measurements taken from the raw data

Before taking any measurements from the chart paper of the event recorder a line was drawn across all four channels to indicate one minute from the beginning of each trial. The chart paper moved at a constant rate of five inches per minute.

Ten measures were taken from the raw data. The first four were the same as in experiment 1, and the remaining six were new. All of the measures are described below.

The Old Measures

Total Visual Fixation. This was the sum of the amount of time in seconds that the child looked at the two patterns which were presented on each of the eight trials. The maximum total visual fixation for any trial was sixty seconds.

The reason for this measure, as for all of the others, was to discover if the visual behaviours of the normal and mongol children to the 2 D and 3 D patterns were comparable. Three questions were asked. First, whether the two groups would look for similar lengths of time at the patterns as found in experiment 1 with 2 D patterns. Second, whether either or both of the groups would show more fixation of the 3 D patterns than the 2 D patterns as reported for young normal children (Chapter 2, section II.D). The final question was whether the finding, also from experiment 1, that two patterns which differed from one another in both colour and shape were fixated for longer than two identical patterns, would also occur when the patterns only varied in shape.

Number of Fixations. This measure was the sum of the number of fixations that were made to both patterns presented on each of the eight trials.

The reason for this measure was to examine the form of the children's visual behaviour when they were presented with 2 D and 3 D patterns. The previous measure of total visual fixation will show how long the children look at the two types of pattern, but will not show whether during this time the child makes many fixations which are short in duration or a few long fixations. A child might look for a similar length of time at 2 D and 3 D patterns but make more fixations to one than to the other. Alternatively, the number of fixations might be similar but the total visual fixation times different. Or the children

might discriminate between the patterns on both measures of total visual fixation and number of fixations.

By inspecting the number of fixations and, if necessary taking into account differences in total visual fixation times, the particular pattern of fixations to the two types of object can be ascertained.

As in experiment 1, the number of fixations was divided into alternations of fixation between the patterns and repetitions of fixation of the same pattern, to see whether either of these would indicate any differences in the patterns of fixation by the two groups of children to 2 D and 3 D objects.

Alternations. This was the number of times in each trial that the child looked away from one pattern and towards the other pattern.

Repetitions. This was the number of times on each trial that the child made repeated fixations to the same pattern.

The New Measures

The remaining six measures were not scored in experiment 1. Of these six, the amount of touching could not have been scored because in experiment 1 the patterns were presented out of the child's reach. In this third experiment the 3 D objects were presented within reach and so touching of them could be measured. The remaining measures were taken to compare further the way in which the mongol and normal children looked at 2 D patterns and 3 D objects.

Time to Fixate the First Pattern. This was the time in seconds from the beginning of each trial until the child looked at one of the patterns. The pattern which was the first on each trial to be looked at will be referred to as the first pattern, and the other as the second pattern.

Adult mongols have been found to respond more slowly than other retarded persons of similar C.A. and I.Q. (Chapter 1, section II.D.2). Therefore this measure was taken to examine whether or not the mongol children would be slower to look at the patterns than the normal children.

Time to Fixate the Second Pattern. This was the time in seconds from the beginning of each trial that the child took to look at the second pattern. If only one pattern was fixated during the trial, the time to first fixate the second

pattern was taken as 60 seconds which was the length of each trial.

This measure was scored to provide further information about whether the mongol children were slower than the normal children to look at the patterns.

Average Fixation Length. This measure was the mean of the average lengths of the child's fixations to the two patterns presented on each trial. The average fixation length to each pattern was calculated by dividing the total visual fixation to the pattern by the number of fixations to the same pattern. Included in the total visual fixation was the time that a pattern was fixated beyond the end of a trial provided that the fixation began before the trial should have ended. If only one pattern was looked at, the measure was taken as the average fixation length to that pattern.

This measure was taken to see if there was any difference in the average fixation length to the 2 D and 3 D patterns.

The Length of the First Fixation to the First Pattern. This was the length of the first fixation in seconds made by the child to the first pattern that he looked at on each trial.

This and the next measure were taken to see if the lengths of the first fixations made by the child to each pattern on a trial were similar to or different from the average fixation length on a trial.

The Length of the First Fixation to the Second Pattern. This was the length in seconds of the first fixation to the second pattern that the child looked at on each trial.

Touching. This was the length of time in seconds that the child spent touching the 3 D patterns when they were presented. Since both patterns could be touched for sixty seconds, the maximum score for each trial was 120 seconds.

This measure was taken to see if there was any difference in the amount of time that the mongol and normal children touched the patterns. If there were differences between the groups in the amount of touching, then any differences found in their visual behaviour on those trials when 3 D patterns were presented might be confounded with the touching differences.

III. RESULTS

The general method used for analysing the measures in the present experiment was similar to that used for experiment 1. The only difference, apart from the measures, was in the variables examined in the analyses of variance and covariance. Details of the variables examined for each measure in the present experiment are given below. The reader is referred to Chapter 4, section III.A for the details of the general method.

III.A. Factors Examined in the Analyses of Variance and Covariance

Each of the measures of the visual behaviour was analysed using a four-way split plot analysis of variance. For each of these measures there were two between subject variables and two within subject variables. The between subject variables were Groups (Mongol vs. Normal) and Ages (I vs. II). The within subject variables were Patterns (2D vs. 3 D) and Conditions (8-8 vs. 14-14 vs. 14-8 vs. 8-14).

For the measure of total touching the Patterns term was omitted, since touching could only occur when the patterns were 3 D.

In addition two analyses of covariance were performed on each measure. For one the covariate was C.A., and for the other it was M.A. The design was the same for each measure as for the analysis of variance.

III.B. Measures

III.B.1. Total Visual Fixation

This was the sum of the time in seconds that the child looked at the two patterns presented on each of the eight one minute trials. The maximum for any trial was sixty seconds.

The most appropriate transformation was found to be a logarithmic one, and since some of the scores were small the transformation log (X + 1), where X are the raw data, was selected.

Table 33 gives the means and standard deviations for each cell of the transformed data. From this table it can be seen that the total visual fixation times for the four groups of children appear to be almost identical.

Another striking result is that all of the children seem to have longer total visual fixation times when the objects are 3 D as opposed to 2 D.

The final aspect of this table worthy of notice is that there seems to be no difference in the amount of total visual fixation to each of the four conditions.

The analyses, which are summarised in Table 34, confirm these observations. The only significant F ratio was for the Patterns term ($F = 213.3$, df 1/199, $p < .001$). This showed that when the patterns were 3 D they attracted greater visual fixation, than when the patterns were 2 D.

It may be concluded from the results of this measure that both the mongol and the normal children at each age level are able at some level to discriminate between when the patterns are 2 D and when they are 3 D. They show this by looking for longer at the latter patterns than at the former. The results also show, as was found in the first experiment, that there is no difference between the fixation times of the mongol and normal children. However, in contrast to the results of experiment 1, no difference was found in the fixation times to patterns which were identical and to patterns which were different. This suggests that if the difference between two patterns is in the terms of shape only the patterns will not be looked at for longer than a pair of identical patterns, but that if the patterns are also of different colours they will be fixated for longer. However, it is possible that the differences in the shapes used in the present experiment were not sufficient to be noticed by the children, or that if they were noticed, they did not attract any more attention than two identical patterns.

It is necessary to take into account the difference in the inspection times of the 2 D and 3 D patterns when the results of measures which are not independent of total looking time are considered. These are the measures of number of fixations, alternations and repetitions which are reported in sections III.B.2, III.B.3 and III.B.4, respectively. This was achieved by an analysis of covariance of each measure with the covariate of total visual fixation transformed $\log (X + 1)$.

Table 33: Means and Standard Deviations for Total Visual Fixation. The raw data were transformed log (X + 1)

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	1.02	0.39	1.01	0.16	1.12	0.43	1.00	0.21	1.04
14-14	1.08	0.36	1.10	0.23	1.09	0.33	1.02	0.21	1.08
14-8	1.16	0.33	1.04	0.10	1.03	0.36	1.02	0.26	1.06
8-14	1.11	0.44	1.06	0.16	1.04	0.49	1.08	0.22	1.07
Means of Totals	1.09		1.05		1.07		1.03		1.06
	1.07				1.05				

3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	1.45	0.21	1.51	0.16	1.50	0.21	1.33	0.22	1.45
14-14	1.38	0.31	1.47	0.16	1.57	0.14	1.35	0.17	1.44
14-8	1.50	0.25	1.41	0.25	1.54	0.13	1.41	0.16	1.47
8-14	1.45	0.32	1.51	0.14	1.52	0.18	1.40	0.23	1.47
Means of Totals	1.45		1.48		1.53		1.37		1.46
	1.46				1.45				

Table 34: Analysis of variance for total visual fixation (transformed log (X + 1)) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.02	0.1	1.2	0.1
Ages (A)	1	0.18	0.8	0.3	0.0
GxA	1	0.15	0.6	2.0	0.7
S.W.G.	28	0.23			
Total subjects	31				
Patterns (P)	1	1.00	213.3^{xxxx}		
Conditions (C)	3	0.01	0.2		
GxP	1	0.00	0.0		
GxC	3	0.00	0.1		
AxP	1	0.01	0.2		
AxC	3	0.02	0.3		
PxC	3	0.01	0.1		
GxAxP	1	0.14	3.0		
GxAxC	3	0.05	1.0		
GxPxC	3	0.03	0.7		
AxPxC	3	0.00	0.0		
Final Residual	199	0.05			
Grand Total	255				

III.B.2. Number of Fixations

This was the sum of the number of times that the two patterns presented on each of the eight trials were looked at by the children.

The most suitable transformation was $\sqrt{(X + 0.5)}$ where X are the raw data.

The means and standard deviations for each cell of the transformed data are given in Table 35. A number of points arise from this table.

More fixations seem to occur to patterns which are 3 D than to those which are 2 D. When the four groups are considered separately, the mongol age I children do not appear to show an increased number of fixations to 3 D patterns compared to 2 D ones. All of the other groups, in particular the two groups of normal children, seem to show an increase. Finally, there seems to be a tendency for fewer fixations to occur to patterns presented in Condition 8-8.

The data were subjected to an analysis of variance and three analyses of covariance in which the covariates were total visual fixation transformed $\log (X + 1)$, C.A. and M.A. respectively. These are summarised in Table 36.

The analysis of variance confirms that the Patterns term is significant ($F = 44.9$, df 1/199, $p < .001$). However when total visual fixation is covaried out this term becomes nonsignificant ($F = 0.1$, df 1/198, n.s.). Therefore the larger number of fixations made by the children to the 3 D patterns is due to these patterns being looked at for longer than the 2 D patterns.

There was a significant interaction between Groups and Patterns ($F = 19.8$, df 1/199, $p < .001$), and this interaction is still significant when total visual fixation is covaried out ($F = 24.5$, df 1/198, $p < .001$). Tukey's HSD test was used to find the source of these interactions. The normal children made significantly more fixations to the 3 D patterns than to the 2 D patterns ($p < .01$) both when total visual fixation was taken into account and when it was not. On the other hand the mongol children made fewer fixations to the 3 D patterns than to the 2 D patterns when total visual fixation times were controlled ($p < .01$). Also when total visual fixation was held constant the mongols made fewer fixations when the patterns were 3 D than the normals did ($p < .01$).

Table 35: Means and Standard Deviations for the Number of Fixations. The data were transformed $\sqrt{(X + 0.5)}$

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	2.65	0.53	2.97	0.57	2.56	0.60	3.15	0.91	2.83
14-14	3.21	0.80	3.25	0.72	2.78	0.41	3.05	0.63	3.07
14-8	3.04	0.79	3.23	0.48	2.89	0.53	3.08	0.76	3.06
8-14	2.85	0.64	3.25	0.63	2.71	0.69	3.25	0.69	3.01
Means of Totals	2.94		3.17		2.74		3.13		2.99
	3.06				2.93				

3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	2.93	0.95	3.52	0.63	3.43	0.92	3.40	0.43	3.32
14-14	3.02	0.83	3.22	0.42	4.05	0.61	3.58	0.50	3.47
14-8	2.85	0.83	3.47	0.71	4.05	0.36	3.83	0.73	3.55
8-14	3.16	0.94	3.58	0.44	3.89	0.68	3.79	0.77	3.60
Means of Totals	2.99		3.45		3.85		3.65		3.49
	3.22				3.75				

Table 36: Analysis of variance for number of fixations (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed log (X + 1)), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	2.69	2.2	2.5	0.0	2.2
Ages (A)	1	3.14	2.5	3.5	3.9	0.2
GxA	1	1.01	0.8	0.5	2.2	0.8
S.W.G.	28	1.25				
Total subjects	31					
Patterns (P)	1	1.55	44.9^{XXXX}	0.1		
Conditions (C)	3	0.78	2.3	2.2		
GxP	1	6.82	19.8^{XXXX}	24.5^{XXXX}		
GxC	3	0.11	0.3	0.5		
AxP	1	0.58	1.7	1.5		
AxC	3	0.42	1.2	1.6		
PxC	3	0.10	0.3	0.3		
GxAxP	1	2.69	7.8^{XXX}	4.9^{X}		
GxAxC	3	0.04	0.2	0.8		
GxPxC	3	0.63	1.8	1.2		
AxPxC	3	0.09	0.2	0.2		
Final Residual	199	0.34				
Grand Total	255					

The results of these interactions suggest that when the number of fixations are adjusted for visual fixation times the mongol children make fewer and therefore longer fixations when the patterns are 3 D compared to when they are 2 D. In contrast to this the normal children make more shorter fixations to 3 D patterns than to 2 D ones. This then is the first measure to indicate a difference in the visual behaviour of normal and mongol children, and gives support to the argument that although the visual behaviour of normal and mongol children may be similar when the patterns are 2 D, they may differ when the patterns are 3 D.

The possibility that the age of the child effects how 2 D and 3 D patterns are fixated is indicated by the interaction between Groups, Ages and Patterns which is significant both when the data are not adjusted for fixation times ($F = 7.8$, df 1/199, $p < .01$), and when they are ($F = 4.9$, df 1/198, $p < .05$). Tukey's HSD test was used to find the source of the effect of these interactions which are illustrated in Figure 8 a,b.

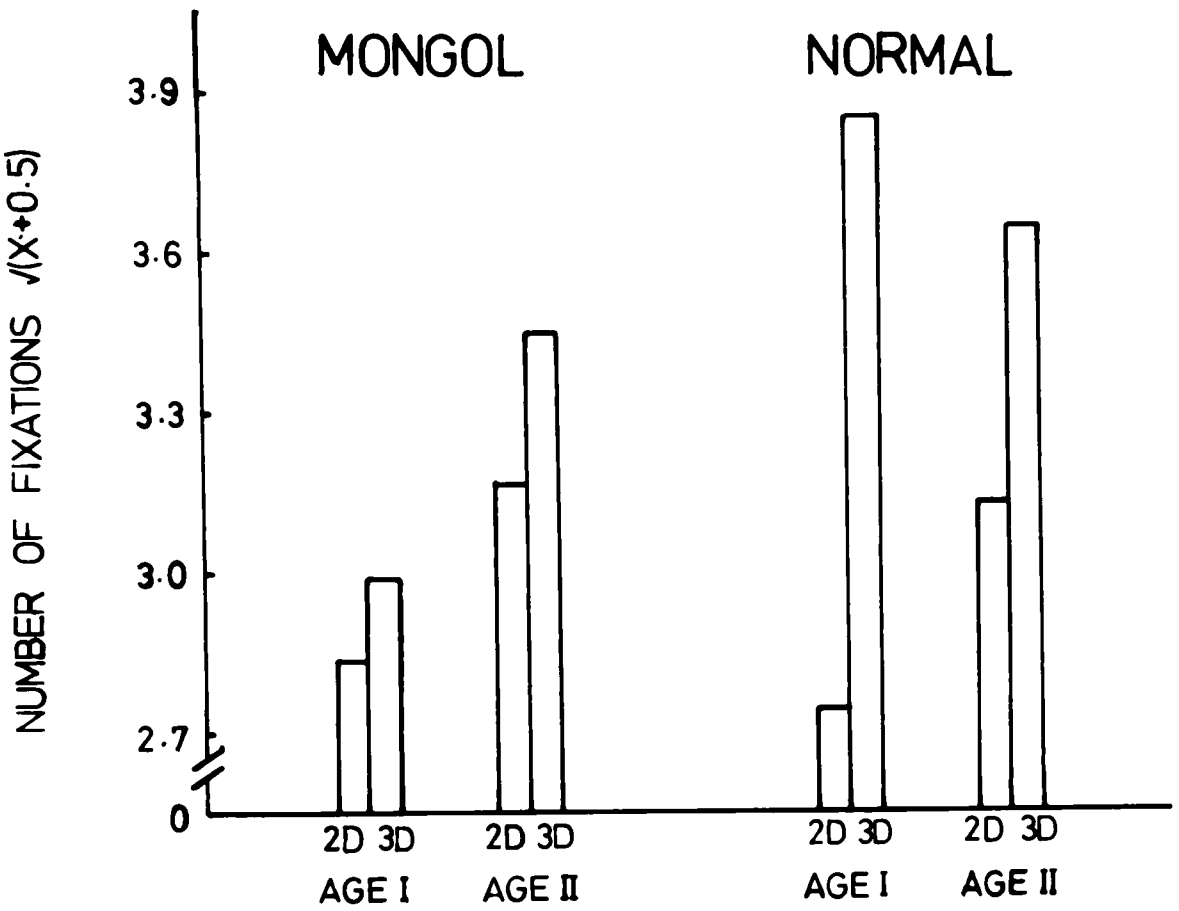
From this figure it can be seen that the effect of removing differences in total visual fixation times is to increase the number of fixations to the 2 D patterns and to decrease the number of fixations which are made when the patterns are 3 D. In particular, post-hoc tests showed that the normal children made more fixations to the 3 D patterns than to the 2 D patterns at age I ($p < .01$) both when total visual fixation was ignored and when it was taken into account. However, this difference was only significant for the age II normal children when total visual fixation times were ignored ($p < .01$). On the other hand, the mongol age I children made more fixations to the 2 D patterns than to the 3 D ones ($p < .05$) when total visual fixation times were controlled.

When the patterns were 3 D, the mongol age I children made fewer fixations than the mongol age II children ($p < .05$) and the normal age I children ($p < .01$), both when differences in total visual fixation were taken into account and when they were not. Finally when the patterns were 2 D the normal age I children made fewer fixations than the normal age II children but only when these data were adjusted for differences in total visual fixation ($p < .05$).

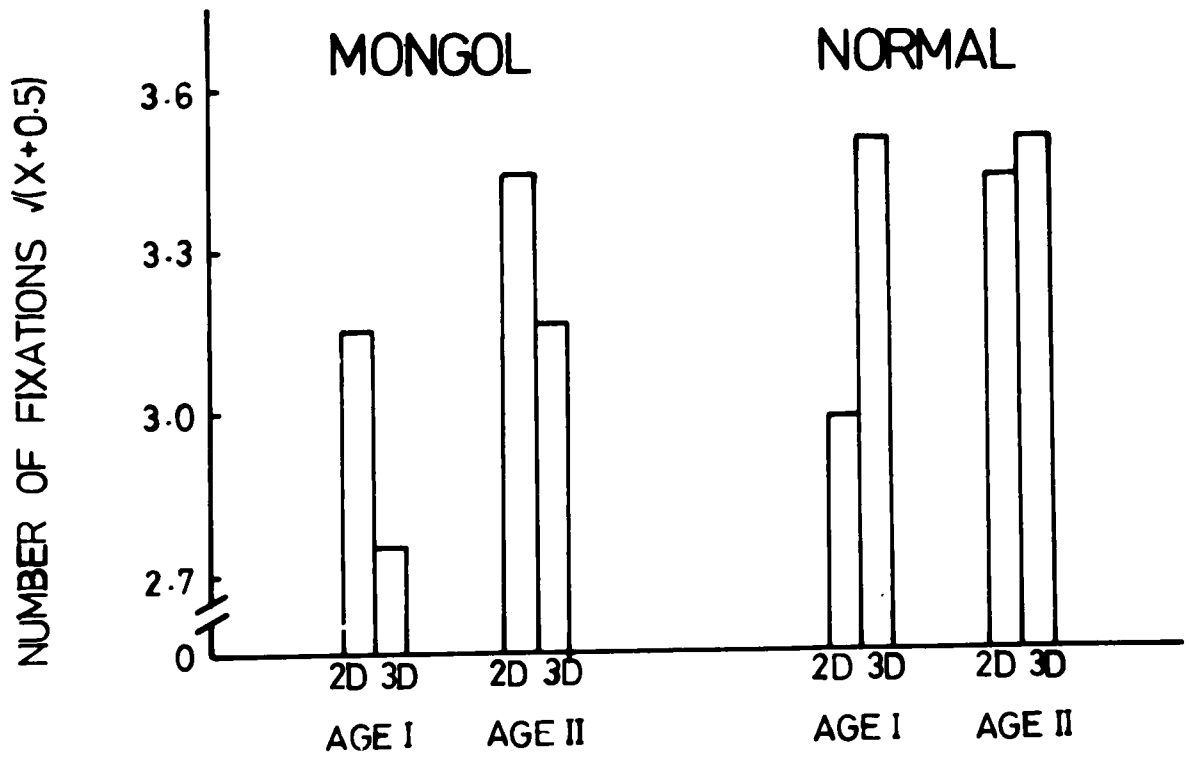
This measure is the first to show a difference in the way in which the mongol and normal children inspect patterns visually. The difference is most clear at age I when the mongol children fixate 2 D patterns more often than 3 D patterns,

Figure 8: Groups by Ages by Patterns interaction for number of fixations (transformed $\sqrt{(X + 0.5)}$)

a) Total visual fixation not controlled



b) Total visual fixation (transformed log (X + 1)) controlled



whereas normal children fixate 3 D patterns more often than 2 D patterns.

III.B.3. Alternations

This was the number of times in each trial that the child looked from one pattern to the other.

The most appropriate transformation was found to be $\sqrt{(X + 0.5)}$. The means and standard deviations for each cell of this transformed data are given in Table 37. From this table it is worth noticing the following points.

When the patterns are 2 D, the number of alternations of fixation that the two groups of mongol and normal children make are almost identical.

Both mongol and normal children tend to make more alternations when the patterns are 3 D compared with when they are 2 D. This difference in the number of alternations to the 2 D and 3 D patterns seems to occur in all age groups but is least obvious in the mongol age I children.

These data were analysed by an analysis of variance and three analyses of covariance in which the covariates were total visual fixation transformed log $(X + 1)$, C.A. and M.A. These are summarised in Table 38.

In the analysis of variance the main effect of Patterns was significant ($F = 52.7$, df 1/199, $p < .001$). However it became nonsignificant when differences in total visual fixation times were taken into account ($F = 1.4$, df 1/198, n.s.). Thus the fact that more alternations occur when the patterns are 3 D rather than 2 D is accounted for by differences in how long the patterns are fixated.

There was an interaction between Patterns and Groups ($F = 4.7$, df 1/199, $p < .05$) and this remained when total visual fixation times were controlled ($F = 5.1$, df 1/198, $p < .05$). Tukey's HSD test was used to examine the differences between the means in order to find the sources of the interactions. The normal children made more alternations when the patterns were 3 D compared to when they were 2 D ($p < .01$), and this difference persisted ($p < .05$) when total visual fixation was taken into account. The mongol children also made more alternations to the 3 D patterns than to the 2 D patterns, but only when total visual fixation times were ignored ($p < .01$). When the patterns were 3 D the normal children made more alternations than the mongol children ($p < .01$) both when total visual fixation was

Table 37: Means and Standard Deviations for Alternations. The data were transformed $\sqrt{(X + 0.5)}$

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	1.93	0.43	1.91	0.75	1.63	0.61	2.29	0.85	1.94
14-14	2.41	0.90	2.09	0.78	1.89	0.58	2.28	0.60	2.17
14-8	1.66	0.84	2.26	0.56	1.90	0.56	2.09	0.56	1.98
8-14	1.74	0.62	2.25	0.71	1.80	0.38	2.42	0.76	2.05
Means of Totals	1.93		2.12		1.81		2.27		2.03
	2.03				2.04				

3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	2.26	0.93	2.82	0.59	2.55	0.75	2.36	0.46	2.50
14-14	2.20	0.80	2.49	0.60	3.14	0.86	2.53	0.65	2.59
14-8	2.04	0.90	2.70	0.84	3.15	0.63	2.87	0.84	2.69
8-14	2.40	1.06	2.50	0.66	2.88	0.48	2.70	0.97	2.62
Means of Totals	2.22		2.63		2.93		2.62		2.60
	2.42				2.77				

Table 38: Analysis of variance for alternations (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed log (X + 1)), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	2.04	1.4	1.6	0.0	1.4
Ages (A)	1	2.19	1.5	2.2	3.5	0.0
GxA	1	0.79	0.5	0.3	2.0	0.5
S.W.G.	28	1.46				
Total subjects	31					
Patterns (P)	1	20.44	52.7^{XXXX}	1.4		
Conditions (C)	3	0.30	0.8	0.7		
GxP	1	1.84	4.7^{X}	5.1^{X}		
GxC	3	0.36	0.9	1.2		
AxP	1	1.28	3.3	3.1		
AxC	3	0.45	1.2	1.5		
PxC	3	0.23	0.6	0.5		
GxAxP	1	3.89	10.0^{XXX}	7.2^{XXX}		
GxAxC	3	0.36	0.9	1.9		
GxPxC	3	0.54	1.4	0.9		
AxPxC	3	0.19	0.5	0.5		
Final Residual	199	0.39				
Grand Total	255					

ignored and when it was taken into account. Thus when differences in total visual fixation times are eliminated the normal children, but not the mongol children, make more alternations between two 3 D patterns than between two 2 D patterns.

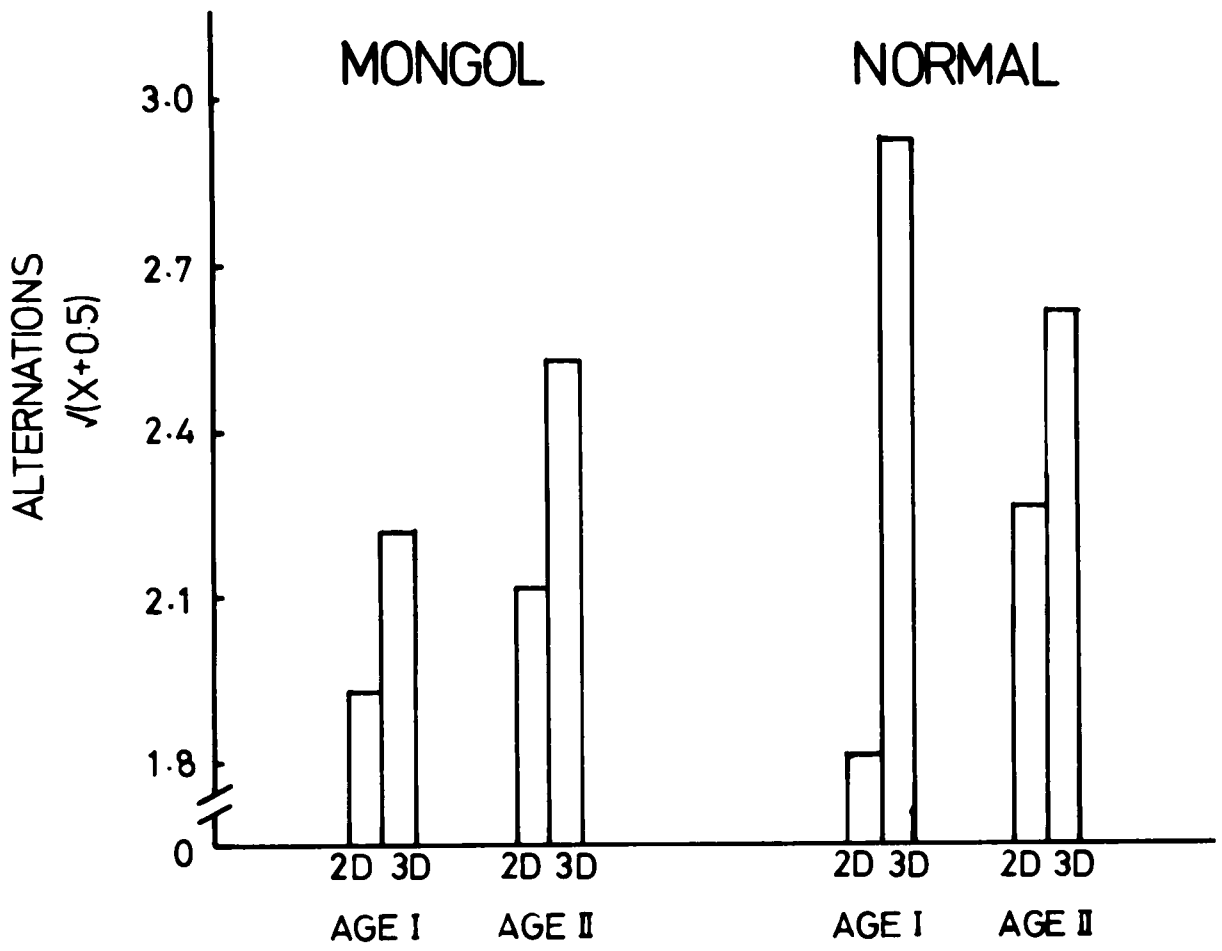
The possibility that there are age differences in these behaviours is indicated by the interaction between Groups, Ages and Patterns ($F = 10.0$, df 1/199, $p < .01$) which was still significant when total visual fixation was covaried out ($F = 7.2$, df 1/198, $p < .01$). The interactions are illustrated in Figure 9 a,b, and Tukey's HSD test was used to examine the differences between the means.

The normal age I children made more alternations when the patterns were 3 D compared with when they were 2 D ($p < .01$), even when differences in fixation times are controlled ($p < .01$). When fixation times are ignored the mongol age II children also make more alternations to 3 D than to 2 D patterns ($p < .05$), but this difference is nonsignificant when fixation times are taken into account. In both analyses, when the patterns are 3 D, the normal age I children make more alternations than the mongol age I children ($p < .01$). Finally the normal age II children make more alternations than the normal age I children to the 2 D patterns, but only when total visual fixation times are covaried out ($p < .05$).

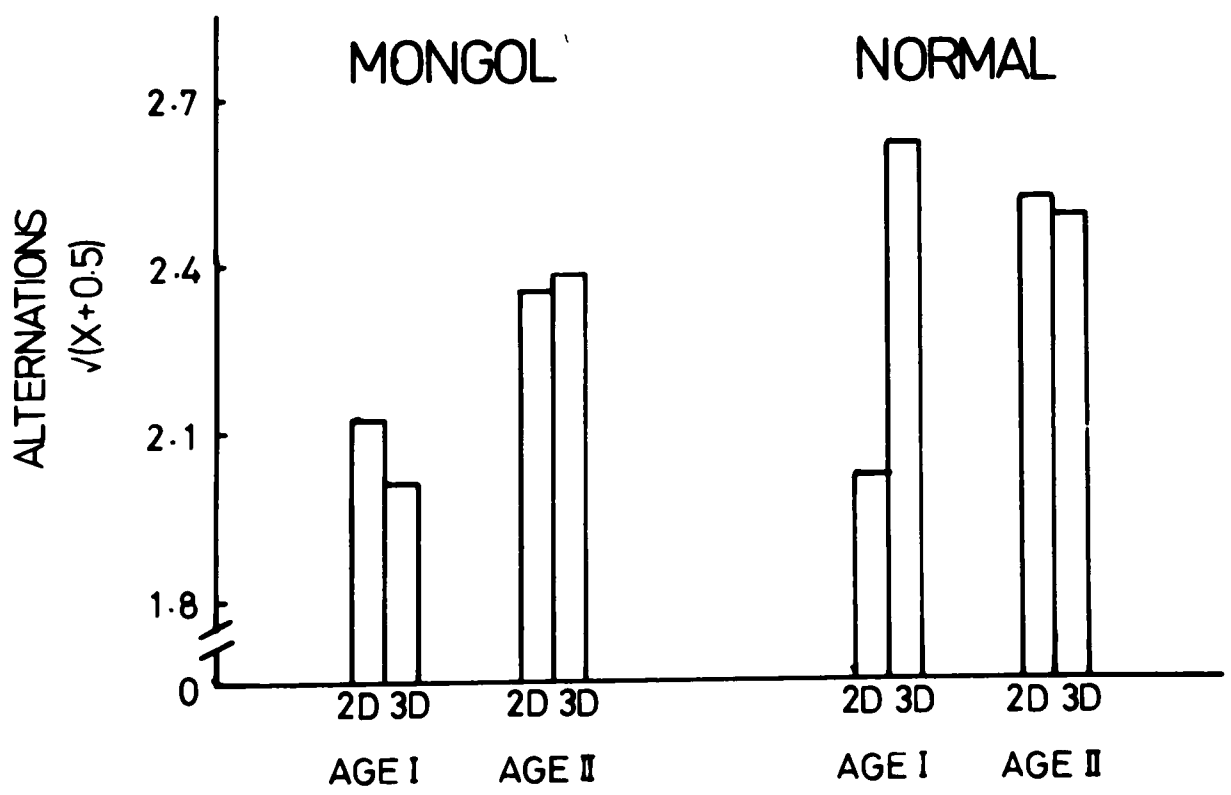
These results indicate a marked difference in the visual behaviours of the younger age level in the mongol and normal groups. Whereas the normal age I children compare the 3 D objects more often than the 2 D objects, the mongol age I children do not show this differentiation. This might account for the failure of the age I mongol children on the visual within-modal tasks of experiment 2. If they did not compare the 3 D objects as often as the normal children, they may not have been aware that the two objects were different and that one was identical to the one which they had seen making a noise. The older mongol children on the other hand made as many alternations as the age II normal children and this might explain their success on one of the visual within-modal tasks.

Figure 9: Groups by Ages by Patterns interaction for alternations (transformed $\sqrt{(X + 0.5)}$)

a) Total visual fixation not controlled



b) Total visual fixation (transformed log (X + 1)) controlled



III.B.4. Repetitions

This was the number of times that a child repeatedly looked at one pattern without looking at the second pattern that was presented on the same trial.

When the data were tested for transformations, the most appropriate one was a logarithmic one, and since some of the scores were equal to 0 the transformation log (X + 1) was used. The means and standard deviations for each cell of the transformed data are given in Table 39.

The main aspect to notice from the table of means is that whereas the normal children tend to make more repetitions when the patterns are 3 D compared with when they are 2 D, the mongol children tend to make less. In addition, there seems to be a tendency for more repetitions to be made in Condition 14-14, Condition 8-14 and Condition 14-8 than in Condition 8-8, and for the age II children to make more repetitions than the age I children.

The analysis of variance and three analyses of covariance are summarized in Table 40. These provide support for the first and third points noted from the table of means, but not for the second. When total visual fixation time is controlled the age II children are found to make more repetitions than the age I children ($F = 4.3$, df 1/27, $p < .05$).

The interaction between Groups and Patterns is significant both when total visual fixation is ignored ($F = 19.4$, df = 1/199, $p < .001$) and when it is taken into account ($F = 20.4$, df = 1/198, $p < .001$). Tukey's HSD test was used to test the differences between the means. The normal children made more repetitions when the patterns were 3 D than when they were 2 D ($p < .01$); however this difference became nonsignificant when the data were adjusted for differences in fixation time and therefore can be accounted for by these differences. For both the unadjusted and adjusted data the normals made more repetitions than the mongols to the 3 D patterns ($p < .01$). The mongols made more repetitions to the 2 D patterns than to the 3 D patterns but this only became significant ($p < .01$) when total visual fixation was held constant.

We are now in a position to consider how the mongol and the normal child fixate 2 D and 3 D patterns when differences in total visual fixation times are controlled. The characteristic fixation pattern of a normal age I child is to

Table 39: Means and Standard Deviations for Repetitions. The data were transformed log (X + 1)

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.45	0.31	0.69	0.12	0.53	0.23	0.61	0.25	0.57
14-14	0.63	0.11	0.76	0.16	0.56	0.20	0.59	0.16	0.64
14-8	0.77	0.21	0.70	0.14	0.57	0.32	0.65	0.32	0.67
8-14	0.66	0.22	0.70	0.17	0.56	0.32	0.63	0.17	0.64
Means of Totals	0.63		0.71		0.56		0.62		0.63
	0.67				0.59				

3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.46	0.32	0.61	0.21	0.61	0.41	0.74	0.20	0.69
14-14	0.58	0.24	0.59	0.10	0.76	0.21	0.79	0.11	0.68
14-8	0.54	0.19	0.61	0.17	0.78	0.19	0.78	0.10	0.68
8-14	0.55	0.25	0.79	0.14	0.76	0.34	0.78	0.27	0.72
Means of Totals	0.53		0.65		0.73		0.77		0.67
	0.59				0.75				

Table 40: Analysis of variance for repetitions (transformed log (X + 1)) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed log (X + 1)), C.A. and M.A.

Source	D.F.	M.A.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.09	1.0	1.0	0.2	0.9
Ages (A)	1	0.38	4.1	4.3^{x}	2.0	2.0
GxA	1	0.04	0.4	0.3	0.5	0.4
S.W.G.	28	0.09				
Total subjects	31					
Patterns (P)	1	0.11	2.4	3.7		
Conditions (C)	3	0.12	2.6	2.4		
GxP	1	0.89	19.4^{xxxx}	20.4^{xxxx}		
GxC	3	0.01	0.2	0.2		
AxP	1	0.00	0.0	0.1		
AxC	3	0.05	1.1	1.1		
PxC	3	0.01	0.3	0.4		
GxAxP	1	0.01	0.2	0.0		
GxAxC	3	0.01	0.3	0.2		
GxPxC	3	0.03	0.7	0.4		
AxPxC	3	0.01	0.3	0.3		
Final Residual	199	0.05				
Grand Total	255					

compare two 3 D patterns more than two 2 D patterns. These children make a similar number of repetitions to both types of pattern. In contrast the mongol age I child will make more repeated fixations of a 2 D pattern than a 3 D pattern but will make a similar number of comparisons between 3 D patterns as between 2 D patterns. At age II the normal children make as many alternations between 2 D patterns as between 3 D patterns, and make as many repetitions to 2 D patterns as to 3 D patterns. The age II mongols however still make more repetitions to 2 D than to 3 D patterns.

III.B.5. Time to Fixate the First Pattern

This measure was the time from the beginning of each trial before the child looked at a pattern.

The most suitable transformation was found to be $\frac{1}{(x + 1)}$, and the means and standard deviations for each cell of these data are given in Table 41.

There are two points to notice from this table. First, the normal children at both age levels seem to take a shorter time to look at the first pattern than do the mongol children. Secondly, when the patterns are 3 D all of the children appear to be faster at looking at the first pattern than if the patterns are 2 D.

Both of these observations were confirmed by the analyses which are summarised in Table 42. The Group effect was significant ($F = 8.0$, df 1/28, $p < .01$) showing that the normals were faster than the mongols in fixating the first pattern. The two analyses of covariance showed that this was a true group difference and not due to any age differences between the groups. When C.A. was covaried out the F ratio was reduced but still significant ($F = 5.1$, df 1/27, $p < .05$), and covarying out M.A. had hardly any effect ($F = 7.8$, df 1/27, $p < .01$).

The Patterns term was highly significant ($F = 16.6$, df 1/199, $p < .001$) showing that the time to fixate the first pattern was shorter if the patterns were 3 D rather than 2 D.

This measure provides evidence that mongol children take longer than normal children to look at patterns, which is in line with the finding that mongol adults have slower reaction times than normal adults (Chapter 1, section II.D.2). The only other result was that the 3 D patterns were looked at faster by all of the children than the 2 D ones. This may have been due to the way the patterns

Table 41: Means and Standard Deviations for the Time to Fixate the First Pattern of the Pair. The data were transformed $\frac{1}{(x+1)}$

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.28	0.23	0.16	0.13	0.37	0.24	0.47	0.32	0.32
14-14	0.42	0.32	0.35	0.19	0.45	0.30	0.38	0.29	0.40
14-8	0.31	0.24	0.42	0.18	0.61	0.16	0.38	0.14	0.43
8-14	0.28	0.23	0.30	0.15	0.40	0.27	0.56	0.27	0.39
Means of Totals	0.32		0.31		0.46		0.45		0.38
	0.32				0.45				

3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.48	0.27	0.49	0.27	0.57	0.27	0.52	0.23	0.51
14-14	0.41	0.28	0.46	0.26	0.66	0.19	0.51	0.24	0.51
14-8	0.35	0.25	0.37	0.29	0.63	0.19	0.43	0.29	0.45
8-14	0.41	0.26	0.51	0.23	0.62	0.19	0.52	0.24	0.52
Means of Totals	0.41		0.46		0.62		0.50		0.50
	0.44				0.56				

Table 42: Analysis of variance for the time to fixate the first pattern in a pair (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	1.06	8.0^{xxx}	5.1^{x}	7.8^{xxx}
Ages (A)	1	0.04	0.3	0.5	0.0
GxA	1	0.10	0.8	0.2	0.8
S.W.G.	28	0.13			
Total subjects	31				
Patterns (P)	1	0.81	16.6^{xxxx}		
Conditions (C)	3	0.02	0.4		
GxP	1	0.00	0.1		
GxC	3	0.01	0.2		
AxP	1	0.01	0.2		
AxC	3	0.05	1.0		
PxC	3	0.09	1.7		
GxAxP	1	0.13	2.7		
GxAxC	3	0.09	1.9		
GxPxC	3	0.06	1.2		
AxPxC	3	0.01	0.2		
Final Residual	199	0.05			
Grand Total	255				

were presented since the 3 D patterns were nearer to the child than the 2 D ones.

III.B.6. Time to Fixate the Second Pattern

This was the time in seconds from the beginning of each trial until the child looked at the second pattern for the first time.

The most appropriate transformation was log (X + 1) and the means and standard deviations for these data are given in Table 43.

From this table it can be seen that the time to fixate the second pattern tends to be shorter when the patterns are 3 D rather than 2 D. All of the children exhibit this tendency, although it is most obvious for the normal age I and mongol age II children.

Second, in Condition 14-8 the mongol age I children seem to be particularly slow to look at the second pattern, whilst the normal age I children seem to be particularly fast.

The analyses are summarised in Table 44. It can be seen that the Patterns term was significant ($F = 15.2$, df 1/199, $p < .001$) confirming that the second pattern is looked at sooner when the patterns are 3 D rather than 2 D.

The three way interaction between Groups, Ages and Patterns was significant ($F = 5.2$, df 1/199, $p < .025$) and is shown in Figure 10. Pairwise comparisons between the means by Tukey's HSD test showed that the time taken to look at the second of a pair of 3 D patterns was shorter than for the second of a pair of 2 D patterns for the normal age I ($p < .05$) and the mongol age II ($p < .05$) children.

The remaining three way interaction was between Groups, Ages and Conditions ($F = 5.3$, df 3/199, $p < .01$) and is shown in Figure 11. Tukey's HSD test showed that this interaction was due first to the fact that in Condition 14-8 the mongol age I children were slower to fixate the second pattern compared with the mongol age II children ($p < .05$) and the normal age I children ($p < .01$). Second, the normal age I children were quicker to look at the second pattern in Condition 14-8 compared to Condition 8-8 ($p < .01$).

This shows that all of the children, but in particular the normal age I and the mongol age II children, looked at the second pattern in a shorter time when the patterns were 3 D rather than 2 D. It is also possible to see some order in

Table 43: Means and Standard Deviations for the Time to Fixate the Second Pattern of the Pair. The data were transformed log (X + 1)

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	1.21	0.38	1.33	0.38	1.48	0.29	1.08	0.51	1.27
14-14	1.14	0.30	1.28	0.37	1.13	0.42	0.99	0.39	1.13
14-8	1.34	0.51	0.85	0.26	0.72	0.18	1.05	0.41	0.99
8-14	1.06	0.43	1.03	0.37	1.33	0.27	0.92	0.38	1.08
Means of Totals	1.19		1.12		1.16		1.01		1.12
	1.15				1.09				

3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	1.00	0.43	0.90	0.28	1.01	0.50	0.87	0.46	0.95
14-14	1.05	0.61	0.66	0.20	0.86	0.24	0.99	0.38	0.89
14-8	1.34	0.38	0.93	0.51	0.74	0.39	0.90	0.44	0.98
8-14	1.07	0.59	0.90	0.32	0.91	0.38	0.97	0.30	0.96
Means of Totals	1.11		0.85		0.88		0.93		0.94
	0.98				0.91				

Table 44: Analysis of variance for the time to fixate the second pattern of the pair (transformed log (X + 1)) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.33	0.9	0.1	0.9
Ages (A)	1	0.77	2.2	1.6	0.2
GxA	1	0.21	0.6	0.8	0.6
S.W.G.	28	0.34			
Total subjects	31				
Patterns (P)	1	1.99	15.2^{xxxx}		
Conditions (C)	3	0.19	1.4		
GxP	1	0.00	0.0		
GxC	3	0.27	2.1		
AxP	1	0.00	0.0		
AxC	3	0.02	0.1		
PxC	3	0.31	2.4		
GxAxP	1	0.68	5.2^{xx}		
GxAxC	3	0.70	5.3^{xxx}		
GxPxC	3	0.10	0.8		
AxPxC	3	0.06	0.5		
Final Residual	199	0.13			
Grand Total	255				

Figure 10: Groups by Ages by Patterns interaction for the time to fixate the second pattern (transformed log (X + 1))

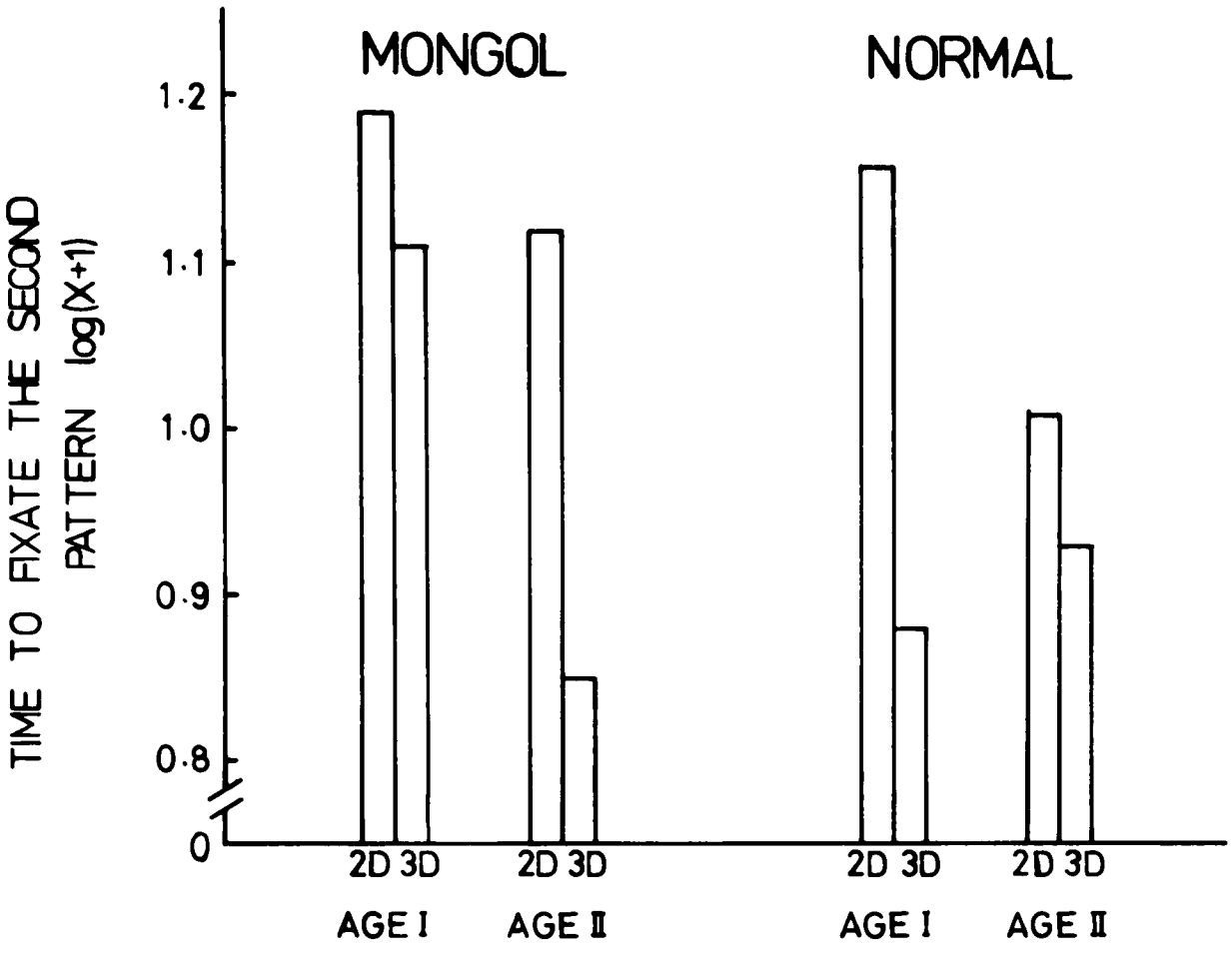
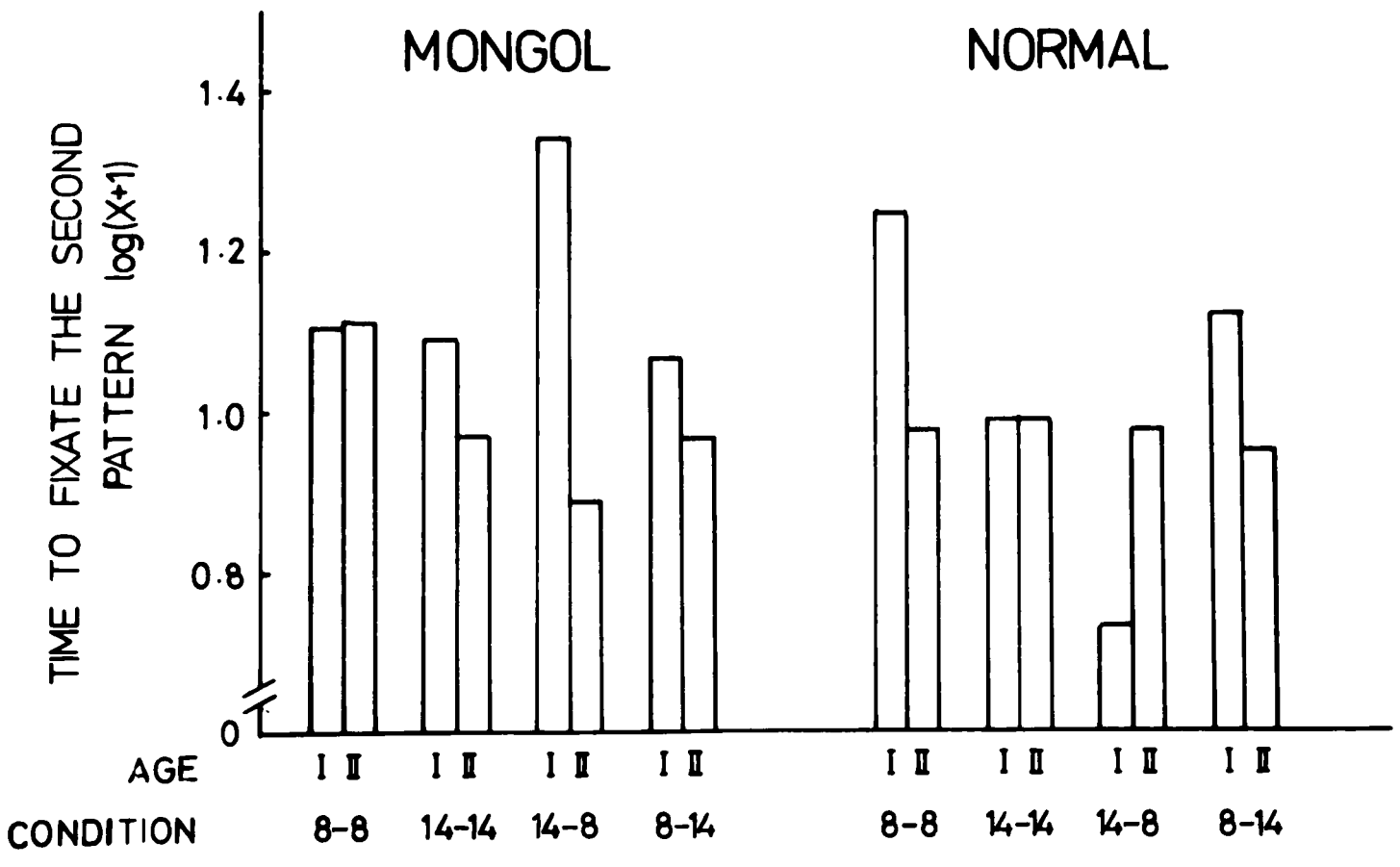


Figure 11: Groups by Ages by Conditions interaction for the time to fixate the second pattern (transformed log (X + 1))



the difference in the times that the four groups of children took to look at the second pattern. The mongol age I children were slow to look at the second pattern when the patterns were either 2 D or 3 D. By age II the mongol children were quicker to look if the patterns were 3 D, but were just as slow as the age I mongols if the patterns were 2 D. The normal age I children took about the same lengths of time to look at the 2 D and 3 D patterns as the mongol age II children, but by age II the normals were as quick to look when the patters were either 2 D or 3 D as the normal age I and the mongol age II children were when the patterns were 3 D. This suggests that the mongol children do show some of the behaviours that are seen in normal children, but this similarity is only seen when mongol children are compared to normal children who are younger than the mongol children in both chronological age and mental age.

The remaining result of this measure was as follows. When the patterns were presented in Condition 14-8, the mongol age I children look longer than both the normal age I and the mongol age II children. This further emphasises the difference between the mongol age I and the normal age I children, and similarity between the latter group and the mongol age II children. Finally the normal age I children fixated the second pattern faster in Condition 14-8 than in Condition 8-8.

III.B.7. Average Fixation Length

The average fixation length to each pattern presented on any trial was calculated by dividing the visual fixation to each pattern by the number of fixations to that pattern. The visual fixation included the total length of any fixation which began during a trial and extended beyond the one minute duration of that trial. The present measure was the mean of the average fixation lengths to the two patterns on each trial, or the average fixation length to one pattern, if only one was fixated.

The transformation $\frac{1}{(x + 1)}$ was selected as the most appropriate. Table 45 gives the means and standard deviations for each cell of the transformed data.

It can be seen from this table that both groups of mongol and normal children tend to make longer average fixations when the patterns are 3 D compared with when they are 2 D. The average fixation lengths of the two groups of mongol children to the 3 D patterns also seem to be longer than those of the corresponding

groups of normal children.

The analyses are summarised in Table 46. The Patterns term is significant ($F = 129.2$, df 1/199, $p < .001$) indicating that the average fixation lengths to 3 D patterns are longer than to 2 D patterns.

The interaction between Groups and Patterns is the only significant two-way interaction ($F = 6.3$, df 1/199, $p < .025$). Tukey's HSD test was used to find the source of this interaction. It showed that the average fixation lengths made to the 3 D patterns were longer than those made to the 2 D ones by both the mongol children ($p < .01$) and the normal children ($p < .01$). However, the average fixation lengths of the mongol children to the 3 D patterns are longer than those of the normal children ($p < .01$).

One three-way interaction was significant. This was between Groups, Ages and Conditions ($F = 2.6$, df 3/199, $p < .05$), and is shown in Figure 12. Tukey's HSD test was used to test the difference between appropriate means but none of these was found to be significant. From the graph it can be seen that although none of the comparisons was significant, the interaction must be due to the normal age II children making shorter average fixations to patterns in Condition 8-8 than the other children, and to the average fixation lengths of the mongol age I children to the patterns in Condition 14-8 being longer than those of the other children. It is interesting to note that the average fixation lengths of the mongol age II children are most similar to those of the normal age I children.

It may be recalled from the results of two previous measures that although both the mongol and the normal children looked for longer when the patterns were 3 D rather than 2 D (section III.B.1), only the normal children fixated the 3 D patterns more often than the 2 D ones (section III.B.2). From those results it was suggested that the fixations of the normal children to 3 D and 2 D patterns would be similar in length, and that the mongol children would make longer fixations to the 3 D patterns than to the 2 D ones. The results of the present measure of average fixation length was that both groups were found to make longer fixations to 3 D than to 2 D patterns, but the mongol children made longer fixations than the normal children to 3 D patterns. Thus the normal children as well as looking at the 3 D patterns more often than the 2 D ones, also looked at them on average for a longer time than the 2 D patterns.

Table 45: Means and Standard Deviations for Average Fixation Length. The transformation used was $\frac{1}{(x+1)}$

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.42	0.18	0.44	0.13	0.38	0.21	0.48	0.09	0.43
14-14	0.47	0.12	0.45	0.09	0.40	0.14	0.48	0.07	0.45
14-8	0.39	0.15	0.50	0.04	0.47	0.13	0.48	0.07	0.46
8-14	0.43	0.20	0.48	0.09	0.44	0.21	0.46	0.10	0.45
Means of Totals	0.43		0.47		0.42		0.48		0.45
	0.45				0.45				

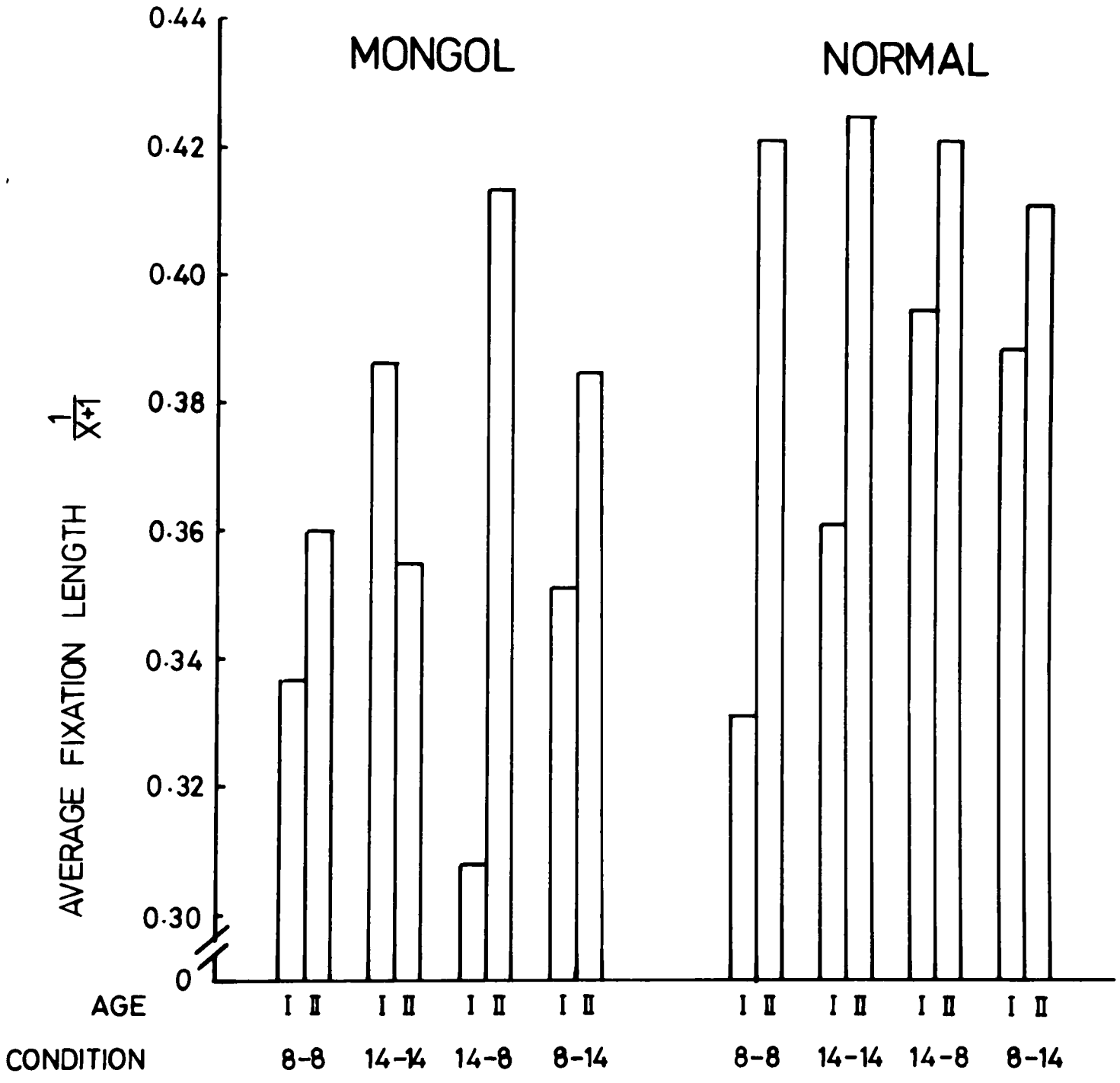
3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.25	0.15	0.28	0.10	0.28	0.12	0.36	0.09	0.29
14-14	0.31	0.16	0.26	0.09	0.32	0.08	0.37	0.09	0.31
14-8	0.23	0.10	0.33	0.11	0.33	0.05	0.36	0.06	0.31
8-14	0.28	0.15	0.29	0.09	0.34	0.09	0.36	0.06	0.32
Means of Totals	0.26		0.29		0.32		0.37		0.31
	0.28				0.34				

Table 46: Analysis of variance for averagefixation length (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for the analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.07	1.4	1.3	1.5
Ages (A)	1	0.11	2.4	0.3	0.1
GxA	1	0.01	0.1	0.3	0.1
S.W.G.	28	0.05			
Total subjects	31				
Patterns (P)	1	1.26	129.2^{XXXX}		
Conditions (C)	3	0.01	0.8		
GxP	1	0.06	6.3^{XX}		
GxC	3	0.00	0.2		
AxP	1	0.00	0.1		
AxC	3	0.01	0.9		
PxC	3	0.00	0.1		
GxAxP	1	0.00	0.1		
GxAxC	3	0.03	2.6^{X}		
GxPxC	3	0.00	0.2		
AxPxC	3	0.00	0.1		
Final Residual	199	0.01			
Grand Total	255				

Figure 12: Groups by Ages by Conditions interaction for the average fixation length (transformed $\frac{1}{(x + 1)}$)



III.B.8. Length of the First Fixation to the First Pattern

This was the length of the first fixation made to the first pattern that the child looked at.

The most appropriate transformation was $\frac{1}{(x + 1)}$ and Table 47 gives the means and standard deviations for each cell of these data.

From this table it can be observed that all of the children tend to make longer first fixations to 3 D patterns than to 2 D ones. There is also a tendency for the age I children to make longer first fixations than the age II children, in particular when the patterns are 3 D.

These observations were confirmed by the analyses which are summarised in Table 48. The Age effect was significant ($F = 4.5$, df 1/28, $p < .05$) confirming that the age I children make longer first fixations than the age II children. This age effect disappeared when C.A. was covaried out ($F = 0.1$, df 1/27, n.s.) or M.A. was taken into account ($F = 0.1$, df 1/27, n.s.). This means that the age effect was due to difference in age between the two age groups.

The effect of Patterns was highly significant ($F = 26.9$, df 1/199, $p < .001$) and supported the observation that 3 D patterns received longer first fixations than 2 D patterns.

III.B.9. Length of the First Fixation to the Second Pattern

This was the length of the first fixation made to the second pattern that the child looked at on each trial.

The most appropriate transformation was $\frac{1}{(x + 1)}$ and the means and standard deviations for this measure are summarised in Table 49. It is noticeable from this table that the length of the first fixation to the second pattern seems to be longer when the patterns are 3 D rather than 2 D.

The analyses which are summarised in Table 50 support this observation. The only significant F ratio is for Patterns ($F = 20.3$, df 1/199, $p < .001$). The first fixation to a second 3 D pattern to be looked at is significantly longer than that to a second 2 D pattern.

Table 47: Means and Standard Deviations of the Length of the First Fixation to the First Pattern. The data were transformed $\frac{1}{(x+1)}$

2 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.52	0.22	0.54	0.17	0.48	0.22	0.52	0.13	0.51
14-14	0.48	0.21	0.54	0.21	0.39	0.22	0.49	0.09	0.47
14-8	0.61	0.12	0.55	0.16	0.54	0.17	0.55	0.10	0.56
8-14	0.45	0.20	0.51	0.19	0.49	0.16	0.56	0.11	0.50
Means of Totals	0.52		0.53		0.48		0.53		0.51
	0.52				0.50				

3 D Patterns

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.31	0.21	0.32	0.20	0.38	0.27	0.44	0.15	0.36
14-14	0.42	0.26	0.48	0.18	0.32	0.18	0.36	0.16	0.40
14-8	0.17	0.10	0.47	0.23	0.42	0.18	0.44	0.23	0.37
8-14	0.37	0.27	0.50	0.26	0.38	0.18	0.56	0.20	0.45
Means of Totals	0.32		0.44		0.37		0.45		0.40
	0.38				0.41				

Table 48: Analysis of variance for the length of the first fixation to the first pattern (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for the analyses of covariance with the covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.00	0.0	0.9	0.0
Ages (A)	1	0.30	4.5^{x}	0.1	0.1
GxA	1	0.00	0.0	0.3	0.0
S.W.G.	28	0.07			
Total subjects	31				
Patterns (P)	1	0.88	26.9^{xxxx}		
Conditions (C)	3	0.03	0.9		
GxP	1	0.05	1.4		
GxC	3	0.06	1.8		
AxP	1	0.07	2.0		
AxC	3	0.02	0.6		
PxC	3	0.07	2.0		
GxAxP	1	0.03	0.9		
GxAxC	3	0.02	0.5		
GxPxC	3	0.04	1.1		
AxPxC	3	0.04	1.1		
Final Residual	199	0.03			
Grand Total	255				

Table 49: Means and Standard Deviations for the Length of the First Fixation to the Second Pattern. The data were transformed $(\sqrt{x+1})$

2 D Patterns

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
8-8	0.54	0.20	0.58	0.23	0.62	0.25	0.46	0.11	0.55	
14-14	0.57	0.18	0.65	0.20	0.49	0.22	0.56	0.11	0.57	0.55
14-8	0.59	0.30	0.51	0.18	0.63	0.11	0.52	0.13	0.56	
8-14	0.55	0.23	0.49	0.23	0.54	0.28	0.46	0.15	0.51	
Means of Totals	0.56		0.56		0.57		0.50			
	0.56				0.54					

3 D Patterns

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
8-8	0.43	0.31	0.33	0.18	0.34	0.21	0.44	0.18	0.38	
14-14	0.49	0.25	0.44	0.26	0.38	0.09	0.47	0.18	0.44	0.43
14-8	0.37	0.30	0.50	0.16	0.48	0.22	0.45	0.15	0.45	
8-14	0.52	0.32	0.38	0.27	0.43	0.22	0.46	0.24	0.45	
Means of Totals	0.45		0.41		0.41		0.46			
	0.43				0.43					

Table 50: Analysis of variance for the length of the first fixation to the second pattern (transformed $(\sqrt{x+1})$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.01	0.1	1.7	0.1
Ages (A)	1	0.02	0.3	0.7	0.3
GxA	1	0.00	0.0	0.5	0.0
S.W.G.	28	0.08			
Total subjects	31				
Patterns (P)	1	0.87	20.3^{xxxx}		
Conditions (C)	3	0.03	0.6		
GxP	1	0.01	0.2		
GxC	3	0.02	0.5		
AxP	1	0.03	0.6		
AxC	3	0.03	0.8		
PxC	3	0.03	0.7		
GxAxP	1	0.10	2.3		
GxAxC	3	0.02	0.5		
GxPxC	3	0.00	0.0		
AxPxC	3	0.03	0.7		
Final Residual	199	0.04			
Grand Total	255				

III.B.10 Touching

This was the total time that the child spent touching the two patterns on each of the trials when the patterns were 3 D.

The most suitable transformation was found to be log (x + 1), and Table 51 gives the means and standard deviations for each cell of these data.

From this table the following points are worth noticing. First the normal children seem to spend more time touching the patterns than the mongol children especially when the age II children are compared.

Second, both the mongol and normal age I children appear to touch the patterns less than the mongol and normal age II children respectively.

The analyses, which are summarised in Table 52, do not provide any evidence for the first point noticed above, but the second point is confirmed. The Age factor is significant ($F = 8.4$, df 1/28, $p < .01$) and shows that the age I children touch the patterns less than the age II children. This difference disappears in both analyses of covariance, which would be expected if the effect was the result of the age difference between the two groups.

III.C. Summary of Results

The results of this experiment will be summarised in two sections. The first section gives those results which show similarities in the behaviour of the mongol and normal children, and the second section gives those results which show differences. Within these sections each measure will be summarised separately.

III.C.1. Similarities in the Behaviour of the mongol and normal children

Total Visual Fixation. The mongol and normal children spent a similar amount of time looking at the patterns. When the patterns were 3 D both groups looked at them for longer compared with when two 2 D patterns were presented.

Number of Fixations. The mongol children fixated the patterns as often as the normal children. However, when the 2 D and 3 D patterns were considered separately differences emerged between the groups.

Table 51: Means and Standard Deviations for Touching. The transformation applied to the data was log (X + 1)

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
8-8	0.75	0.72	1.08	0.41	0.65	0.66	1.36	0.28	0.96
14-14	0.71	0.70	1.22	0.26	0.91	0.76	1.37	0.32	1.05
14-8	0.62	0.85	1.00	0.46	0.87	0.71	1.48	0.45	0.99
8-14	0.64	0.75	0.95	0.49	0.53	0.64	1.28	0.46	0.84
Means of Totals	0.68		1.06		0.74		1.37		
	0.87				1.06				

Table 52: Analysis of variance for touching (transformed log (X + 1)) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	1.09	1.1	1.4	1.3
Ages (A)	1	8.24	8.4^{xxx}	0.2	0.9
GxA	1	0.52	0.5	0.7	0.7
S.W.G.	28	0.99			
Total subjects	31				
Conditions (C)	3	0.23	1.7		
GxC	3	0.13	1.0		
AxC	3	0.00	0.0		
GxAxC	3	0.10	0.7		
Final Residual	84	0.13			
Grand Total	127				

Alternations. The number of alternations made by the mongol and normal children was similar. On the other hand the groups differed in the number of alternations which they made to 2 D and 3 D patterns.

Repetitions. There was no difference in the number of repetitions made by the two groups of children. In both groups the age II children made more repetitions than the age I children. However, the distribution of repetitions to the 2 D and 3 D patterns was different in the two groups of mongol and normal children.

Time to Fixate the First Pattern. Both groups of children were faster to fixate the first pattern if the patterns were 3 D rather than 2 D.

Time to Fixate the Second Pattern. This measure showed no difference between the mongol and normal children who all tended to look sooner at the second pattern when the patterns were 3 D than when they were 2 D; however, this difference was only significant for the normal age I and the mongol age II children.

Average Fixation Length. All of the mongol and normal children had the same average fixation length. When the patterns were 3 D they all made longer fixations on average than when the patterns were 2 D.

Length of the First Fixation to the First Pattern. The two groups of children were similar on this measure. In both groups the age I children made longer first fixations to the first pattern than the age II children, and longer fixations occurred when the patterns were 3 D than when they were 2 D.

Length of the First Fixation to the Second Pattern. There was no group difference for this measure, and both groups made longer first fixations to the second pattern when the patterns were 3 D than when they were 2 D.

Touching. Both groups of mongol and normal children touch the 3 D patterns for a similar length of time. Within both groups the age I children spent less time in contact with the patterns than the age II children.

III.C.2. Differences in the Behaviour of the mongol and normal children

In this section the measures of Total Visual Fixation, Length of the First Fixation to the First Pattern, Length of the First Fixation to the Second Pattern and Touching will be omitted since they showed no differences in the behaviour of the normal and mongol children. These results have already been summarised.

Number of Fixations. The normal age I children made more fixations to the 3 D patterns than to the 2 D patterns whereas the mongol age I children made more fixations to the 2 D patterns than to the 3 D ones. This difference had disappeared by age II, because the normal age II children made more fixations to the 2 D patterns than the normal age I children; and the mongol age II children made more fixations to the 3 D patterns than the mongol age I children.

Alternations. The normal age I children made more alternations between 3 D patterns than between 2 D patterns. Compared to the normal age I children, the mongol age I children made a similar number of alternations to 2 D patterns but significantly fewer alternations to 3 D patterns. The normal age II children made more alternations to 2 D patterns than the normal age I children.

Repetitions. The mongol children made more repetitions to 2 D patterns than to 3 D patterns. The normal children made more repetitions to 3 D patterns than the mongol children.

Time to Fixate the First Pattern. With this measure it was found that the normal children were quicker than the mongol children to look at the display for the first time on each trial.

Time to Fixate the Second Pattern. When the patterns were presented in Condition 14-8, the normal age I and the mongol age II children were faster to look at the second pattern for the first time compared with the mongol age I children. Also the normal age I children fixated the second pattern of Condition 14-8 faster than that of Condition 8-8.

Average Fixation Length. Although both mongol and normal children made longer fixations on average to 3 D than to 2 D patterns, the average fixation length of the mongol children to the 3 D patterns was longer than that of the normal children.

IV. DISCUSSION

The aim of this experiment was to provide data on how normal and mongol children of the same developmental level look at 3 D objects. The background to this was that in experiment 1 the way in which the two groups looked at 2 D patterns was shown to be extremely similar, whereas in experiment 2 mongol children were found to be inferior to normal children at visually discriminating 3 D objects. On the basis of these findings it was tentatively suggested that the mongols' failure at visual discrimination might be due to their visual reaction towards 3 D objects being different from that of normal children.

The results of this third experiment provide some support for this suggestion. It was found that the patterns of fixation made by the mongol and normal children to a pair of 3 D objects were different. This was especially true for the youngest mongols and normals. When the patterns were 2 D there were no significant differences between the visual reactions of the mongol and normal children. This was in contrast to the situation when the patterns were 3 D. The normal children, particularly the younger group, compared the 3 D patterns more often than the 2 D patterns, whereas the mongol children at both ages did not make a different number of alternations to 2 D and 3 D patterns. The normal children made more repeated fixations of 3 D patterns than did the mongols, who in fact made more repetitions to 2 D patterns than to 3 D patterns.

It seems most probable that the more often that two patterns or objects are compared, the more likely it is that differences between them will be noticed. Also it would be expected that more information will be obtained about an object which is scanned several times. If this is correct it would suggest that a child who compares two objects would perform better on a visual discrimination task than a child who compares the objects less frequently. From the results of the present experiment therefore it would be predicted that normal children would perform much better on the visual within-modal task of experiment 2 than the mongol children because the task employed 3 D objects. This was found.

Of course this difference in visual behaviour is only one possible explanation for the inferior performance of the mongol children compared to that of the normal children on the visual within-modal tasks of experiment 2. An alternative

explanation might be that the mongol child cannot remember what the object which made a noise looked like. However, the difference in visual behaviour seems a likely candidate since the difference was most marked in the age I mongol and normal children and at this age the mongol children failed both visual within-modal tasks. By age II there was less difference in visual behaviour, and in experiment 2 the older mongols did succeed at one of the visual within-modal tasks. This perhaps reflects a development from age I to age II in the scanning of the young mongol which enables him to solve certain visual discrimination tasks more easily.

It should be made clear however that the ages of the children in these first three experiments were not totally equivalent. The mean M.A.s of all of the age I children, both mongol and normal, were approximately 10, 12 and 7 months in experiments 1, 2 and 3 respectively. The mean M.A.s of the age II children in these same experiments were about 14, 16 and 13 months. Thus in terms of M.A. the age II children in experiment 3 were more similar to the age I children in experiment 2. This makes it even more difficult to use evidence from one experiment to account for the results of another experiment. But despite this it seems reasonable to conclude that the visual behaviour of the mongol child is different from that of the normal child when they are presented with 3 D objects, and that these differences may account for the difficulty that the young mongol has at discriminating 3 D objects visually.

The measures of how long the mongol and normal children took to look at the patterns provided confirmation of the suggestion from the adult literature that the mongol person takes longer to respond than the normal person.

However, despite these differences in the way in which and the speed with which the mongol and normal children scanned 2 D and 3 D patterns, a number of the measures indicated that both groups responded in a similar way to 2 D and 3 D patterns. Both groups looked longer at 3 D patterns than they did at 2 D patterns in terms of total visual fixation, average fixation length and the lengths of the first fixations. These suggest that both mongol and normal children perceive some difference between presentations of 2 D and 3 D patterns such that the latter attract greater attention than the former. Presumably associated with this, it was also found that 3 D patterns are fixated more quickly than 2 D patterns especially

by the younger normals and older mongols. It should therefore be stressed that the results of this experiment do show that mongol children as well as normal children can differentiate between when 2 D patterns are presented and when 3 D patterns are presented. However the important result is that the mongols scan the patterns in a different way from the normals.

In addition there were a number of differences between the age levels of both the mongol and the normal children. The older children touched the 3 D patterns more, made more repetitions and made shorter first fixations than the younger children. Thus in a number of respects the mongol and normal children behaved in a similar way to one another and exhibited comparable developments with increasing age.

One of the features of this experiment with 2 D and 3 D patterns which may have influenced the results and which was noted in the Introduction (section I) is that the children could touch the 3 D objects but not the 2 D ones. In experiment 2 in which the mongol children failed the tactile-visual cross-modal tasks, it was argued that although a tactile deficit in the young mongol is not proven, it is implicated. Since the normal children succeeded on at least one of the tactile-visual cross-modal tasks it is possible that the difference in visual behaviour to 3 D objects by mongol and normal children has something to do with the effect of touch. There was no difference in the lengths of time which the two groups spent touching the 3 D objects, but this does not rule out the possibility that the act of touching had a different effect on the visual behaviour of the two groups. One obvious way to look at the influence of touch is to make a direct comparison between the ways in which 3 D objects are looked at when they can be touched and when they cannot be touched.

The next experiment therefore examined the possibility that the differences found in the visual behaviours of normal and mongol children when they were presented with 3 D objects, depended upon the children being allowed to touch the patterns.

CHAPTER 7

Experiment 4: An Examination of the Effect of Touch on the Visual Responses of Normal and Mongol Children to Two Dimensional and Three Dimensional Objects

I. INTRODUCTION

The previous experiment provided evidence that the mongol child looks at 3 D objects in a different way from the normal child, whereas their visual responses to 2 D patterns are similar. It has been suggested that this difference may account for the similarity in the visual behaviour of the two groups in experiment 1 when the patterns were 2 D, and the inferiority of the mongols compared to the normals on the visual within-modal tasks of experiment 2 when the objects to be visually discriminated were 3 D.

Before this explanation can be accepted however, it is necessary to show that the difference in the visual responses of the children towards 3 D objects is independent of the sense of touch. For in the last experiment the 3 D objects always could be touched whereas the 2 D patterns were presented out of the child's reach. It was decided to do this because of the possibility of some link between the visual and tactile perceptions of the young mongol. This possibility arose because of the finding in experiment 2 that the mongols were not only inferior to the normal children on the visual within-modal tasks but also on the tactile-visual cross-modal tasks. Since the last experiment has demonstrated that the young mongol looks at 3 D objects which can be touched in a different way from the normal child, it is now necessary to examine whether these differences in visual behaviour are dependent on touch or not.

If for example the visual responses of normal and mongol children to 3 D objects are similar when touching of the objects is not permitted, but different when touching is allowed, we could suggest that touch plays some role in the way in which 3 D objects are perceived visually. If the difference is a result of a change in the normals' behaviour when the objects can be touched from when they cannot, this would suggest that touch influences the way in which 3 D objects are

perceived visually by a normal child but not by a mongol child. However, if the behaviour of the mongol changes when touching is allowed whilst that of the normal does not, then this might indicate that the difference in the mongols' and normals' visual behaviour to 3 D objects which can be touched is accounted for by some effect of touch on the mongols' visual behaviour.

In complete contrast, if there is a difference in the visual responses of the mongol and normal children to 3 D objects regardless of whether or not the objects can be touched, this might indicate that touch does not play any important role in determining the visual response of these children to these patterns.

For these reasons an experiment was designed in which mongol and normal children were shown two patterns in a series of trials, and were allowed to touch them on only half of these trials. Sometimes one pattern was 2 D and the other 3 D; sometimes both were 2 D and sometimes both were 3 D.

II. METHOD

II.A. Subjects

Forty-eight children took part in this experiment and their C.A.s ranged from 4 to 45 months. Half of the children were mongol and half were normal.

The mongol and normal children were matched in pairs for M.A., sex and social class. These pairs were assigned to one of three age groups, age I, age II and age III on the basis of the mongols' C.A.s. Table 53 presents the means, standard deviations and ranges for the C.A.s of the groups.

The table shows that at each age level the mongol children were older than the normal children, and that although there was some overlap between adjacent age levels, the means were quite different. The reason for the difference in the C.A.s of the mongol and normal children and the way in which it was taken into account in the analyses were the same as described in Chapter 4, section II.A.2.

Since this experiment was designed to clarify the results of the previous experiment it is important to compare the ages of the mongol and normal children who completed these two experiments. If Table 53 is compared to Table 28 it will be seen that the mongol and normal age I children in the present experiment

Table 53: Chronological Ages of the groups (in months)

	MONGOL		NORMAL			
AGE I	Mean	13.19	Mean	8.21	Mean	10.7
	S.D.	5.0	S.D.	3.36	S.D.	4.84
	Range	5.75-18.0	Range	4.0-13.75		
AGE II	Mean	23.43	Mean	14.0	Mean	18.7
	S.D.	3.28	S.D.	1.8	S.D.	5.51
	Range	16.5-27.0	Range	12.0-16.5		
AGE III	Mean	35.37	Mean	18.1	Mean	26.75
	S.D.	5.53	S.D.	3.29	S.D.	9.93
	Range	29.0-45.0	Range	13.75-22.0		
	Mean	24.0	Mean	13.44		
	S.D.	10.3	S.D.	5.0		

had mean C.A.s of about 13 and 8 months respectively, whereas the mean C.A.s for the mongol and normal age I children in experiment 3 were approximately 10 and 7 months respectively (Chapter 6, section II.A). Therefore the age I children in this fourth experiment were older chronologically than the age I children in experiment 3.

There was also a difference in the C.A.s of the age II children. In experiment 3 the age II mongol and normal children had mean C.A.s of about 30 and 13 months respectively. Thus these mongol children had C.A.s which fell between those of the age II and age III mongols in the present experiment, whereas the normal age II children in experiment 3 were slightly younger than the age II normal children in this fourth experiment.

The difference in the ages of the children in these two experiments is one problem of researching with young handicapped children. The sample is small and therefore those children who are available have to be tested almost regardless of age.

II.A.1. Matched Aspects of the Mongol and Normal Children

a) Mental Age

Table 54 gives the means, standard deviations and ranges in months of the M.A.s of the groups of children.

Table 54: Mental Ages of the groups (in months)

	MONGOL		NORMAL			
	Mean	7.84	Mean	8.24	Mean	8.04
AGE I	S.D.	3.56	S.D.	3.6	S.D.	3.47
	Range	3.25-13.75	Range	3.8-14.25		
	Mean	13.88	Mean	14.25	Mean	14.06
AGE II	S.D.	1.82	S.D.	1.86	S.D.	1.79
	Range	12.0-16.75	Range	12.2-17.0		
	Mean	17.88	Mean	17.74	Mean	17.78
AGE III	S.D.	3.14	S.D.	3.3	S.D.	3.11
	Range	14.25-21.5	Range	13.5-21.75		
	Mean	13.18	Mean	13.41		
	S.D.	5.04	S.D.	4.94		

The table shows that for both groups of mongol and normal children the age III children had higher M.A.s than the age II children who themselves had higher M.A.s than the age I children. There is little difference between the mean M.A.s of the mongol and normal children at any age level and so they were well matched.

The difference in the mean C.A.s of the mongol and normal children in experiment 3 and those completing the present experiment which was noted in the previous section, also occurred for M.A. The relevant data are given in Tables 29 and 54. The mongol and normal age I children in experiment 3 had mean M.A.s of about 6.5 months (Chapter 6, section II.A.1) whereas the age I children, both mongol and normal, in the present experiment had a mean M.A. of approximately 8 months. Thus the age I children in this fourth experiment had M.A.s which on average were one and a half months older than those of the

children in experiment 3. The age II children in experiment 3 had a mean M.A. of about 13 months which is approximately one month younger than the mean M.A. of the age II children in the present experiment.

b) Sex

Seven of the mongol children were female and these were each individually matched with seven normal females. Three of these female pairs were in age I, and two in each of age II and age III. All of the remaining mongol and normal children were male.

c) Social Class

Each normal child was selected so that his father's occupation fell into the same class of the Registrar General's Index as the father's occupation of the mongol child.

Table 55 gives the number of mongol and normal children at each age level who were classified into each of the six social classes. It can be seen from this table that the number of mongol children in each social class was equal to the number of normal children in the same social class.

Table 55: The Social Classes of the children in the groups as given by the Registrar General's Index

	MONGOL						NORMAL					
	I	II	IIIN	IIIM	IV	V	I	II	IIIN	IIIM	IV	V
AGE I	1	4	1	1	1	0	1	4	1	1	1	0
AGE II	0	3	1	2	1	1	0	3	1	2	1	1
AGE III	1	0	5	2	0	0	1	0	5	2	0	0
Total	2	7	7	5	2	1	2	7	7	5	2	1

Each of the mongol children who completed the experiment was matched with a normal child who had essentially the same M.A., was of the same sex, and whose father's occupation fell into the same social class, but who had a lower C.A.

II.A.2. Discarded Subjects

The final sample of 24 mongol children and 24 normal children was obtained from an original sample of 30 mongol and 30 normal children. The 12 children were discarded for the following reasons.

Two mongol children had severe squints which would have made it impossible to correctly judge their direction of gaze as was required in the experiment. One mongol and two normal children seemed to be frightened of the apparatus.

While one mongol child and one normal child were being tested the apparatus failed and the results were incomplete. Two mongol children and one normal child became upset during the course of the experiment and it was therefore terminated.

Two of the normal children completed the experiment but when they were tested on the Bayley Scales of Mental Development they were found to have M.A.s which differed by more than two months. from those of the mongol children with whom they were to be matched. They were therefore considered not to be adequate controls.

II.B. Apparatus

The apparatus was the same as that used for experiment 3 (Chapter 6, section II.B) but modified so that both 2 D and 3 D patterns could be presented within the reach of the child. In previous experiments 2 D patterns were presented out of reach at the back of the box, but the aim of the present experiment was to examine the effect of touch on the way in which 2 D and 3 D patterns are looked at. Therefore the 2 D patterns had to be presented at the same distance from the child as the 3 D patterns.

The modified box is illustrated in Figure 13. There were two plywood boards into which panels, on which the patterns were presented, were slotted. Both boards measured 39.5 cm. wide by 25 cm. high and were painted matt black. A peg $\frac{1}{2}$ cm. in diameter was fixed to the back of each board so that it extended one cm. below the base of the board and would fit into one of the two platforms in the box. When in position the two boards did not touch but there was not enough room for the child to reach around or between them.

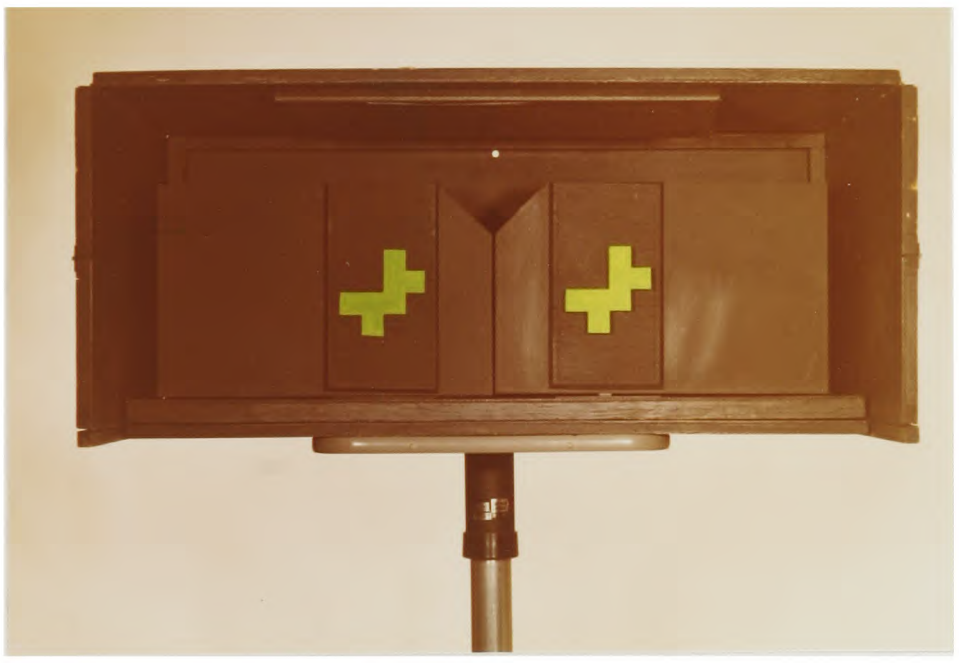


Figure 13: The presentation of the patterns

The panels on which the patterns were presented slotted into grooves on the front face of the two boards. When in position there were 16.5 cm. between the two patterns.

The final modification was a clear perspex screen which could be fitted over the front of the box. When this screen was in position the child could see the patterns but was unable to touch them.

II.C. Stimulus Material

It was decided to use only one shape throughout the experiment so that in each trial the two patterns were identical in shape and thus shape was the same in all trials. The shape chosen was the same as that labelled 14A in experiment 3 (Chapter 6, Figure 7), although it was increased in size until its overall extent both horizontally and vertically was 10 cm. The reason for presenting two identical shapes was that in experiment 3, whether the patterns were of either identical or different shapes made little difference to the visual behaviour of the children.

Each pattern was presented in the centre of a panel which measured 11.5 cm. wide by 21 cm. high. The panel, apart from the pattern, was painted matt black and could be slotted into grooves on either of the plywood boards. Some of the patterns were 2 D and for these the shape was painted onto the middle of a panel. The other patterns were 3 D, and here the shape was cut out of 1.7 cm. thick plywood and attached to a panel so that it quite clearly protruded from the centre of the panel.

There were two identical sets of stimulus material and each was composed of eight patterns, of which four were 2 D and four 3 D. Each of these four was painted a different colour, and the colours were pink, green, blue and orange. Different colours were used so that the colour of the patterns could be varied across trials in order to maintain the child's interest.

II.D. Procedure

All of the children completed eight trials and on each trial two patterns were presented side by side. On four consecutive trials the child was allowed to touch as well as to look at the patterns. This will be called the visual plus tactile modality (abbreviated to V + T). On the other four consecutive trials the child was allowed to look at the patterns but was prevented from touching them by the presence of the clear perspex screen. This will be called the visual modality (abbreviated to V).

Each of the four trials within each modality, i.e. V or V + T, represented a different condition. The patterns which were presented for each condition are shown in Table 56. In Condition 2D-2D the two patterns were identical and both 2 D. In Condition 3D-3D the two patterns were identical and both 3 D. In Condition 3D-2D the 3 D pattern was presented to the child's left and the 2 D one to his right. In Condition 2D-3D the pattern to the child's left was 2 D, whilst that to his right was 3 D.

Table 56: The patterns presented on each of the four conditions

		Pattern on the child's right	
		2D	3D
Pattern on the child's left	2 D	Condition 2D-2D	Condition 2D-3D
	3 D	Condition 3D-2D	Condition 3D-3D

On each trial the two patterns were identical in shape and colour, but although shape was always the same from trial to trial, the colour of the patterns was varied.

It was possible to include the four conditions and to present them in the two modalities because of the decision to omit a comparison between the visual responses to two identical patterns and those to two patterns which differed in shape (section II.C). This halved the number of trials and so it was decided to increase the number by presenting simultaneously a 2 D and a 3 D pattern in Conditions 3D-2D and 2D-3D to examine the visual responses to such pairs of patterns.

II.D.1. Counterbalancing

Three variables were balanced across the eight children in each group and these are summarised in Table 57A. The variables were: 1) the order of presenting the modalities. Four children in each group were presented with the patterns in the V modality first: the other four were first shown the patterns in the V + T modalities. 2) the order of presentation of the four conditions. Four orders of presenting the four conditions were obtained from a Latin Square. 3) the order of presenting the four colours. A second Latin Square was used to obtain four orders of presenting the four colours. This second Latin Square was superimposed on the first, with the constraint that each condition occurred once in each colour. There were therefore four orders of presenting the conditions and colours combined to the children. Table 57B summarises how the eight children in each group were treated.

II.D.2. The Method of Presentation

The general procedure during each trial was essentially the same as in experiment 1 (Chapter 4, section II.D.2).

As in experiment 1 there were two testing sessions separated by more than three days and less than eight days. The first four trials were presented on the first visit and the second four trials were presented on the second visit.

On each visit the child sat on his mother's lap in front of the box for at least one minute before the experiment began. This was to accustom the child to the apparatus, and in particular to the boards on which the patterns were to be presented.

All of the trials were initiated by the experimenter and terminated after one minute provided that the child was not looking at either of the patterns. If he was fixating a pattern when the trial should have been terminated, it was not terminated until the child looked away from the pattern.

As in the previous experiments the child sat approximately 40 cm. in front of the back of the box and was therefore 20 cm. in front of the patterns. In this position there were 23^{o} of visual angle between the edges of the patterns.

Table 57 A: Summary of the Randomisation Procedure

1) Order of presentation of modalities

Order	First four trials	Second four trials
a	V	V + T
b	V + T	V

2) Order of presentation of the four conditions

Order	First Trial	Second Trial	Third Trial	Fourth Trial
i	2D-3D	2D-2D	3D-2D	3D-3D
ii	3D-3D	3D-2D	2D-2D	2D-3D
iii	2D-2D	2D-3D	3D-3D	3D-2D
iv	3D-2D	3D-3D	2D-3D	2D-2D

3) Order of presentation of the four colours

Order	First Trial	Second Trial	Third Trial	Fourth Trial
p	Pink (P)	Green (G)	Orange (O)	Blue (B)
q	Orange (O)	Blue (B)	Pink (P)	Green (G)
r	Blue (B)	Orange (O)	Green (G)	Pink (P)
s	Green (G)	Pink (P)	Blue (B)	Orange (O)

Table 57 B: Assignment of the eight subjects in one group

Subject	Order	Modality		Order of Conditions & Colours in both Modalities			
		Trials 1-4	Trials 5-8	First	Second	Third	Fourth
1	a i p	V	V + T	2D-3D(P)	2D-2D(G)	3D-2D(O)	3D-3D(B)
2	a ii q	V	V + T	3D-3D(O)	3D-2D(B)	2D-2D(P)	2D-3D(G)
3	a iii r	V	V + T	2D-2D(B)	2D-3D(O)	3D-3D(G)	3D-2D(P)
4	a iv s	V	V + T	3D-2D(G)	3D-3D(P)	2D-3D(B)	2D-2D(O)
5	b i p	V + T	V	2D-3D(P)	2D-2D(G)	3D-2D(O)	3D-3D(B)
6	b ii q	V + T	V	3D-3D(O)	3D-2D(B)	2D-2D(P)	2D-3D(G)
7	b iii r	V + T	V	2D-2D(B)	2D-3D(O)	3D-3D(G)	3D-2D(P)
8	b iv s	V + T	V	3D-2D(G)	3D-3D(P)	2D-3D(B)	2D-2D(O)

II.D.3. The Scoring of the Experimental Observations

a) Data Collection

The data consisted of a permanent record of the children's fixations to each of the two patterns presented on the eight trials. This was recorded in the same way as before (Chapter 4, section II.D.3a).

In the visual plus tactual modality the amount of time that each child touched either or both patterns was also recorded. When the child touched a pattern the board on which it was presented moved and this movement was recorded automatically as described in Chapter 6, section II.B for experiment 3. If the child touched the board but not the pattern, this was recorded as though he had touched the pattern; however this seldom occurred.

b) Measurements Taken from the Raw Data

The measurements were identical to those taken from the raw data for experiment 3 (Chapter 6, section II.D.3b).

III. RESULTS

The measures were analysed by the same general method as for experiment 1 (Chapter 4, section III.A). Apart from the measures the only difference was in the variables examined in the analyses of variance and covariance. The variables are described below.

III.A. Variables Examined in the Analyses of Variance and Covariance

The nine measures of visual behaviour were each analysed using a four-way split plot analysis of variance. In each case there were two between subject variables and two within subject variables. The between subject variables were Groups (Mongol vs. Normal), and Ages (I vs. II vs. III). The within subject variables were Modalities (V vs. V + T) and Conditions (2D-2D vs. 3D-3D vs. 3D-2D vs. 2D-3D).

The modality term was omitted for the tenth measure which was of touching, since touching only occurred in the V + T modality.

Each measure was also analysed by two analyses of covariance. In one the covariate was C.A., and in the other it was M.A. In each case the design was the same for each measure as for the analysis of variance.

It should be noted that the ways in which the 2 D and the 3 D patterns which were presented together in Conditions 3D-2D and 2D-3D could not be distinguished. This was because the responses to them were not independent of one another since when one pattern was being fixated the other one was not.

III.B. Measures

III.B.1. Total Visual Fixation

This measure was of the sum of the times in seconds that the child looked at the two patterns presented on each of the eight one minute trials.

When the data were tested for transformations the most appropriate one was found to be a logarithmic one. The means and standard deviations for each cell of this transformed data are given in Table 58. Several features of this table are worthy of notice.

First, overall the normal children seem to have longer total visual fixation scores than the mongol children. Second, the pair of 2 D patterns, presented in Condition 2D-2D, appears to receive less visual fixation than the patterns presented on the other three conditions. This is most noticeable in the V + T modalities.

The analyses are summarised in Table 59 and they support these two observations. The Group effect is significant ($F \simeq 17.6$, df 1/42, $p < .001$) showing that the amount of total visual fixation is greater for the normal than for the mongol children. This effect remains significant when C.A. ($F = 8.1$, df 1/41, $p < .01$) and when M.A. ($F = 17.2$, df 1/41, $p < .001$) are covaried out. Thus although the C.A. differences between the children account for some of the difference in looking time, it does not account for all of the difference.

The second and only other significant main effect was for Conditions ($F = 6.6$, df 3/300, $p < .001$). Tukey's HSD test was used to find the source of this effect. This showed that less total visual fixation occurred in Condition 2D-2D than in

Table 58: Means and Standard Deviations for Total Visual Fixation. The raw data were transformed log X

Visual

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	1.31	0.20	1.23	0.20	1.20	0.16	1.27	0.14	1.23	0.10	1.29	0.15	1.25	
3D-3D	1.20	0.33	1.22	0.20	1.22	0.13	1.29	0.13	1.38	0.05	1.33	0.15	1.27	1.28
3D-2D	1.15	0.17	1.33	0.12	1.19	0.17	1.39	0.10	1.40	0.13	1.41	0.14	1.31	
2D-3D	1.22	0.24	1.26	0.20	1.15	0.18	1.40	0.19	1.31	0.06	1.34	0.15	1.28	
Means of Totals	1.22		1.26		1.19		1.34		1.33		1.34			
			1.22						1.34					

Visual plus Tactile

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	1.12	0.26	1.09	0.32	1.14	0.12	1.22	0.14	1.18	0.19	1.33	0.16	1.18	
3D-3D	1.15	0.20	1.30	0.21	1.23	0.15	1.37	0.06	1.37	0.11	1.41	0.17	1.31	1.27
3D-2D	1.15	0.31	1.19	0.26	1.29	0.23	1.35	0.19	1.43	0.13	1.43	0.20	1.30	
2D-3D	1.14	0.10	1.31	0.16	1.20	0.27	1.35	0.24	1.30	0.12	1.45	0.15	1.29	
Means of Totals	1.14		1.22		1.21		1.32		1.32		1.40			
			1.19						1.35					

Table 59: Analysis of variance for total visual fixation (transformed log X) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ. F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	1.78	17.6^{xxxx}	8.1^{xxx}	17.2^{xxxx}
Ages (A)	2	0.04	0.4	0.1	0.1
GxA	2	0.07	0.7	0.8	0.7
S.W.G.	42	0.10			
Total Subjects	47				
Modalities (M)	1	0.01	0.4		
Conditions (C)	3	0.16	6.6^{xxxx}		
GxM	1	0.04	1.7		
GxC	3	0.05	2.2		
AxM	2	0.07	3.0^{x}		
AxC	6	0.03	1.2		
MxC	3	0.05	2.1		
GxAxM	2	0.00	0.2		
GxAxC	6	0.02	0.9		
GxMxC	3	0.01	0.5		
AxMxC	6	0.01	0.3		
Final Residual	300	0.02			
Grand Total	383				

either Condition 3D-3D ($p < .01$), Condition 3D-2D ($p < .01$) or Condition 2D-3D ($p < .05$).

The Conditions factor did not interact significantly with either modalities or groups although the F ratios for both interactions reached the 10% level of significance.

The only significant interaction was between Ages and Modalities ($F = 3.0$, df 2/300, $p < .05$). Tukey's HSD test was used to examine the differences between the means in order to find the source of the interaction. None of the differences reached significance, and therefore this interaction cannot be interpreted.

This is the first time that the mongol and normal children have had different total visual fixation times. This difference will have to be taken into account in the analyses of the measures of the number of fixations, alternations and repetitions in sections III.B.2, III.B.3, and III.B.4, since a group difference in any of these measures could be due to the difference in total visual fixation times. This can be achieved by covarying out the transformed total visual fixation times on each measure.

Apart from this difference, this measure confirms the findings from experiment 3 that both mongols and normals look more at 3 D patterns than at 2 D patterns. This would suggest that both groups find the 3 D patterns more interesting to look at than the 2 D patterns. The absence of any interaction between modalities and conditions suggests that the differential fixation times are unaffected by whether or not the child can touch the patterns.

III.B.2. Number of Fixations

This was the sum of the number of fixations made to the two patterns presented on each of the eight trials.

The most appropriate transformation was found to be log X where X is the raw datum. Table 60 gives the means and standard deviations for each cell of these transformed data. A number of points in this table are worthy of notice.

Firstly, the normal children at all ages appear to make more fixations than the mongol children. Secondly, the age I children whether mongol or normal seem to make fewer fixations than the two older age groups. Thirdly, the

children tend to make fewer fixations when they are allowed to touch the patterns than when they are not.

Finally, the normal children appear to make fewer fixations to the patterns in Condition 2D-2D compared to those in the other three conditions, whereas the mongol children seem to make approximately the same number of fixations in all conditions.

In addition to the analysis of variance and two analyses of covariance with the covariates of C.A. and M.A., another analysis of covariance was performed on the data. This was to take account of the differences which had been found in total visual fixation (section III.B.1). Thus the covariate was total visual fixation transformed log X. All of these analyses are summarised in Table 61.

The normal children made more fixations than the mongol children ($F = 19.8$, df 1/42, $p < .001$) and this was not affected by covarying out the differences between the groups in either C.A. ($F = 25.8$, df 1/41, $p < .001$) or M.A. ($F = 21.9$, df 1/41, $p < .001$). However the effect was reduced, although the difference was still significant when total visual fixation time was taken into account ($F = 4.7$, df 1/41, $p < .05$). Therefore the normal children made more fixations than the mongol children even when total visual fixation times were controlled.

The age effect was significant when differences in total visual fixation times were ignored ($F = 8.7$, df 2/42, $p < .001$) and when they were taken into account ($F = 9.2$, df 2/41, $p < .001$). The differences between the means were examined by Tukey's HSD test. When the data were adjusted for total visual fixation and when they were not, the age I children made fewer fixations than the age II children ($p < .01$) and the age III children ($p < .01$). This effect was removed by covarying out C.A. ($F = 2.0$, df 2/41, n.s.) and M.A. ($F = 0.9$, df 2/41, n.s.). Thus when the age groups were equated for either C.A. or M.A. there was no difference between them in the number of fixations.

The modalities term was significant and showed that more fixations occurred to patterns which could only be looked at compared to patterns which could also be touched ($F = 16.1$, df 1/300, $p < .001$). This effect remained when the total visual fixation times were equated ($F = 19.1$, df 1/299, $p < .001$).

Table 60: Means and Standard Deviations for the Number of Fixations. The raw data have been transformed log X

Visual

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	1.02	0.12	1.14	0.14	1.13	0.12	1.10	0.15	1.17	0.13	1.14	0.14	1.12	
3D-3D	0.91	0.22	1.10	0.16	1.12	0.10	1.15	0.14	1.20	0.09	1.19	0.14	1.11	1.12
3D-2D	0.92	0.16	1.14	0.14	1.14	0.10	1.18	0.07	1.24	0.08	1.25	0.11	1.14	
2D-3D	0.92	0.29	1.12	0.15	1.07	0.11	1.16	0.11	1.21	0.11	1.20	0.18	1.11	
Means of Totals	0.94		1.12		1.11		1.15		1.20		1.19			
			1.06						1.18					

Visual plus Tactile

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.87	0.21	0.99	0.23	1.07	0.12	1.08	0.15	1.09	0.17	1.12	0.13	1.03	
3D-3D	0.92	0.13	1.10	0.11	1.10	0.12	1.11	0.10	1.16	0.11	1.20	0.20	1.10	1.07
3D-2D	0.86	0.18	1.06	0.16	1.11	0.17	1.12	0.10	1.19	0.11	1.22	0.20	1.09	
2D-3D	0.80	0.21	1.09	0.10	1.09	0.15	1.10	0.12	1.15	0.09	1.20	0.14	1.07	
Means of Totals	0.86		1.06		1.09		1.10		1.15		1.19			
			1.01						1.14					

Table 61: Analysis of variance for number of fixations (transformed log X) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed log X), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	1.63	19.8^{xxxx}	4.7^{x}	25.8^{xxxx}	21.9^{xxxx}
Ages (A)	2	0.71	8.7^{xxxx}	9.2^{xxxx}	2.0	0.9
GxA	2	0.21	2.5	3.1	1.3	2.8
S.W.G.	42	0.08				
Total Subjects	47					
Modalities (M)	1	0.21	16.1^{xxxx}	19.1^{xxxx}		
Conditions (C)	3	0.03	2.6	0.6		
GxM	1	0.01	0.5	0.0		
GxC	3	0.03	2.5	1.0		
AxM	2	0.02	1.9	0.3		
AxC	6	0.01	0.8	0.7		
MxC	3	0.02	1.6	0.4		
GxAxM	2	0.00	0.2	0.1		
GxAxC	6	0.01	0.4	0.2		
GxMxC	3	0.01	0.8	0.5		
AxMxC	6	0.01	0.3	0.2		
Final Residual	300	0.01				
Grand Total	383					

The effect of conditions was nonsignificant and this variable did not interact significantly with any other. There was therefore no replication of the finding in the previous experiment that at age I the normals fixated 3 D patterns more often than 2 D ones whereas the opposite was true for the mongols. This failure to replicate however should not be taken as disproof of the first finding. There are many differences between the experiments which could account for this discrepancy.

Possibly the most important difference is that the age I mongol and normal children in the fourth experiment were older in terms of mean C.A.s and M.A.s than the age I children in the previous experiment (sections II.A and II.A.1). The effect of 2 D and 3 D patterns on the number of fixations was most obvious in the age I children of experiment 3 and was not significant by age II (Chapter 6, section III.B.2). Since the age I children in the present experiment had mean C.A.s and M.A.s which were intermediate between those of the age I and age II children of experiment 3, it is feasible that they were behaving like the age II children of experiment 3.

There were of course many other differences between the experiments. It may be that presenting a 2 D pattern simultaneously with a 3 D object (Conditions 3D-2D and 2D-3D in experiment 4) effected the way in which the children viewed the patterns when they were both 2 D (Condition 2D-2D) and when they were both 3 D (Condition 3D-3D). In experiment 3 on the other hand, 3 D objects were always presented together and never with 2 D patterns and vice versa. Another difference between the experiments is that in experiment 3 the 2 D patterns were further away from the children than the 3 D objects; in the present experiment both types of pattern were presented at the same distance from the child. Yet another difference is that in experiment 3 the 3 D objects were presented on the base of the box, whilst the 2 D patterns were presented in the middle of the back of the box. In this fourth experiment all of the patterns were presented towards the front of the box.

It is clear that there are many differences between the two experiments which either separately or in some combination could have influenced the results. Many more detailed experiments are required to unravel the question of how young normal and mongol children view 2 D and 3 D patterns.

III.B.3. Alternations

This was the number of times on each trial that the child looked from one pattern to the other.

The data were found to be best transformed by log (X + 1) where X is the raw datum, and the means and standard deviations for each cell of this transformed data are given in Table 62. From this table the following points are apparent.

First, the normal children seem to make more alternations than the mongol children. Secondly, the age I children appear to make fewer alternations compared to the age II and age III children. This is particularly noticeable when the age groups of the mongol children are compared with one another. Third, more alternations seem to occur to patterns which can only be looked at compared to those which can also be touched. Finally, fewer alternations seem to occur in Condition 2D-2D than in any of the other conditions, particularly when the children are normal.

The analyses which are summarised in Table 63 provide general confirmation of the observations made from the table of means.

When total visual fixation times were ignored, the normal children were found to make more alternations than the mongol children ($F = 16.9$, df 1/42, $p < .001$). However when the looking times were taken into account this effect became nonsignificant ($F = 4.0$, df 1/41, just n. s.). Thus the normal children made more alternations than the mongol children because they looked at the patterns for longer. The finding that the normal children made more alternations when total visual fixation time was not controlled was still present when either C.A. ($F = 25.1$, df 1/41, $p < .001$) or M.A. ($F = 19.4$, df 1/41, $p < .001$) were controlled. The group difference is therefore not accountable for by any age differences, only by differences in fixation times.

The age term was significant both when total visual fixation was ignored ($F = 9.7$, df 2/42, $p < .001$) and when it was taken into account ($F = 9.9$, df 2/41, $p < .001$). Tukey's HSD test indicated that in both cases the age I children made fewer alternations than the age II children ($p < .01$) and the age III children ($p < .01$). This age effect was removed by covarying out either C.A. ($F = 1.9$, df 2/41, n.s.)

Table 62: Means and Standard Deviations for Alternations. The data were transformed log (X + 1)

Visual

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.71	0.27	0.86	0.30	0.88	0.14	0.79	0.24	1.02	0.10	0.85	0.29	0.85	
3D-3D	0.64	0.31	0.94	0.19	0.90	0.17	0.96	0.18	1.03	0.20	0.99	0.29	0.91	0.89
3D-2D	0.53	0.35	0.97	0.23	0.96	0.10	0.95	0.19	1.10	0.13	1.10	0.19	0.93	
2D-3D	0.66	0.32	0.88	0.21	0.79	0.27	0.89	0.23	0.98	0.17	1.06	0.20	0.88	
Means of Totals	0.63		0.91		0.88		0.90		1.03		1.00			
			0.81						0.98					

Visual plus Tactile

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.57	0.31	0.73	0.26	0.86	0.18	0.88	0.19	0.81	0.25	0.91	0.22	0.79	
3D-3D	0.63	0.23	0.86	0.12	0.92	0.17	0.95	0.17	0.90	0.25	1.03	0.28	0.88	0.85
3D-2D	0.64	0.20	0.89	0.22	0.93	0.21	0.93	0.16	1.02	0.21	1.03	0.22	0.91	
2D-3D	0.36	0.38	0.85	0.15	0.94	0.19	0.84	0.18	0.93	0.16	1.04	0.19	0.83	
Means of Totals	0.55		0.84		0.91		0.90		0.91		1.00			
			0.77						0.94					

Table 63: Analysis of variance for alternations (transformed log (X + 1)) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed log X), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	2.76	16.9^{xxxx}	4.0	25.1^{xxxx}	19.4^{xxxx}
Ages (A)	2	1.59	9.7^{xxxx}	9.9^{xxxx}	1.9	0.8
GxA	2	0.44	2.7	3.1	1.4	3.1
S.W.G.	42	0.16				
Total Subjects	47					
Modalities (M)	1	0.15	4.4^{x}	4.0^{x}		
Conditions (C)	3	0.18	5.4^{xxx}	2.7^{x}		
GxM	1	0.00	0.0	0.2		
GxC	3	0.01	1.6	0.7		
AxM	2	0.10	3.1^{x}	2.1		
AxC	6	0.04	1.1	1.2		
MxC	3	0.01	0.2	0.2		
GxAxM	2	0.04	1.2	1.0		
GxAxC	6	0.02	0.7	0.5		
GxMxC	3	0.02	0.5	0.4		
AxMxC	6	0.06	1.7	1.7		
Final Residual	300	0.03				
Grand Total	383					

or M.A. ($F = 0.8$, df 2/41, n.s.), indicating that the differences in age between the three age levels accounted for the significant effect of age.

The main effect of modalities was significant when total visual fixation times were ignored ($F = 4.4$, df 1/300, $p < .05$) and when they were covaried out ($F = 4.0$, df 1/299, $p < .05$). This indicated that more alternations were made to patterns which could be looked at but not touched than to those which could also be touched.

The fourth main effect, conditions, was also significant when total visual fixation times were ignored ($F = 5.4$, df 3/300, $p < .01$) and when they were taken into account ($F = 2.7$, df 3/299, $p < .05$). Tukey's HSD test was employed to find the source of this effect. When total visual fixation times were covaried out none of the differences between the means was significant. However, since it appeared that more alternations occurred in Conditions 2D-3D and 3D-3D than occurred in Conditions 2D-2D and 3D-2D, Scheffé's S test was used to test this nonpairwise comparison. It was found to be significant ($p < .05$). When total visual fixation times were not controlled, Tukey's HSD test indicated that fewer alternations occurred in Condition 2D-2D than in Condition 3D-3D ($p < .05$) and in Condition 3D-2D ($p < .01$). More alternations occurred in Condition 3D-2D than in Condition 2D-3D ($p < .05$). The number of alternations which occurred to the patterns in Condition 2D-2D was found to be significantly less ($p < .05$) than the number occurring to the patterns in the other three conditions. Scheffé's S method was used for this comparison.

The only interaction to be significant was between Ages and Modalities and this was only significant when total visual fixation times were ignored ($F = 3.1$, df 2/300, $p < .05$). When the differences between the means were examined by Tukey's HSD test to find the source of the interaction, the only significant ones were between age I children and the older age groups in both modalities. That is, the age I children made fewer alternations than the age II ($p < .01$) and age III ($p < .01$) children in both the V and the V + T modalities. Although none of the relevant differences were significant, it seems probable that the interaction was due to the fact that at ages I and II more alternations occurred in the V modality than in the V + T modalities, while the reverse was true at age III.

These results are different from those of experiment 3 where it was found

that the normal children, particularly those at age I, made more alternations between two 3 D objects than between two 2 D patterns, whilst the mongol children made a similar number of alternations to both types of pattern. In the present results there was no significant interaction between Groups and Conditions although it was found that more alternations occurred in Conditions 3D-3D and 2D-3D than in Conditions 2D-2D and 3D-2D. It seems possible that, as was suggested in the previous section (section III.B.2), the fact that the age I children in this experiment were older than the age I children in experiment 3 could account for the differences in the results.

III.B.4. Repetitions

This measure was the number of times in each trial that the child repeatedly looked at one pattern without looking at the other pattern.

When the data were tested for transformations, no transformation was found to be more appropriate than the raw data. Table 64 gives the means and standard deviations for each cell of the raw data.

From this table of means it can be observed that the normal children appear to make more repetitions than the mongol children. The second feature of this table is that more repetitions seem to be made to patterns presented only in the V modality compared to those presented in the V + T modalities.

The analyses are summarised in Table 65. This shows that the Group effect was nonsignificant in the analyses of variance ($F = 3.5$, df 1/42, n.s.) and in the two analyses of covariance in which the covariates were total visual fixation transformed log X ($F = 0.1$, df 1/41, n.s.) and M.A. ($F = 3.4$, df 1/41, n.s.). However when the C.A. differences between the groups were taken into account the normal children were found to make more repetitions than the mongol children ($F = 4.5$, df 1/41, $p < .05$).

The effect of Modalities was significant both when total visual fixation times were ignored ($F = 7.4$, df 1/300, $p < .01$) and when they were taken into account ($F = 7.0$, df 1/299, $p < .01$). This supported the observation from the table of means that more repetitions occurred to patterns presented in the V modality than to those presented in the V + T modalities.

Table 64: Means and Standard Deviations for Repetitions. The raw data were not transformed

Visual

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	6.00	1.20	5.75	1.17	5.88	2.85	6.13	2.64	4.75	2.71	6.13	1.81	5.77	
3D-3D	3.88	2.36	3.75	1.91	5.13	1.13	5.00	1.69	4.75	2.82	4.88	3.00	4.56	5.10
3D-2D	4.50	2.45	4.25	2.25	5.00	2.00	5.63	2.00	4.63	1.85	4.88	1.36	4.81	
2D-3D	4.00	2.67	5.63	2.33	4.88	2.23	6.13	1.64	6.50	1.77	4.38	2.45	5.25	
Means of Totals	4.59		4.84		5.22		5.72		5.12		6.06			
			4.89						5.31					

Visual plus Tactile

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	3.63	2.67	4.75	2.49	4.13	1.89	4.50	2.78	5.50	1.85	4.75	2.12	4.54	
3D-3D	3.75	1.83	5.50	2.33	4.13	1.73	3.75	1.39	5.88	2.03	4.63	1.92	4.60	4.55
3D-2D	2.88	1.46	3.63	1.51	4.63	2.72	4.50	2.33	4.38	2.13	6.25	3.37	4.38	
2D-3D	3.75	1.83	5.38	1.51	3.75	2.05	5.38	2.33	5.25	1.98	4.50	2.93	4.67	
Means of Totals	3.50		4.81		4.16		4.53		5.25		5.03			
			4.16						4.94					

Table 65: Analysis of variance for repetitions (raw data) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (transformed log X), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	35.04	3.5	0.1	4.5^{x}	3.4
Ages (A)	2	6.10	0.6	0.4	0.7	0.3
GxA	2	5.39	0.5	0.6	0.2	0.5
S.W.G.	42	9.93				
Total Subjects	47					
Modalities (M)	1	29.26	7.4^{xxx}	7.0^{xxx}		
Conditions (C)	3	7.66	1.9	3.9^{xx}		
GxM	1	3.01	0.8	0.3		
GxC	3	2.02	0.5	0.2		
AxM	2	10.99	2.8	2.8		
AxC	6	7.82	2.0	2.0		
MxC	3	6.60	1.7	1.0		
GxAxM	2	2.85	0.7	0.9		
GxAxC	6	1.62	0.4	0.4		
GxMxC	3	2.60	0.7	0.6		
AxMxC	6	5.20	1.3	1.4		
Final Residual	300	3.94				
Grand Total	383					

The only other significant F ratio was for the main effect of Conditions when total visual fixation was taken into account ($F = 3.9$, df 3/299, $p < .025$). Tukey's HSD test showed that more repetitions occurred in Condition 2D-2D than in Condition 3D-3D ($p < .05$) and in Condition 2D-3D ($p < .05$).

Once again these results do not indicate quite the same as those of experiment 3. One result of that experiment was that the age II children made more repetitions than the age I children. The absence of this result here is not surprising in view of the age differences in the experiments which have already been discussed (sections III.B.2 and III.B.3). In the previous experiment it was also found that the mongol but not the normal children made more repetitions when the patterns were 2 D compared to when they were 3 D. This was found for both groups in this fourth experiment. Again, the age differences may account for the absence of a significant interaction between Groups and Conditions.

An additional and interesting feature to emerge so far from this fourth experiment is the way in which the children respond to a 2 D pattern presented simultaneously with a 3 D pattern. The two measures of alternations and repetitions indicate that the response to the patterns in Condition 2D-3D is similar to the response to the patterns in Condition 3D-3D. On the other hand, the patterns in Condition 3D-2D are responded to in a similar way to the patterns in Condition 2D-2D. This was not expected, and it suggests that the relationship between two patterns presented simultaneously is important in determining certain aspects of the child's response.

III.B.5. Time to Fixate the First Pattern

This was the time in seconds from the beginning of each trial until the child looked at a pattern. This pattern was termed the first pattern, and the other one will be referred to as the second pattern.

The best transformation was found to be $\frac{1}{(x + 1)}$ and Table 66 gives the means and standard deviations for each cell of these data. There are three points worth noticing in this table.

First, the normal children seem to look more quickly at the patterns than the mongol children. Second, the difference between the two groups is most

noticeable for the age I children. Finally, patterns which are presented in the V modality seem to be fixated faster than those presented in the V + T modalities.

The analyses, which are summarised in Table 67, provide support for these observations. The normal children take a shorter time to fixate the first pattern compared with the mongol children ($F = 8.3$, df 1/42, $p < .01$). The analyses of covariance show that this is not due to any age differences between the groups since the effect is still significant when either C.A. ($F = 7.3$, df 1/41, $p < .025$) or M.A. ($F = 8.1$, df 1/41, $p < .01$) is covaried out.

The significant effect of modalities confirms that when the patterns cannot be touched the children are faster to look at the first pattern compared with when the patterns can be touched ($F = 4.8$, df 1/300, $p < .05$).

The only significant interaction was between Groups and Ages ($F = 6.6$, df 2/41, $p < .025$) and Tukey's HSD test was employed to find the source of the interaction. The age I mongol children took longer from the beginning of each trial to look at a pattern compared with the age III mongol ($p < .05$) and the age I normal ($p < .01$) children. This interaction became nonsignificant when the C.A. differences between the six groups of children were taken into account ($F = 2.6$, df 2/41, n.s.), but remained significant when the M.A. differences were covaried out ($F = 6.5$, df 2.41, $p < .025$).

The finding of a group difference for this measure confirms the finding of experiment 3 that the normals take less time than the mongols to begin to look at a pattern (Chapter 6, section III.B.5). However, no difference was found in the speed with which the 2 D and 3 D patterns were fixated, whereas in experiment 3 the 3 D patterns were fixated more rapidly than the 2 D patterns. When this result was discussed (Chapter 6, section III.B.5), it was pointed out that this might have arisen because the 3 D patterns were presented nearer to the children than the 2 D patterns. In this fourth experiment both types of patterns were presented at the same distance from the children. The absence of a significant Conditions effect in this experiment therefore supports the suggestion that the different times taken to fixate the 2 D and 3 D patterns in experiment 3 were due to the difference in the distance from the child at which they were presented.

Table 66: Means and Standard Deviations for the Time to Fixate the First Pattern. The data were transformed $\frac{1}{(x+1)}$

Visual

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.57	0.27	0.64	0.27	0.69	0.16	0.70	0.19	0.70	0.22	0.68	0.18	0.66	
3D-3D	0.68	0.25	0.68	0.19	0.75	0.07	0.80	0.00	0.74	0.13	0.75	0.14	0.73	0.69
3D-2D	0.56	0.29	0.68	0.24	0.71	0.16	0.75	0.15	0.76	0.13	0.73	0.17	0.70	
2D-3D	0.47	0.29	0.67	0.25	0.68	0.24	0.67	0.17	0.78	0.05	0.69	0.16	0.66	
Means of Totals	0.57		0.67		0.71		0.73		0.74		0.71			
			0.65						0.73					

Visual plus Tactile

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.55	0.27	0.47	0.35	0.77	0.06	0.80	0.00	0.65	0.22	0.61	0.28	0.64	
3D-3D	0.32	0.25	0.53	0.30	0.73	0.17	0.78	0.05	0.59	0.30	0.66	0.28	0.60	0.64
3D-2D	0.57	0.33	0.62	0.18	0.70	0.22	0.72	0.15	0.74	0.09	0.61	0.30	0.66	
2D-3D	0.61	0.28	0.63	0.28	0.67	0.18	0.80	0.00	0.77	0.08	0.54	0.28	0.67	
Means of Totals	0.51		0.56		0.71		0.78		0.69		0.60			
			0.60						0.69					

Table 67: Analysis of variance for the time to fixate the first pattern (transformed $\frac{1}{(x+1)}$ and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.71	8.3^{xxx}	7.3^{xx}	8.1^{xxx}
Ages (A)	2	0.05	0.5	0.2	0.0
GxA	2	0.57	6.6^{xx}	2.6	6.5^{xx}
S.W.G.	42	0.09			
Total Subjects	47				
Modalities (M)	1	0.19	4.8^{x}		
Conditions (C)	3	0.01	0.3		
GxM	1	0.00	0.1		
GxC	3	0.01	0.1		
AxM	2	0.04	1.1		
AxC	6	0.05	1.2		
MxC	3	0.09	2.3		
GxAxM	2	0.10	2.6		
GxAxC	6	0.02	0.4		
GxMxC	3	0.02	0.6		
AxMxC	6	0.05	1.2		
Final Residual	300	0.04			
Grand Total	383				

III.B.6. Time to Fixate the Second Pattern

This measure was the time in seconds from the beginning of each trial until the child looked at the second pattern for the first time.

The most adequate transformation for these data was found to be log (X + 1), and Table 68 gives the means and standard deviations for each cell of these transformed data.

From this table the following points are worth noticing. First, the normal children seem to look at the second pattern in a shorter time than the mongol children. Second, the difference in the times taken by the two groups seems to be greatest for the age I children. By age III there seems to be little difference in the times to fixation for the mongol and normal children.

Third, the normal children seem to take the same amount of time to fixate the second pattern when it is presented in the V modality as in the V + T modalities. The mongol children appear to take longer to fixate the second pattern when it is presented in the V + T modalities compared with patterns presented in the V modality.

These observations were confirmed by the analyses which are summarised in Table 69. The Group effect was significant ($F = 18.0$, df 1/42, $p < .001$) and showed that the time to fixate the second pattern was shorter for the normal children compared with the mongol children. The covariance analyses showed that this difference could not be accounted for by the difference in age between the two groups. When either C.A. was covaried out ($F = 22.41$, df 1/41, $p < .001$) or M.A. was the covariate ($F = 21.72$, df 1/41, $p < .001$), the effect remained highly significant.

The main effect of Ages was significant ($F = 7.5$, df 2/42, $p < .01$) and the differences between the means were examined using Tukey's HSD test. The age I children took longer to fixate the second pattern compared with the age II ($p < .05$) and the age III ($p < .01$) children. The two analyses of covariance showed that this effect was accounted for by the age differences at the three age levels, since covarying out either C.A. ($F = 1.2$, df 2/41, n.s.) or M.A. ($F = 0.6$, df 2/41, n.s.) made the effect nonsignificant.

Table 68: Means and Standard Deviations for the Time to Fixate the Second Pattern. The transformation log (X + 1) was applied to the data

Visual

Group	Mongol						Normal						
Age	I		II		III		I		II		III		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	1.13	0.48	0.77	0.42	0.47	0.32	0.74	0.47	0.39	0.24	0.66	0.50	0.69
3D-3D	1.12	0.56	0.71	0.37	0.62	0.41	0.63	0.50	0.49	0.35	0.51	0.51	0.68
3D-2D	1.20	0.48	0.51	0.32	0.57	0.31	0.54	0.47	0.38	0.32	0.59	0.39	0.63
2D-3D	0.97	0.51	0.64	0.32	0.73	0.38	0.90	0.54	0.43	0.27	0.54	0.25	0.70
Means of Totals	1.11		0.66		0.60		0.70		0.42		0.57		0.68
			0.79						0.57				

Visual plus Tactile

Group	Mongol						Normal						
Age	I		II		III		I		II		III		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	1.17	0.46	0.94	0.56	0.63	0.32	0.53	0.42	0.49	0.23	0.54	0.30	0.72
3D-3D	1.07	0.37	0.95	0.26	0.54	0.30	0.51	0.34	0.65	0.52	0.55	0.30	0.71
3D-2D	1.09	0.42	0.84	0.45	0.59	0.33	0.51	0.40	0.67	0.32	0.50	0.41	0.70
2D-3D	1.48	0.30	0.82	0.26	0.75	0.34	0.60	0.45	0.41	0.32	0.53	0.30	0.76
Means of Totals	1.20		0.89		0.63		0.54		0.56		0.53		0.72
			0.91						0.54				

Table 69: Analysis of variance for the time to fixate the second pattern (transformed log (X + 1)) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	8.23	18.0^{xxxx}	22.4^{xxxx}	21.7^{xxxx}
Ages (A)	2	3.42	7.5^{xxx}	1.2	0.6
GxA	2	1.78	3.9^{x}	0.6	4.6^{xxx}
S.W.G.	42	0.46			
Total Subjects	47				
Modalities (M)	1	0.20	1.8		
Conditions (C)	3	0.07	0.6		
GxM	1	0.50	4.5^{x}		
GxC	3	0.02	0.2		
AxM	2	0.45	4.0^{x}		
AxC	6	0.12	1.1		
MxC	3	0.01	0.1		
GxAxM	2	0.08	0.7		
GxAxC	6	0.10	0.9		
GxMxC	3	0.16	1.4		
AxMxC	6	0.07	0.6		
Final Residual	300	0.11			
Grand Total	383				

There were three significant two-way interactions. The first was between Groups and Ages ($F = 3.9$, df 2/42, $p < .05$). When this interaction was investigated by Tukey's HSD test it was found to be caused by the mongol age I children taking longer to fixate the second pattern compared to the mongol age II ($p < .05$), the mongol age III ($p < .01$) and the normal age I ($p < .01$) children. The interaction became nonsignificant when C.A. was the covariate ($F = 0.6$, df 2/41, n.s.), but remained significant when the covariate was M.A. ($F = 4.6$, df 2/41, $p < .025$).

The second interaction was between Groups and Modalities ($F = 4.5$, df 1/300, $p < .05$) and was examined using Tukey's HSD test. The normals took less time to fixate the second pattern than the mongol children both when the patterns were presented in the V modality ($p < .01$) and the V + T modalities ($p < .01$). The interaction seemed to be due to the mongol children tending to take longer to fixate the second pattern in the V + T modalities than in the V modality, although this difference was just not significant.

The remaining interaction was between Ages and Modalities ($F = 4.0$, df 2/300, $p < .05$). Tukey's HSD test showed that in the V modality, the age I children took longer than the age II ($p < .01$) and the age III ($p < .01$) children to fixate the second pattern. In the V + T modalities the age I children took longer than the age III children ($p < .01$). At age II the children took longer to fixate the second pattern in the V + T modalities than in the V modality ($p < .05$).

Like the previous measure (section III.B.5), this measure found no difference between 2 D and 3 D patterns, whereas in experiment 3 the second of a pair of 3 D objects was looked at more rapidly than the second of a pair of 2 D patterns. As before this may be because the 2 D and 3 D patterns used in the present experiment were presented at the same distance from the child, whilst in experiment 3 the 3 D patterns were nearer to the child than the 2 D patterns.

An additional result was that the mongol age I children were significantly slower to fixate the second pattern than the normal age I children. In experiment 3 the youngest mongol children tended to take longer than the youngest normal children to look at the second pattern when the patterns were 3 D. There was no such tendency when the patterns were 2 D (Chapter 6, section III.B.6). It is

possible that the group difference in the present experiment arose because in three out of the four conditions at least one pattern was 3 D (Conditions 3D-3D, 2D-3D and 3D-2D), whereas only in Condition 2D-2D were both patterns 2 D. The tendency observed in experiment 3 for the youngest mongol and normal children to take different times to look at the 3 D patterns may have been accentuated in this fourth experiment by the fact that one 3 D pattern at least was presented on six out of the eight trials.

III.B.7. Average Fixation Length

The average fixation length to each pattern was calculated by dividing the total visual fixation to that pattern by the corresponding number of fixations. The total visual fixation included the total length of any fixation which began before the trial ended and ended after the trial should have been terminated. The present measure was the mean of the average fixation lengths to the two patterns presented together on each trial. When only one pattern was looked at, the measure was taken as the average fixation length to that pattern.

The most suitable transformation was found to be $\frac{1}{x}$, and Table 70 gives the means and standard deviations for each cell of the data.

From this table it can be seen firstly that the average fixation length to patterns presented in the V modality seems to be shorter than that to patterns presented in the V + T modalities. Secondly, the average fixation length to patterns in Condition 2D-2D appear to be shorter than those in the other three conditions.

The analyses which are summarised in Table 71 support these observations. The modality factor is significant ($F = 8.6$, df 1/300, $p < .01$) indicating that patterns presented in the V modality receive shorter average fixation lengths than those presented in the V + T modalities.

The Conditions effect is also significant ($F = 3.4$, df 3/300, $p < .025$) and the differences between the means were examined by Tukey's HSD test to find the source of the effect. These showed that the average fixation length to patterns in Condition 2D-2D were shorter than in Condition 2D-3D ($p < .05$). With Scheffé's S method it was shown that the average fixation length to Condition 2D-2D patterns

Table 70: Means and Standard Deviations for Average Fixation Length. The data were transformed $\frac{1}{x}$

Visual

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.62	0.26	0.82	0.20	0.91	0.21	0.73	0.19	0.89	0.19	0.76	0.24	0.79	
3D-3D	0.70	0.44	0.82	0.25	0.83	0.19	0.74	0.12	0.68	0.19	0.74	0.24	0.75	0.75
3D-2D	0.66	0.21	0.69	0.22	0.95	0.29	0.66	0.16	0.71	0.20	0.71	0.19	0.73	
2D-3D	0.55	0.28	0.78	0.24	0.91	0.32	0.62	0.20	0.82	0.19	0.73	0.14	0.73	
Means of Totals	0.63		0.78		0.90		0.69		0.78		0.74			
			0.77						0.73					

Visual plus Tactile

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.64	0.27	0.83	0.18	0.88	0.24	0.77	0.29	0.81	0.19	0.67	0.17	0.77	
3D-3D	0.70	0.32	0.68	0.21	0.75	0.23	0.56	0.10	0.61	0.12	0.64	0.11	0.66	0.69
3D-2D	0.72	0.39	0.77	0.21	0.73	0.27	0.64	0.25	0.60	0.15	0.61	0.09	0.68	
2D-3D	0.53	0.32	0.66	0.25	0.84	0.34	0.60	0.26	0.75	0.19	0.60	0.17	0.66	
Means of Totals	0.64		0.74		0.80		0.64		0.69		0.63			
			0.73						0.66					

Table 71: Analysis of variance for average fixation length (transformed $\frac{1}{x}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.28	1.8	0.1	1.9
Ages (A)	2	0.48	3.1	0.4	0.3
GxA	2	0.32	2.1	0.5	2.0
S.W.G.	42	0.15			
Total Subjects	47				
Modalities (M)	1	0.34	8.6^{xxx}		
Conditions (C)	3	0.14	3.4^{xx}		
GxM	1	0.03	0.7		
GxC	3	0.05	1.1		
AxM	2	0.06	1.6		
AxC	6	0.06	1.6		
MxC	3	0.02	0.6		
GxAxM	2	0.01	0.2		
GxAxC	6	0.04	1.1		
GxMxC	3	0.03	0.1		
AxMxC	6	0.02	0.4		
Final Residual	300	0.04			
Grand Total	383				

was shorter than in the other three conditions together ($p < .025$).

The finding that the patterns in Condition 2D-2D receive shorter average fixations than the patterns in the other conditions in which at least one pattern is 3 D, is consistent with the finding in experiment 3 that the fixations to the 3 D patterns are on average longer than those to 2 D patterns.

III.B.8. Length of the First Fixation to the First Pattern

This measure was the length of the first fixation that the child made to the first pattern which he fixated on each trial.

The most adequate transformation was found to be $\frac{1}{(x + 1)}$, and the means and standard deviations for each cell of these transformed data are given in Table 72.

The only noticeable aspect from this table of means is that the normal children seem to make shorter first fixations to the first pattern than do the mongol children.

This observation was not confirmed by the analyses which are summarised in Table 73. The only significant F ratio was that for the interaction between Ages, Modalities and Conditions ($F = 2.1$, df 6/300, $p < .05$), but none of the differences between the means reached significance on Tukey's HSD test.

In the previous experiment there were two significant results with this measure. The first was that the age I children made longer first fixations to the first pattern than the age II children. The absence of this result in the present experiment is not surprising in view of the fact, discussed in section III.B.2, that the age I children in this experiment were older than those in experiment 3.

The second significant result in experiment 3 was that the first fixation was longer if the patterns were 3 D rather than 2 D. The absence of this result in the present experiment is slightly surprising and is most likely due to the many differences in the way in which the patterns were presented in the two experiments.

Table 72: Means and Standard Deviations for the Length of the First Fixation to the First Pattern. The data were transformed $\frac{1}{(x+1)}$

Visual

Group	Mongol						Normal						
Age	I		II		III		I		II		III		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.44	0.08	0.47	0.20	0.63	0.13	0.45	0.22	0.65	0.12	0.59	0.10	0.54
3D-3D	0.43	0.26	0.46	0.25	0.55	0.19	0.64	0.10	0.52	0.21	0.55	0.25	0.52
3D-2D	0.48	0.18	0.56	0.20	0.56	0.15	0.60	0.14	0.60	0.19	0.54	0.22	0.56
2D-3D	0.40	0.21	0.49	0.17	0.51	0.04	0.49	0.27	0.58	0.19	0.49	0.16	0.49
Means of Totals	0.44		0.49		0.56		0.55		0.59		0.54		0.53
			0.50						0.56				

Visual plus Tactile

Group	Mongol						Normal						
Age	I		II		III		I		II		III		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.54	0.18	0.47	0.11	0.51	0.12	0.58	0.21	0.55	0.08	0.56	0.13	0.54
3D-3D	0.46	0.17	0.58	0.12	0.52	0.20	0.53	0.15	0.55	0.21	0.51	0.16	0.53
3D-2D	0.52	0.11	0.50	0.17	0.54	0.15	0.55	0.17	0.46	0.18	0.61	0.15	0.53
2D-3D	0.50	0.18	0.40	0.14	0.54	0.09	0.54	0.18	0.58	0.19	0.58	0.19	0.52
Means of Totals	0.51		0.49		0.53		0.55		0.54		0.57		0.53
			0.51						0.55				

Table 73: Analysis of variance for the length of the first fixation to the first pattern (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.25	3.3	3.6	3.2
Ages (A)	2	0.05	0.6	0.1	0.2
GxA	2	0.04	0.6	0.1	0.5
S.W.G.	42	0.08			
Total Subjects	47				
Modalities (M)	1	0.00	0.0		
Conditions (C)	3	0.02	1.0		
GxM	1	0.01	0.3		
GxC	3	0.01	0.2		
AxM	2	0.03	1.4		
AxC	6	0.01	0.2		
MxC	3	0.01	0.5		
GxAxM	2	0.04	1.5		
GxAxC	6	0.03	1.2		
GxMxC	3	0.01	0.6		
AxMxC	6	0.05	2.1		
Final Residual	300	0.02			
Grand Total	383				

III.B.9. Length of the First Fixation to the Second Pattern

This was the length of the first fixation which the child made to the pattern which he looked at second on each trial.

The data were best transformed by $\frac{1}{(\overline{x} + 1)}$ and Table 74 gives the means and standard deviations for each cell of these data.

From this table it can be seen that all of the children except for those in the mongol age I group seem to make longer first fixations to the second pattern when the patterns are presented in the V + T modalities compared with in the V modality.

The analyses which are summarised in Table 75 showed that patterns presented in the V + T modalities received longer first fixations of the second pattern than those presented in the V modality ($F = 4.0$, df 1/300, $p < .05$).

The remaining significant F ratio was for the interaction between modalities and conditions ($F = 2.7$, df 3/300, $p < .05$). Tukey's HSD test showed that in Condition 3D-2D longer fixations to the second pattern occurred in the V + T modalities than in the V modality ($p < .05$). No other difference between the means was significant.

In experiment 3 it was found that the length of the first fixation to the second pattern was longer when the patterns were 3 D rather than 2 D. As in the previous measure, this difference was not significant in this fourth experiment.

III.B.10. Touching

This was the sum of the time which the child spent touching each of the two patterns which were presented for each of the four conditions in the V + T modalities.

The most appropriate transformation was found to be log (X + 1), and the means and standard deviations for each cell of these transformed data are given in Table 76.

From this table the following points can be noticed. The normal children seem to spend more time touching the patterns than the mongol children. Second, in both groups, the age I children seem to touch the patterns less than the age II

Table 74: Means and Standard Deviations for the Length of the First Fixation to the Second Pattern. The data were transformed $\frac{1}{(x+1)}$

Visual

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.41	0.09	0.49	0.17	0.58	0.17	0.57	0.14	0.56	0.14	0.46	0.14	0.51	
3D-3D	0.44	0.26	0.54	0.14	0.46	0.17	0.49	0.22	0.45	0.15	0.50	0.17	0.48	0.51
3D-2D	0.60	0.28	0.51	0.15	0.50	0.06	0.60	0.12	0.56	0.19	0.55	0.10	0.55	
2D-3D	0.46	0.29	0.50	0.13	0.47	0.06	0.46	0.18	0.52	0.14	0.52	0.13	0.49	
Means of Totals	0.48		0.51 0.50		0.50		0.53		0.52 0.52		0.51			

Visual plus Tactile

Group	Mongol						Normal						Means of Totals	
Age	I		II		III		I		II		III			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.52	0.25	0.47	0.17	0.50	0.13	0.45	0.15	0.52	0.12	0.54	0.17	0.50	
3D-3D	0.48	0.14	0.42	0.17	0.45	0.17	0.44	0.16	0.46	0.16	0.40	0.18	0.44	0.48
3D-2D	0.43	0.25	0.44	0.21	0.46	0.15	0.44	0.14	0.43	0.16	0.50	0.17	0.45	
2D-3D	0.60	0.30	0.47	0.12	0.50	0.10	0.45	0.19	0.51	0.17	0.53	0.23	0.51	
Means of Totals	0.51		0.45 0.48		0.48		0.44		0.48 0.47		0.49			

Table 75: Analysis of variance for the length of the first fixation to the second pattern (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.01	0.1	0.3	0.1
Ages (A)	2	0.00	0.0	0.0	0.1
GxA	2	0.01	0.1	0.1	0.1
S.W.G.	42	0.06			
Total Subjects	47				
Modalities (M)	1	0.10	4.0^{x}		
Conditions (C)	3	0.04	1.5		
GxM	1	0.02	0.9		
GxC	3	0.01	0.3		
AxM	2	0.01	0.3		
AxC	6	0.01	0.2		
MxC	3	0.07	2.7^{x}		
GxAxM	2	0.05	1.8		
GxAxC	6	0.02	0.7		
GxMxC	3	0.00	0.1		
AxMxC	6	0.01	0.6		
Final Residual	300	0.03			
Grand Total	383				

and age III children. Finally, except for the mongol age I children, all of the children seem to touch the patterns less in Condition 2D-2D than in the other three conditions.

The analyses are summarised in Table 77, and these show that the normal children touched the patterns more than the mongol children ($F = 7.7$, df 1/42, $p < .01$). When C.A. is covaried out ($F = 10.1$, df 1/41, $p < .01$) or M.A. is covaried out ($F = 8.44$, df 1/41, $p < .01$), the group effect remains and is therefore not due to the age differences between the mongol and normal children.

The main effect of age was significant ($F = 7.3$, df 2/42, $p < .01$) and Tukey's HSD test was employed to find the source of the effect. This showed that the age I children touched the patterns less than either the age II ($p < .01$) or the age III ($p < .01$) children. When either C.A. was covaried out ($F = 1.3$, df 2/41, n.s.) or M.A. was covaried out ($F = 0.7$, df 2/41, n.s.), the effect became nonsignificant, and therefore the age effect was due to the age differences between the children.

The final significant F ratio was for Conditions ($F = 8.5$, df 3/126, $p < .001$) and Tukey's HSD test was used to find the source of this effect. It was found that less touching occurred in Condition 2D-2D than in Condition 3D-3D ($p < .01$) and Condition 3D-2D ($p < .01$). Scheffé's S method showed that less touching occurred in Condition 2D-2D than in the mean of the other three conditions ($p < .01$).

This measure confirms the finding in experiment 3 that older children, both mongol and normal, touch patterns more than younger children. However, the difference found here between the groups was not significant in experiment 3 although there was a tendency for the normal children to touch the 3 D objects more than the mongol children. Although there was a difference in this fourth experiment in the amounts that the two groups touched the patterns, there was no indication in the visual measures that this effected their looking behaviour, since there were no significant interactions between Groups and Modalities in any of these measures. Such interactions would have been expected if the amount of touching produced differences in visual behaviour, since the two groups would have behaved similarly in the V modality but differently in the V + T modalities.

Table 76: Means and Standard Deviations for Touching. The data were transformed log (X + 1)

Group	Mongol						Normal						Means of Totals
Age	I		II		III		I		II		III		
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.43	0.43	0.56	0.41	0.67	0.49	0.45	0.49	0.66	0.41	1.02	0.34	0.63
3D-3D	0.29	0.37	1.12	0.50	0.98	0.51	0.88	0.64	1.32	0.35	1.18	0.26	0.96
3D-2D	0.43	0.57	0.79	0.59	0.98	0.54	0.94	0.62	1.32	0.39	1.19	0.42	0.94
2D-3D	0.38	0.54	0.87	0.24	0.78	0.51	0.62	0.70	0.98	0.54	1.21	0.41	0.81
Means of Totals	0.38		0.83		0.85		0.72		1.07		1.15		
			0.69						0.98				

Table 77: Analysis of variance for touching (transformed log (X + 1)) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	4.13	7.7^{xxx}	10.1^{xxx}	8.4^{xxx}
Ages (A)	2	3.91	7.3^{xxx}	1.3	0.7
GxA	2	0.04	0.1	0.6	0.1
S.W.G.	42	0.54			
Total Subjects	47				
Conditions (C)	3	1.12	8.5^{xxxx}		
GxC	3	0.14	1.1		
AxC	6	0.17	1.3		
GxAxC	6	0.17	1.3		
Final Residual	126	0.13			
Grand Total	191				

III.C. Summary of Results

The next two sections summarise the results of this experiment. The results which show no difference between the mongol and normal children are given in the first section, whilst those results which show differences will be found in the second section. Each measure will be summarised separately within each section.

III.C.1. Similarities in the Behaviour of the Mongol and Normal Children

Total Visual Fixation. The mongol and the normal children fixated the patterns in Condition 2D-2D for less time than the patterns in Conditions 3D-3D, 3D-2D and 2D-3D.

Number of Fixations. The age I children made fewer fixations than either the age II or the age III children, and fewer fixations were made to patterns which could be touched than to patterns which could not be touched.

Alternations. Fewer alternations of fixation were made by the age I children than by either the age II or the age III children, both when the patterns could be touched and when they could not be touched. However, the number of alternations made to patterns which could be touched was less than the number made to patterns which could not be touched. Fewer alternations occurred to patterns in Conditions 2D-2D and 3D-2D than to those in Conditions 3D-3D and 2D-3D.

Repetitions. The number of repetitions made to patterns which could be touched was less than the number made to patterns which could not be touched. More repetitions occurred to patterns in Condition 2D-2D than to those in Conditions 3D-3D and 2D-3D.

Time to First Fixate the First Pattern. When the patterns could not be touched the first pattern was first fixated in a shorter time than when the patterns could be touched.

Time to First Fixate the Second Pattern. When the children were not allowed to touch the patterns, the age I children took longer than the age II and the age III children to first fixate the second pattern. When the children could touch the patterns, the age I children took longer than the age III children to first fixate the second pattern. The age II children took longer to fixate the second pattern when they were allowed to touch the patterns compared with when touching was not permitted.

Average Fixation Length. The average fixation length was shorter to patterns which could not be touched than to patterns which could be touched. The patterns presented in Condition 2D-2D received shorter average fixation lengths than those presented in the other three conditions.

Length of the First Fixation to the First Pattern. This measure did not produce any significant results.

Length of the First Fixation to the Second Pattern. The length of the first fixation to the second pattern was longer when the patterns could be touched than when they could not be touched. This was particularly true for the patterns presented in Condition 3D-2D.

Touching. The amount of time that the age I children spent touching the patterns was less than for either of the other two age groups. The patterns presented in Condition 2D-2D were touched less than those patterns presented in the other three conditions when at least one of the patterns was 3 D (Conditions 3D-3D, 3D-2D, 2D-3D).

III.C.2. Differences in the Behaviour of the Mongol and Normal Children

The four measures of alternations, average fixation length, and the lengths of the first fixations to the first pattern and the second pattern will be omitted from this section because they showed no differences in the behaviour of the mongol and the normal children.

Total Visual Fixation. The total visual fixation for the normal children was greater than for the mongol children.

Number of Fixations. The normal children made more fixations than the mongol children, even when these data were adjusted for differences in total visual fixation times.

Repetitions. When the C.A. differences between the normal and mongol children were covaried out, it was found that the normal children made more repetitions than the mongol children.

Time to First Fixate the First Pattern. This time was shorter for the normal children than for the mongol children. This group effect was greatest at age I and had disappeared by age III.

Time to First Fixate the Second Pattern. The normal children were quicker than the mongol children to first fixate the second pattern, when the patterns could be touched and when they could not be touched. The mongol age I children took longer than all of the other children to fixate the second pattern.

Touching. The normal children touched the patterns more than the mongol children.

IV. DISCUSSION

This experiment was designed to compare the way in which 3 D and 2 D patterns are inspected visually by young mongol and normal children both when patterns can be touched and when they cannot. The aim was to discover if touch had any effect on the way in which these children looked at the two types of pattern.

If touch had a different effect on the visual inspection of these patterns depending on whether they were 2 D or 3 D, this would have been demonstrated by significant interactions between Modalities and Conditions. However, the only measure in which this interaction was significant was the length of the first fixation to the second pattern. This showed that the second pattern in Condition 3D-2D to be fixated received a longer first fixation when the patterns could be touched compared with when they could not. For no measure was the interaction between Groups, Modalities and Conditions significant, and this demonstrates that the way in which 2 D and 3 D patterns are looked at by both groups of children is not effected by whether or not they are allowed to touch them. However, this is not to deny that touch does have some overall effect on visual behaviour. This effect will be discussed later.

The absence of any interaction between Groups, Modalities and Conditions might suggest that the difference in the visual responses of the mongol and normal children to 3 D objects which was found in experiment 3 was independent of the fact that these objects could be touched. However in the present experiment no group difference was found for the way in which the 3 D patterns were looked at. This failure to replicate the results of the previous experiment was discussed in sections III.B.2, III.B.3 and III.B.4, when the relevant measures were reported.

It was suggested that this failure to replicate might have occurred because of a difference in the ages of the youngest children in the two experiments. In experiment 3 the difference in the way in which the mongol and normal children inspected 3 D patterns was found mainly with the age I children, and in the present experiment the age I children had mean C.A.s and M.A.s which fell between those of the age I and age II children of experiment 3.

Clearly what is required is to repeat the present experiment with younger mongol children and normal controls to discover whether or not touch plays a role at these younger ages when it seems that there are differences in the visual responses of these children to 3 D objects. Unfortunately this was not possible because at the time I knew of no mongols of suitable ages. This is however an experiment which should be carried out when appropriately aged children are available.

On the positive side there are a number of interesting and important results which emerge from this experiment. Some of these involve differences between the mongol and normal children; others similarities between the two groups.

The striking difference between the groups seems to be that the normal children showed greater overall interest in the patterns than the mongol children. This was demonstrated for example by the normals looking at the patterns and touching them for longer than the mongols. However, neither of these results were obtained in the previous experiments and so may be just a function of the patterns which were presented in the present experiment. On the other hand, in experiment 3, as in the present experiment, the normal children began to look at the patterns in a shorter time than the mongols. The normal children in this fourth experiment also made more fixations, especially repetitions of fixation than did the mongols.

Despite this possible lack of interest on the part of the mongol children, it must be made clear that for many of the results there was no difference between the responses of the mongol and normal children. These fall into two categories. First, results which indicate differences in the responses at the various ages in both groups. Here it can be seen that in both groups the age II and age III children are more responsive to the patterns than are the age I children. In

particular the older age groups make more comparisons between the patterns and touch them more than do the youngest children. This difference in the amount of touching was also found in experiment 3, whereas in both experiments 1 and 3 the age difference in the number of alternations did not occur.

Thus although the results of the present experiment suggest signs of a developmental trend within both groups to explore patterns more extensively in terms of touching and scanning patterns, the alternations data are inconsistent with those of the previous experiments. However, the present age change in alternations is consistent with the results of Harris (1973) when two different patterns were presented (Chapter 2, section II.C.1a). The ages of the children in the three experiments which have been described so far in this thesis and which have measured alternations, have been older than those tested by Harris (1973). Therefore it may be that the failure to find evidence of more active scanning with increasing age in the previous experiments occurred because the children were responding as Harris' oldest children, but that with the sort of patterns used in the present experiment age differences do occur.

The second sort of similarity in the responses of the two groups concerns the effects of the different modalities and conditions. There was only one measure in which the interaction between Groups and Modalities was significant and this was for the time to fixate the second pattern. This just indicated that the normals were faster than the mongols in both modalities, and showed no difference in the effect of the modality on the behaviour of either group.

On the other hand, many of the measures indicated that the visual behaviour of both groups was influenced, and in the same way, by whether or not the patterns could be touched. Both groups of children seemed to be less interested visually in patterns which they could not touch than in patterns which they could touch. This is demonstrated by the fact that patterns which could be touched were fixated on average for longer and received fewer repetitions and alternations of fixation than patterns which could not be touched. This is an important result because for the first time there is an indication that touch can have a similar effect on the behaviour of mongol and normal children. It must mean that although mongol children seem to have some sort of tactile deficit (Chapter 5),

when they are allowed to touch patterns this seems to attract their visual attention in the same way as in normal children of similar mental age.

One result which does not seem to have any obvious explanation was that the patterns were looked at for the first time more quickly if they could not be touched than if they could be touched.

The effect of the four different conditions was clear and indicated that both groups paid more attention to the patterns when at least one was 3 D (Conditions 3D-3D, 3D-2D and 2D-3D) than when both patterns were 2 D (Condition 2D-2D). This was shown by longer total fixation times, more touching and longer average fixation lengths when at least one pattern was 3 D. However there seemed to be some difference between the responses to the patterns in Condition 3D-2D and those to the patterns in Condition 2D-3D. The patterns in Condition 3D-2D received similar numbers of alternations and repetitions as those in Condition 2D-2D. The number of alternations were less and the numbers of repetitions were more in these two conditions than the respective numbers made to the patterns presented in Conditions 3D-3D and 2D-3D. This was an unexpected result and indicated that the relative left-right positions of a 2 D and a 3 D pattern had an effect on how they were inspected visually. This raises the question of whether or not other spatial relationships between two patterns will also influence the way in which the patterns are looked at.

The next experiment made a direct comparison between the visual responses of mongol and normal children to 2 D and 3 D patterns which were presented along the horizontal axis as in all of the preceding experiments, and to the same patterns presented one above the other along the vertical axis.

CHAPTER 8

Experiment 5: A Comparison of the Visual Responses of Normal and Mongol Children to Patterns in Different Locations

I. INTRODUCTION

In the previous experiments the responses of the mongol and normal children were compared when they were presented with two patterns side by side. The last experiment produced an unexpected result which was that the way in which the mongol and normal children scan two different patterns may be influenced by the relative left-right positions of the two patterns. This raises the possibility that the relative spatial locations of two patterns may affect the way in which they are compared visually. In the real world there are other axes than the horizontal one. Therefore it is important to establish whether or not patterns presented along one axis are looked at in a similar way to the same patterns presented along another axis.

This problem has been ignored in studies of visual perception in very young children, although Butterworth (1974) provided some evidence that locations along vertical and horizontal axes may produce different search errors in children under one year old. In the vertical axis there were two locations, up and down. Eight, nine and ten month old infants retrieved an object from one location for five trials after which the object was hidden at the other location. Significantly more infants than expected by chance made an error when the location was changed from up to down, particularly the oldest infants. In other words, they continued to search at the up location although the object had been hidden in the down location. On the other hand when the object was moved from down to up the number of infants making an error did not differ from the number expected by chance. In the horizontal axis children of this age tend to continue to search at the initial location whether the object is moved from the left to the right location or vice versa.

This study indicates that children may respond in different ways to locations

along horizontal and vertical axes. The fifth experiment was therefore designed to compare directly the visual responses of mongol and normal children when two patterns were presented in left and right positions with when they were presented in up and down positions.

Some of the evidence reviewed in Chapter 2, section II.C.1a, indicated that newborns orient their eyes towards vertical contours but not to horizontal contours because of a preponderance of horizontal scans. Such scanning movements will cross vertical contours, but not horizontal contours with the result that the former but not the latter are noticed. If this also tends to occur in older children it would lead to the prediction that two patterns arranged along the horizontal axis would be looked at and compared more frequently than patterns arranged along the vertical axis. Similarly, if a child tends not to scan in a vertical fashion it would be expected that he would concentrate on one of the two vertical patterns. This would result in more repetitions occurring to vertical patterns than to horizontal patterns and the time to fixate the second of two vertical patterns should be longer than that for two horizontal patterns.

In experiment 3 it was found that the youngest normal children made more alternations between two 3 D patterns than the youngest mongol children. This suggests the possibility that under certain circumstances normal children may scan the environment in a more extensive way than mongol children. This difference between the groups was not replicated in experiment 4 and it was pointed out that this may have been because the children in this experiment were older than those in experiment 3. There has therefore been no confirmation or rejection of a difference in the extent of scanning by the normal and mongol children. However, this fifth experiment will provide a further comparison of the extent of the scanning of a visual display by these two groups of children. If mongol children have more restricted scan patterns than normal children, it is just possible that this difference will be emphasised by presenting patterns along the vertical axis.

The results of the last experiment were specific in that they indicated that there was a possible influence of the spatial location of a 3 D pattern relative to that of a 2 D pattern. If this is a stable result, it is possible that when a 2 D and a 3 D pattern are presented together in the up-down position, there will also

be an effect of which pattern is in the top position and which pattern is presented in the bottom position.

Therefore the experiment which was designed was intended to replicate experiment 4 and to extend the results to a situation in which the patterns are presented in an up-down position. The patterns were presented visually and touching was prevented since the results of experiment 4 indicated that any effects that touch had on visual behaviour were similar for both the normal and the mongol children.

II. METHOD

II.A. Subjects

The 32 children who took part in this experiment had C.A.s between 6 and 32 months. Sixteen of these children were normal and 16 were mongol.

As in the previous experiments each mongol child was individually matched with a normal child for M.A., sex and social class. There were two age levels, age I and age II, and the pairs of matched children were assigned to one of these on the basis of the mongol's C.A. Table 78 gives the means, standard deviations and ranges of the C.A.s of the groups. From this table it can be seen that

Table 78: Chronological Ages of the Groups (in months)

	MONGOL		NORMAL			
AGE I	Mean	19.06	Mean	10.21	Mean	14.64
	S.D.	3.98	S.D.	2.51	S.D.	5.59
	Range	14.9-24.5	Range	6.5-14.1		
AGE II	Mean	27.77	Mean	15.16	Mean	21.47
	S.D.	3.73	S.D.	2.34	S.D.	7.17
	Range	20.5-32.0	Range	11.2-17.5		
	Mean	23.42	Mean	12.69		
	S.D.	5.84	S.D.	3.47		

there was a certain amount of overlap in the C.A.s of the two age levels. However, the means of the two ages were quite different, with the age II children being older than the age I children. It should also be noticed from this table that the mongols were chronologically older than the normals. The reason for this difference and the way in which it was taken into account when the data were analysed were the same as described in Chapter 4, section II.A.2.

When the C.A.s of these children are compared to those in previous experiments (Tables 8, 23, 28 and 53) it will be seen that the age I mongol children have essentially the same mean C.A. as those in experiments 1 and 2 but are nine and six months older than those in experiments 3 and 4 respectively. The mongol age II children in the present experiment have a mean C.A. which is similar to those of the equivalent groups of children in experiments 1, 2 and 3, but are intermediate between the mean C.A.s of the age II and III mongols in experiment 4. The normal age I children have a mean C.A. which is similar to that of the corresponding children in experiment 1, two months younger than those in experiment 2, and three and two months older than those in experiments 3 and 4 respectively. The normal age II children in the present experiment have a mean C.A. which is within one or two months of the mean C.A. of the age II normals in all of the other experiments.

II.A.1. Matched Aspects of the Mongol and Normal Children

a) Mental Age

The means, standard deviations and ranges of the M.A.s in months of the groups are reported in Table 79.

Table 79: Mental Ages of the Groups (in months)

	MONGOL		NORMAL			
AGE I	Mean	9.91	Mean	10.16	Mean	10.04
	S.D.	2.89	S.D.	2.93	S.D.	2.81
	Range	5.5-14.3	Range	5.7-14.6		
AGE II	Mean	15.31	Mean	15.20	Mean	15.26
	S.D.	2.54	S.D.	2.43	S.D.	2.40
	Range	10.8-17.8	Range	10.4-17.6		
	Mean	12.61	Mean	12.68		
	S.D.	3.83	S.D.	3.68		

This table indicates that the mongol and normal children at each of the two ages have extremely similar M.A.s, and that the age II children have larger M.A.s than the age I children.

Compared to the mean M.A.s of the children in previous experiments (Tables 9, 24, 29 and 54), it can be seen that both the mongol and normal children at the two ages had almost identical M.A.s to those in experiment 1, and were about two months younger than those in experiment 2. The age I and II children were about three and a half and two months older than the age I and II children in experiment 3 respectively. Both ages had mean M.A.s about one month older than the age I and II children in experiment 4.

b) Sex

Of the 16 mongol children who completed the experiment, seven were female and those were each matched for M.A. and social class with a normal female. Two of the female mongols and their normal controls were in age I and the remaining five female mongols and their normal controls were in age II. All of the other mongol and normal children were male.

c) Social Class

Table 80 gives the number of mongol and normal children at each age level who were classified according to the Registrar General's Index into each of the six social classes. Since each mongol was matched for social class with a normal there are equal numbers of mongol and normal children in each class.

Table 80: The Social Classes of the children in the groups as given by the Registrar General's Index

	MONGOL						NORMAL					
	I	II	IIIN	IIIM	IV	V	I	II	IIIN	IIIM	IV	V
AGE I	0	3	2	3	0	0	0	3	2	3	0	0
AGE II	2	3	1	0	1	1	2	3	1	0	1	1
Total	2	6	3	3	1	1	2	6	3	3	1	1

Thus every mongol child who participated in this experiment was matched with a normal child for M.A., sex and social class.

II.A.2. Discarded Subjects

All of the 16 mongol children who started the experiment completed it successfully. In order to obtain the 16 normal children's data, the records from two normal children had to be discarded and replaced. The datum from one child was discarded because it was incomplete because the apparatus failed. The second normal child whose datum was discarded, successfully completed the experiment. However when he was tested on the Bayley Scales of Mental Development, he was found to have a M.A. which was more than two months different from the M.A. of the mongol with whom he was to be matched. He was therefore not considered adequate as a control and so his datum was discarded.

II.B. Apparatus

The matt black box which was used to present the patterns in experiments 1, 3 and 4 was not suitable for this experiment. The reason was that there was insufficient height from top to bottom to present two patterns along the vertical axis such that they were separated by the same distance as two patterns presented along the horizontal axis. Therefore a new matt black box was designed. The main differences between this box and the box used in the earlier experiments were size and the way in which the patterns were presented to the children.

The box measured 53.5 cm. high by 92 cm. wide by 35.5 cm. deep. As before a 4-channel Rustrak event recorder to which two push button controls were attached was used to provide a permanent record of the visual behaviour of the children. The length of each trial was measured by a clock provided with a sweeping second hand.

The box was open on the side nearest the child and he was prevented from touching the back of the box by a clear perspex screen positioned 15.5 cm. in front of the back of the box. Two clear 25 cm. long 60 W tungsten tubes

were fixed vertically to the sides of the box. Angled side panels painted matt black prevented these lights from being seen from the front of the box but did not restrict the illumination of the back of the box. The child was prevented from reaching around these side panels to touch the lights by the clear perspex screen.

The stimulus material were presented in pairs along either the horizontal or the vertical axis. The box used in the previous experiment had a false bottom and back and the patterns were displayed to the child by rotating the back and base of the box towards the child. The increased height of the new box made this method impractical since the base of the box would have had to have been as deep as the box was high. The reason for this was so that when the base and back of the box were rotated away from the child, the base would prevent the child from seeing the patterns being changed. Therefore a new method for presenting the patterns was devised. Four squares of 12.7 cm. length sides were cut out of the back panel. Two were aligned along the horizontal line which bisected the panel. Two were similarly aligned along the corresponding vertical line. The centre of the back panel was found and the nearest edge of each square was 10 cm. from this point. There was a peep-hole of 0.5 cm. diameter at the centre of the back panel.

Four matt black receiving panels each of 12.6 cm. length sides were pivoted behind the four square openings in the back panel. A stimulus was displayed by hooking it onto a receiving panel and rotating both panels through 180^{o}. This operation is shown in Figure 14.

When two stimuli were in position there were 22.6 17.5 cm. between the edges of the patterns. Figures 15 and 16 show the two patterns presented in the horizontal axis and in the vertical axis respectively. To change the patterns the panels were simply rotated through 180^{o} and the experimenter exchanged the exposed patterns for the next one. While the patterns were being changed all that the child saw was the black back of the receiving panels.

17.5 cm from cent. of sq. to peep.

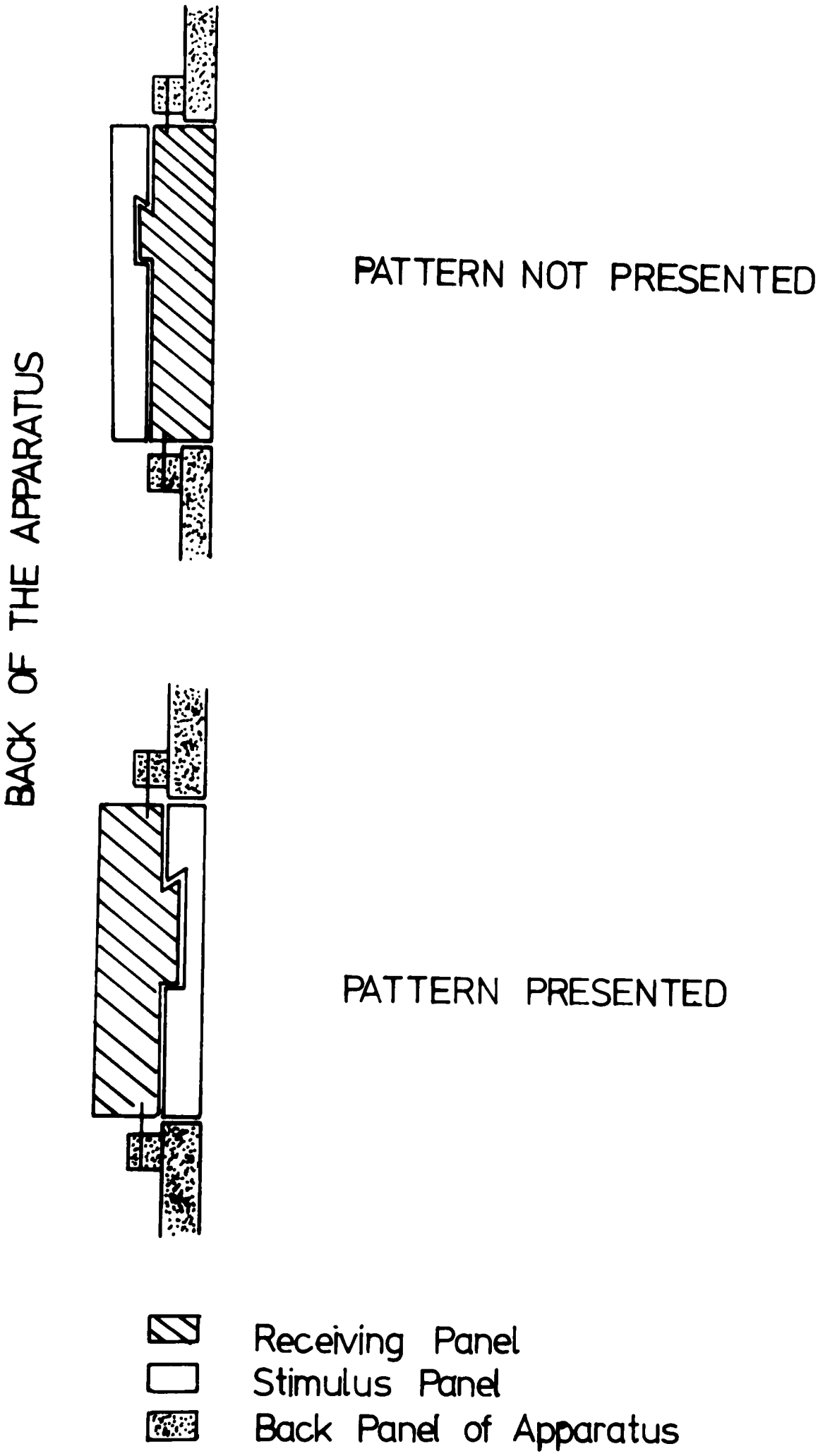


Figure 14: A diagram of the panels used to present the patterns

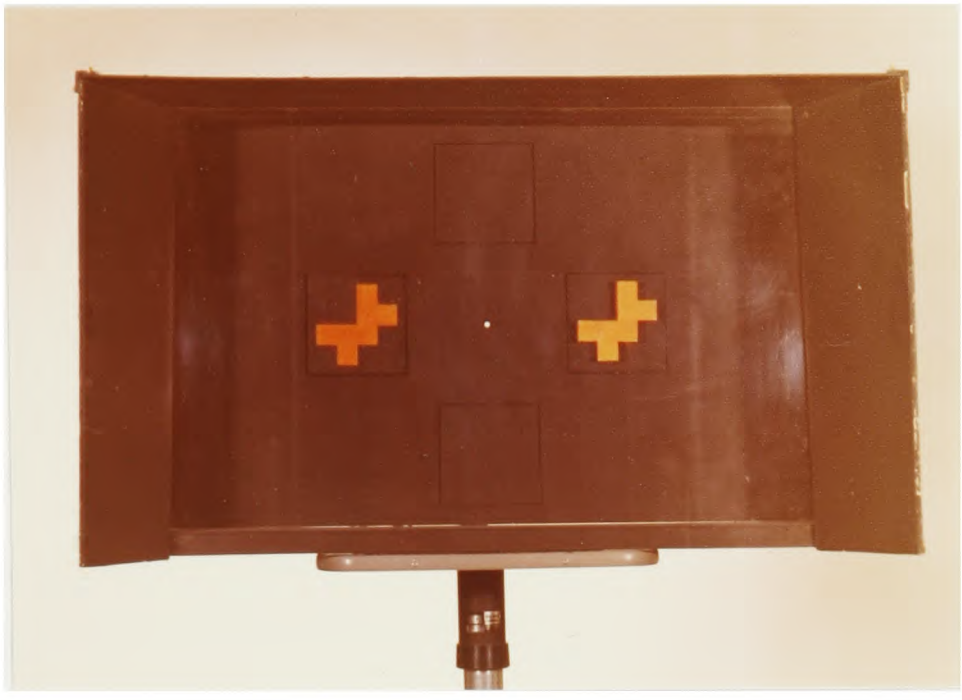


Figure 15: Presentation of patterns along the horizontal axis

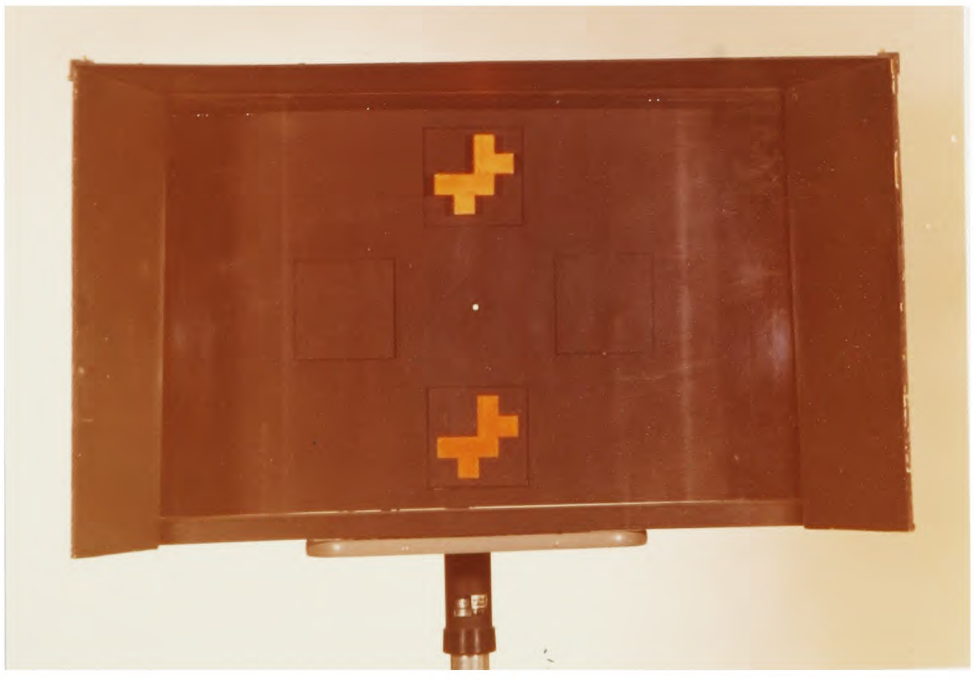


Figure 16: Presentation of patterns along the vertical axis

II.C. Stimulus Material

The stimuli were identical to those used in the previous experiment (Chapter 7, section II.C) except that the matt black panel was cut down to a square of 12.5 cm. length sides, and modified as described below.

There were two identical sets of material each consisting of eight patterns. One set is illustrated in Figure 17. Half of the patterns were 3 D and half were 2 D. One of each type of pattern was painted pink, blue, orange or green. The shape was the same in all cases.

The modification to the panels was that a groove 1.5 cm wide and 0.3 cm. deep was cut horizontally across the back of each panel. The groove was angled so that the panel could be hooked onto one of the four receiving panels of the apparatus.

II.D. Procedure

The procedure was extremely similar to that followed in experiment 4 (Chapter 7, section II.D). However there were several differences. The first difference was that the child was prevented from touching the patterns on all of the trials. The reason for this was that the results of experiment 4 indicated that allowing the children to touch the patterns or preventing them from touching had no significant effect on the visual response to the different left and right arrangements of the patterns.

The second procedural difference from experiment 4 was that on half of the trials the two patterns were presented one above the other along the vertical axis. This was so that the effects of spatial location could be investigated. On the remaining trials the patterns were presented side by side along the horizontal axis. Finally the number of one minute trials was increased to 16 and these were divided between two visits.

Thus each child was tested on two visits and on each visit completed eight trials. Two patterns were presented on each trial. On four consecutive trials of each visit one pattern was presented above the other along the vertical axis; on the other four trials the patterns were presented side by side along the horizontal axis.

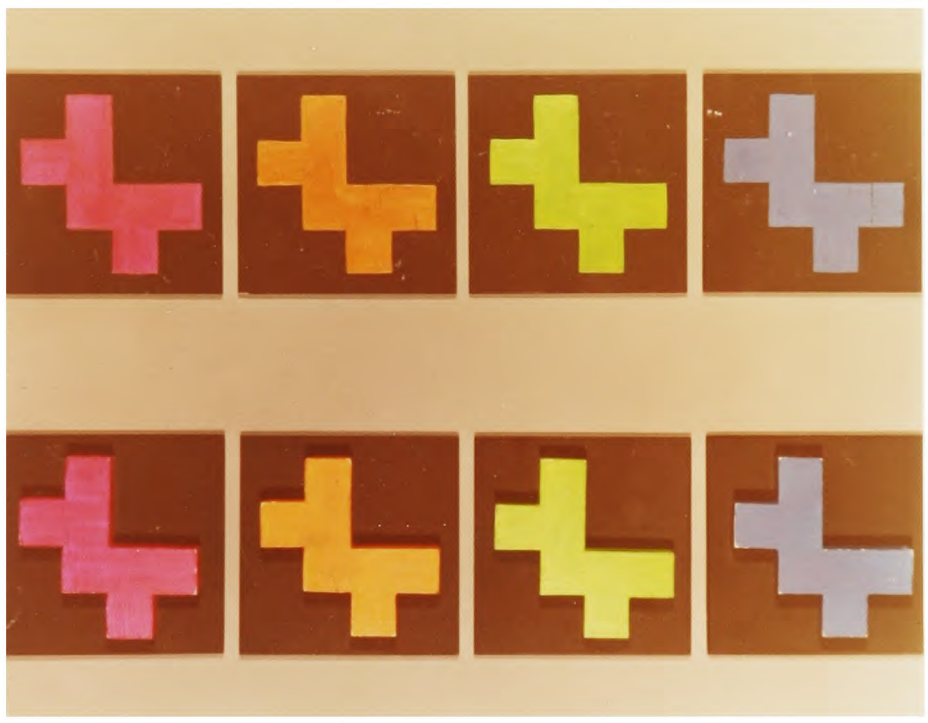


Figure 17: The patterns

There were four different conditions and each was presented on one trial within each block of four trials. The four conditions were the same as in experiment 4 (Chapter 7, section II.D.1) and were 2D-2D, 3D-3D, 3D-2D and 2D-3D. When the patterns in Condition 3D-2D were presented in the vertical axis, the 3 D pattern was above the 2 D pattern and in Condition 2D-3D the 2 D pattern was presented above the 3 D pattern. On each trial the two patterns were of the same colour but the colour was different on each of the four trials within a block.

II.D.1. Counterbalancing

The variables which were balanced across the eight children in each of the four groups are summarised in Table 81 A. One was the order of presenting the patterns along the horizontal (abbreviated to H) and the vertical (abbreviated to V) axes. Four of the children in each group were presented with patterns along the H axis on the first four trials of the first visit and on the second four trials of the second visit. On the other trials the patterns were presented along the V axis. This order was reversed for the remaining four children in each group.

The second and third variables to be randomised across the children are summarised together in Table 81 A as the order of presentation of conditions and colours within each block of four trials. The four orders of conditions and colours combined were the same as those used in experiment 4 and therefore the reader is referred to Chapter 7, section II.D.1 for the details of the way in which these orders were obtained.

Since each child had to complete four blocks of four trials, it was possible for him to be presented with a different order of the conditions and colours for each block. A randomised Latin Square was used to obtain four combinations of the four orders of presenting the conditions and colours. In each group two children with different orders of the axes were assigned to each combination that was derived from the randomised Latin Square. This is summarised in Table 81 B.

Table 81: The Counterbalancing of the Subjects

A. Summary of the randomisation procedures

1) Order of presentation of the patterns along the horizontal (H) and vertical (V) axes

Order	Trials on the first visit		Trials on the second visit	
	1-4	5-8	1-4	5-8
i	Horizontal(H)	Vertical(V)	Vertical(V)	Horizontal(H)
ii	Vertical(V)	Horizontal(H)	Horizontal(H)	Vertical(V)

2) Order of presentation of conditions and colours within each block of four trials

	First Trial		Second Trial		Third Trial		Fourth Trial	
Order	Condition	Colour	Condition	Colour	Condition	Colour	Condition	Colour
a	2D-2D	Blue	2D-3D	Orange	3D-3D	Green	3D-2D	Pink
b	3D-3D	Orange	3D-2D	Blue	2D-2D	Pink	2D-3D	Green
c	3D-2D	Green	3D-3D	Pink	2D-3D	Blue	2D-2D	Orange
d	2D-3D	Pink	2D-2D	Green	3D-2D	Orange	3D-3D	Blue

B. Assignment of subjects

	Order of Axes				Order of Conditions and Colours			
	First Visit Trials		Second Visit Trials		First Visit Trials		Second Visit Trials	
Subject	1-4	5-8	1-4	5-8	1-4	5-8	1-4	5-8
1	H	V	V	H	a	c	d	b
2	H	V	V	H	b	d	c	a
3	H	V	V	H	c	b	a	d
4	H	V	V	H	d	a	b	c
5	V	H	H	V	a	c	d	b
6	V	H	H	V	b	d	c	a
7	V	H	H	V	c	b	a	d
8	V	H	H	V	d	a	b	c

II.D.2. The Method of Presentation

Although the apparatus was different from that used in experiment 4, the method of presentation was almost identical, and therefore reference should be made to Chapter 7, section II.D.2 for details. However there were two differences. First, the height of the child was adjusted until his eyes were in line horizontally with the peep-hole in the centre of the back panel of the box. This was so that he was centred relative to the patterns since these were presented at the same distance from the peep-hole whether they were in the top, bottom, left or right location.

The second difference in the method of presentation was that in this experiment the experimenter initiated and terminated each trial by rotating the two relevant stimulus panels simultaneously towards and away from the child respectively.

II.D.3. The Scoring of the Experimental Observations

This was similar to the scoring of the data in the previous two experiments and the same measurements were taken of the visual responses of the children. Details of the measurements can be found in Chapter 6, section II.D.3. The only difference in the present measures was that each measure was either the total or the mean of the scores from the two trials in which the same condition was presented in the same axis on the two test sessions. Also no measure was taken of the amount of touching since the children were prevented from touching the patterns on all of the trials by the clear perspex screen.

III. RESULTS

III.A. General Method of Analysis

The general method of analysis was the same as that described for experiment 1 except that the variables which were analysed were different. The reader is referred to Chapter 4, section III.A for the general details. The data from the present experiment were analysed using a four-way split-plot analysis of variance. There were two between subject variables and two within subject variables. The between subject variables were Groups (Mongol vs. Normal) and Ages (I vs. II). The within subject variables were Axes (Horizontal vs. Vertical) and Conditions (2D-2D vs. 3D-3D vs. 3D-2D vs. 2D-3D).

The two Conditions 3D-2D and 2D-3D were clearly different in the two Axes. For example in Condition 3D-2D in the horizontal axis the 3 D pattern was presented to the left of the 2 D pattern, whereas in the vertical axis the 3 D pattern was presented above the 2 D pattern. These two types of presentation were arbitrarily combined for the purposes of the analyses, as were the two presentations corresponding to the other conditions. Any differences between the conditions in the two axes would have been signalled by an interaction between Axes and Conditions. This interaction did not occur in any of the analyses. Therefore it was not necessary to separate out the different conditions in the two axes.

As before, two analyses of covariance were performed on the data using the same design as the analysis of variance with the covariates of C.A. and M.A.

III.B. Measures

III.B.1. Total Visual Fixation

This was the sum of the amount of time that each of the two patterns presented on two trials for each condition and axis was fixated.

When these data were tested for transformations none was found to be more suitable than the raw data. Table 82 therefore gives the means and standard deviations for each cell of the raw data.

From this table it can be seen that the age I mongol children tend to look for less time than the age II mongol children, whereas it is the age II normal children who tend to look for less time than the age I normal children. The second point to notice is that the patterns in Condition 3D-3D tend to be fixated for longer than those in any of the other conditions.

The analyses that were performed on these data are summarised in Table 83. The Groups by Ages interaction was significant ($F = 4.5$, df 1/28, $p < .05$). However when the differences between the means were examined by Tukey's HSD test none of them was found to be significant. When C.A. was the covariate this interaction became nonsignificant ($F = 3.1$, df 1/27, n.s.) and when M.A. was the covariate the interaction was still significant ($F = 5.1$, df 1/27, $p < .05$). Thus this interaction was due to the C.A. differences of the four groups of children.

Table 82: Means and Standard Deviations for Total Visual Fixation. The data were not transformed

Horizontal Axis

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	44.88	14.63	51.16	13.81	55.00	14.98	45.63	8.61	49.16	
3D-3D	45.59	15.52	54.00	15.02	57.59	10.29	51.94	9.17	52.28	48.67
3D-2D	38.28	14.46	49.16	17.24	52.16	16.00	44.34	10.21	45.98	
2D-3D	42.72	16.07	49.75	13.97	53.25	12.77	43.34	13.65	47.27	
Means of Totals	42.87		51.02		54.50		46.31			
	46.94				50.41					

Vertical Axis

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	42.34	11.32	53.16	11.58	51.88	11.56	41.81	12.31	47.30	
3D-3D	50.16	18.99	55.63	12.13	50.78	11.43	55.72	15.47	53.07	50.42
3D-2D	42.84	10.15	53.56	14.22	53.78	11.09	47.63	10.63	49.45	
2D-3D	53.34	12.53	54.41	11.94	52.03	6.23	47.63	13.34	51.85	
Means of Totals	47.17		54.19		52.12		48.20			
	50.68				50.16					

Table 83: Analysis of variance for total visual fixation (raw data) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	138.43	0.2	1.1	0.2
Ages (A)	1	37.32	0.1	0.3	3.1
GxA	1	2975.40	4.5^{X}	3.1	5.1^{X}
S.W.G.	28	657.24			
Total Subjects	31				
Axes (As)	1	194.69	1.9		
Conditions (C)	3	317.12	3.1^{X}		
GxAs	1	254.50	2.5		
GxC	3	65.46	0.6		
AxAs	1	39.26	0.4		
AxC	3	79.36	0.8		
AsxC	3	133.35	1.3		
GxAxAs	1	116.57	1.1		
GxAxC	3	112.96	1.1		
GxAsxC	3	12.44	0.1		
AxAsxC	3	12.20	0.1		
Final Residual	199	102.55			
Grand Total	255				

The only other F ratio to reach significance was for the effect of Conditions ($F = 3.1$, df 3/199, $p < .05$). Tukey's HSD test confirmed that the patterns in Condition 3D-3D were fixated for longer than the patterns in Condition 2D-2D ($p < .05$) and Condition 2D-3D ($p < .01$). Scheffé's S test was used to compare the amount of fixation to the patterns in Condition 3D-3D to the mean of the amounts of fixation to the patterns in the other three conditions. The difference failed to reach the five per cent level.

The results of this measure confirm the finding of experiment 3 that there was no difference in the fixation times of the mongol and normal children. These results also replicate the previous finding that the patterns are fixated for longer by all of the children if they are both 3 D than if they are both 2D. Because of this difference it will be necessary, as in the previous experiments, to take fixation times into account when the results of the number of fixations, alternations and repetitions are considered in sections III.B.2, III.B.3 and III.B.4, respectively. This will be achieved by an analysis of covariance for the separate measures with the covariate of total visual fixation.

The effect of Axes was not significant ($F = 1.9$, df 1/199, n.s.) indicating there was no effect on looking time of presenting two patterns in a horizontal or vertical arrangement. Therefore this is evidence that the spatial arrangement of patterns does not influence the total length of time for which the patterns are looked at.

III.B.2. Number of Fixations

This measure was the number of times that the child looked at the patterns presented on the two trials for each combination of condition and axis.

The data were tested to see if a transformation was necessary and the most appropriate one was found to be log X. The means and standard deviations for each cell of these transformed data are given in Table 84.

Several points should be noticed from this table. First, the normal children tend to make more fixations than the mongol children. Second, the mongol age II children seem to make more fixations than the mongol age I children, whereas there seems to be no corresponding age difference for the normal children. Third, more fixations seem to occur to patterns arranged horizontally than to

patterns arranged vertically. Finally in the horizontal axis, but not in the vertical axis, more fixations seem to occur in Condition 3D-3D than in the other three conditions.

Four analyses were carried out on the data: an analysis of variance and three analyses of covariance with the covariates of total visual fixation, C.A. and M.A. All of these analyses are summarised in Table 85.

The analysis of variance confirmed that the normals made more fixations than the mongols ($F = 5.7$, df 1/28, $p < .025$). This effect remained in each analysis of covariance with the covariates of total visual fixation ($F = 12.9$, df 1/27, $p < .01$), C.A. ($F = 6.0$, df 1/27, $p < .025$) and M.A. ($F = 6.8$, df 1/27, $p < .025$). Therefore the group difference in number of fixations is independent of any differences in the fixation times, C.A.s and M.A.s of the two groups.

When total visual fixation times were controlled the age II children made more fixations than the age I children ($F = 7.8$, df 1/27, $p < .01$). This effect can be explained by two facts. First, the mongol age II children looked longer at the patterns and made more fixations to them than did the age I mongols. Second, the age II normals looked at the patterns for less time but made a similar number of fixations compared to the age I normals. Therefore all of the age II children made more fixations per unit of fixation time than the age I children. Hence the significant effect of ages but only when total visual fixation times were controlled.

The other significant F ratio was for Axes ($F = 12.8$, df 1/199, $p < .001$) and this remained significant when total visual fixation times were controlled ($F = 21.8$, df 1/198, $p < .001$). These analyses confirmed the observation made from the table of means that more fixations were made to patterns in the horizontal axis than to those in the vertical axis. This is an important result because it is the first to show that the spatial arrangement of two patterns can have a significant effect on the visual behaviour of mongol and normal children.

In addition, these results replicate those of experiment 4 (Chapter 7, section III.B.2), and like those results failed to find the significant interaction between Groups and Conditions that was found in experiment 3 (Chapter 6, section III.B.2). This interaction came about because the normals made more fixations to 3 D

Table 84: Means and Standard Deviations for Number of Fixations. The data were transformed log X

Horizontal Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	1.38	0.18	1.49	0.15	1.49	0.10	1.57	0.13	1.48
3D-3D	1.42	0.14	1.47	0.17	1.57	0.10	1.58	0.12	1.51
3D-2D	1.35	0.20	1.49	0.20	1.51	0.12	1.58	0.10	1.48
2D-3D	1.36	0.16	1.51	0.13	1.50	0.14	1.52	0.15	1.47
Means of Totals	1.38		1.49		1.52		1.56		1.49
	1.43				1.54				

Vertical Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	1.31	0.12	1.47	0.12	1.52	0.13	1.45	0.15	1.44
3D-3D	1.36	0.11	1.45	0.10	1.46	0.12	1.50	0.14	1.44
3D-2D	1.36	0.11	1.46	0.13	1.50	0.11	1.52	0.10	1.46
2D-3D	1.37	0.15	1.47	0.11	1.47	0.17	1.49	0.18	1.45
Means of Totals	1.35		1.46		1.49		1.49		1.45
	1.41				1.49				

Table 85: Analysis of variance for number of fixations (transformed log X) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (raw data), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.563	5.7^{xx}	12.9^{xxx}	6.0^{xx}	6.8^{xx}
Ages (A)	1	0.305	3.1	7.8^{xxx}	0.0	0.4
GxA	1	0.111	1.1	1.4	0.4	1.2
S.W.G.	28	0.099				
Total Subjects	31					
Axes (As)	1	0.098	12.8^{xxxx}	21.8^{xxxx}		
Conditions (C)	3	0.004	0.6	0.5		
GxAs	1	0.008	1.0	0.1		
GxC	3	0.006	0.8	0.4		
AxAs	1	0.006	0.8	1.7		
AxC	3	0.003	0.4	1.0		
AsxC	3	0.008	1.0	0.8		
GxAxAs	1	0.007	0.9	2.5		
GxAxC	3	0.005	0.7	0.6		
GxAsxC	3	0.003	0.4	0.4		
AxAsxC	3	0.006	0.8	0.7		
Final Residual	199	0.008				
Grand Total	255					

than to 2 D patterns, whereas the mongols made more fixations to 2 D than to 3 D patterns. However this effect was due to the behaviour of the age I mongols and normals in experiment 3. The age I children in the present experiment, like those in experiment 4, were older than those in experiment 3 (section II.A, II.A.1,a). So once again the absence of an interaction between Groups and Conditions is most likely due to the ages of the children.

III.B.3. Alternations

This was the number of times that each child compared the patterns which were presented on the two trials for each axis and condition combination. The most suitable transformation was $\sqrt{(X + 0.5)}$ and Table 86 gives the means and standard deviations for each cell of the transformed data.

From this table it can be seen that the normal children tend to make more alternations than the mongol children. Also the age II children seem to make more alternations than the age I children. Finally, more alternations seem to occur to patterns presented along the horizontal axis than to those presented along the vertical axis, and this difference is most obvious for the mongol age I and the normal age II children.

Four analyses were carried out on these transformed data and they are summarised in Table 87. There was an analysis of variance and three analyses of covariance with the covariates of total visual fixation time, C.A. and M.A. These analyses essentially confirm the observations made from the table of means.

The Group effect was significant in the analysis of variance ($F = 5.2$, df 1/28, $p < .05$) and when total visual fixation times were controlled ($F = 11.6$, df 1/27, $p < .01$) indicating that normal children did make more alternations than the mongol children and that this was independent of any differences in fixation time. The group effect was still significant when C.A. was controlled ($F = 6.5$, df 1/27, $p < .025$) and when M.A. was the covariate ($F = 6.5$, df 1/27, $p < .025$). Therefore the group effect is not accounted for by differences in the agesof the children.

The second significant main effect was Ages ($F = 6.1$, df 1/28, $p < .025$) confirming that the age II children made more alternations than did the age I

Table 86: Means and Standard Deviations for Alternations. The data were transformed $\sqrt{(X + 0.5)}$

Horizontal Axis

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	3.95	1.01	4.43	0.99	4.46	0.66	5.17	0.85	4.50	
3D-3D	4.11	1.00	4.63	1.17	4.76	0.76	5.23	0.88	4.68	4.55
3D-2D	3.81	1.26	4.68	1.40	4.44	1.09	5.33	0.70	4.56	
2D-3D	3.83	0.80	4.61	0.98	4.40	1.00	4.91	1.06	4.44	
Means of Totals	3.92		4.59		4.51		5.16			
	4.26				4.84					

Vertical Axis

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	3.13	0.81	4.36	0.66	4.40	1.14	4.13	1.27	4.01	
3D-3D	3.15	0.83	4.13	0.71	4.01	0.79	4.45	0.90	3.93	3.97
3D-2D	3.06	0.95	4.05	0.90	4.50	0.93	4.43	0.77	4.01	
2D-3D	3.13	0.89	4.31	1.03	3.86	1.36	4.50	1.26	3.95	
Means of Totals	3.12		4.21		4.19		4.38			
	3.66				4.28					

Table 87: Analysis of variance for alternations (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (not transformed), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	23.10	5.2^{x}	11.6^{xxx}	6.5^{xx}	6.5^{xx}
Ages (A)	1	26.93	6.1^{xx}	16.6^{xxxx}	0.2	0.0
GxA	1	3.45	0.8	2.3	0.2	0.8
S.W.G.	28	4.43				
Total Subjects	31					
Axes (As)	1	20.98	44.6^{xxxx}	55.0^{xxxx}		
Conditions (C)	3	0.15	0.3	0.5		
GxAs	1	0.03	0.1	0.6		
GxC	3	0.30	0.6	0.4		
AxAs	1	0.00	0.0	0.1		
AxC	3	0.17	0.4	0.6		
AsxC	3	0.23	0.5	0.6		
GxAxAs	1	3.20	6.8^{xx}	9.4^{xxx}		
GxAxC	3	0.08	0.2	0.0		
GxAsxC	3	0.10	0.2	0.2		
AxAsxC	3	0.41	0.9	0.9		
Final Residual	199	0.47				
Grand Total	255					

children. This difference remained when total visual fixation times were controlled ($F = 16.6$, df 1/27, $p < .001$) but was not significant when the covariate was C.A. ($F = 0.2$, df 1/27, n.s.) and when it was M.A. ($F = 0.0$, df 1/27, n.s.). Thus the age II children made more alternations than the age I children because they were older in terms of C.A. and M.A. and not because of any difference in fixation times.

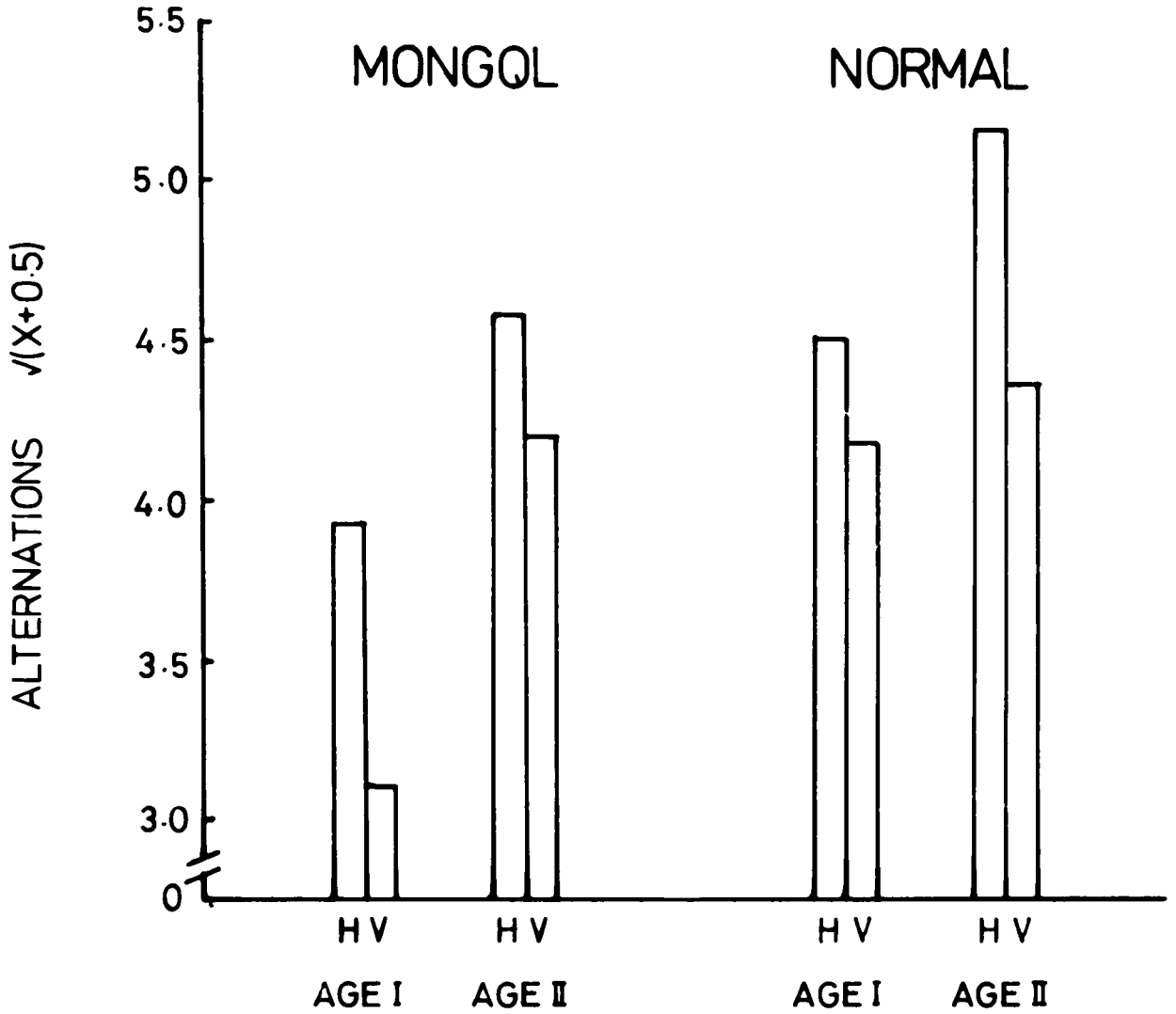
The highly significant Axes term showed that more alternations occurred between horizontally arranged patterns than between vertically arranged patterns ($F = 44.6$, df 1/199, $p < .001$). The effect of Axes was still significant when total visual fixation times were controlled ($F = 55.0$, df 1/198, $p < .001$). This result provides further evidence for a difference in the ways in which two patterns in different spatial arrangements are fixated, in that two horizontal patterns are compared more frequently than two vertical patterns.

However, the possibility that the effect of the different axes is not the same for all of the groups is indicated by the significant interaction between Groups, Ages and Axes ($F = 6.8$, df 1/199, $p < .025$) which remained significant when total visual fixation was covaried out ($F = 9.4$, df 1/198, $p < .01$). The interaction is shown in Figure 18 a and b. When the differences between the means were examined by Tukey's HSD test it was found that the normal age I children made more alternations than the mongol age I children when the patterns were arranged vertically ($p < .01$), and that the normal age II children made more alternations than the mongol age II children when the patterns were arranged horizontally ($p < .05$). Both of these differences were significant when total visual fixation was ignored and when it was controlled. When total visual fixation was ignored, the normal age I children also made more alternations than the mongol age I children when the patterns were arranged horizontally ($p < .01$).

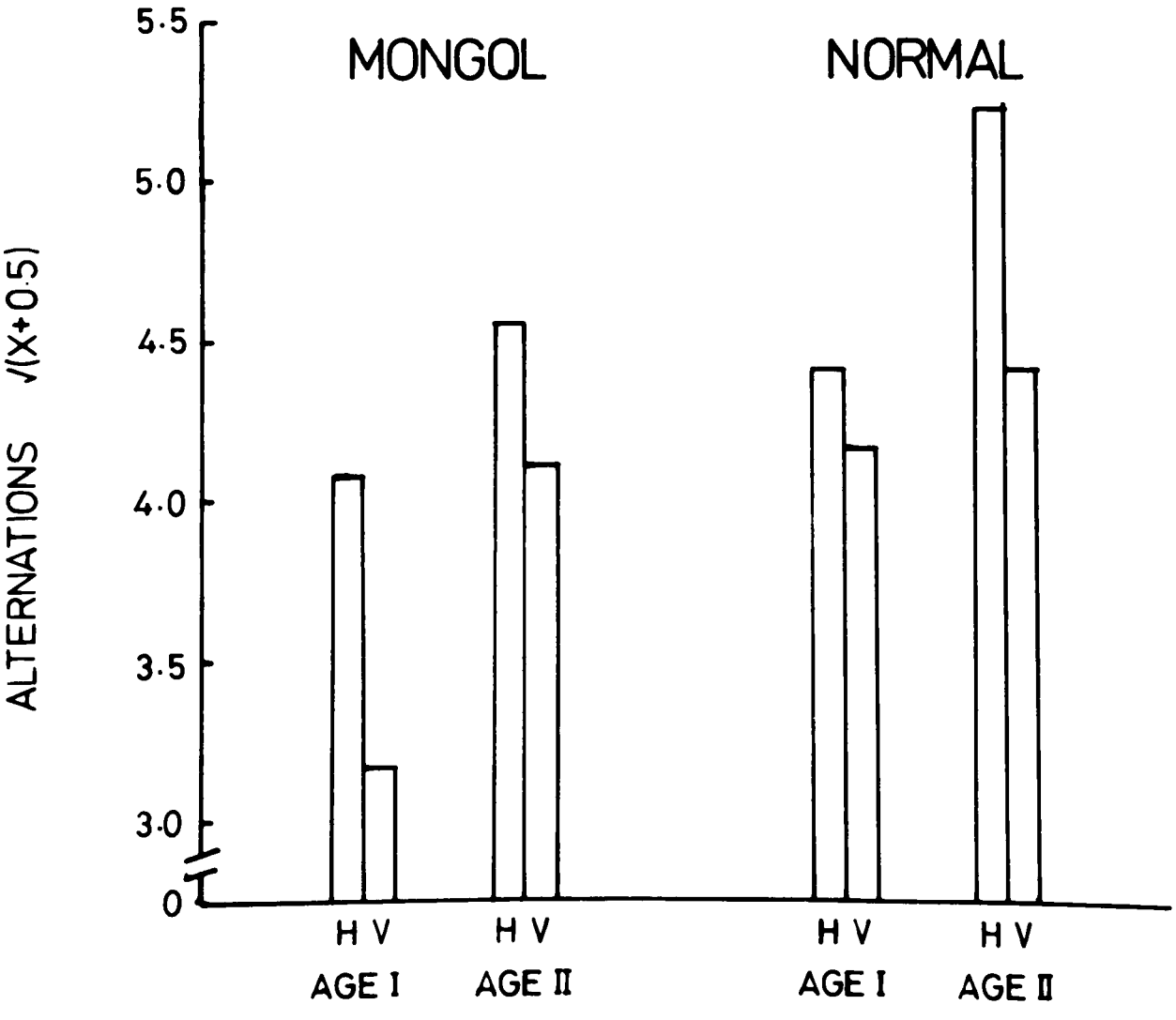
The same interaction between Groups, Ages and Axes showed that the mongol age II children made more alternations than the mongol age I children to vertical patterns ($p < .01$) in both analyses, and when total visual fixation was ignored, the same age difference occurred to the horizontal patterns ($p < .01$). The normal age II children made more alternations than the normal age I children when the patterns were horizontal ($p < .01$) both when total visual fixation was ignored and when it was controlled.

Figure 18: Groups by Ages by Axes interaction for alternations (transformed $\sqrt{(X + 0.5)}$)

a) Total visual fixation not controlled



b) Total visual fixation (raw data) controlled



Finally in the same interaction differences between the number of alternations to the axes were found for the mongol age I children and the normal age II children ($p < .01$ when total visual fixation was ignored, and when total visual fixation was controlled). In both cases the horizontal patterns received more alternations than the vertical patterns.

This measure produced no difference in the number of alternations made to the four different conditions. There is therefore no support for the finding of experiment 4 (Chapter 7, section III.B.3) that more alternations occur to patterns in Conditions 3D-3D and 2D-3D than to patterns in Conditions 2D-2D and 3D-2D. The only evidence from the present experiment that the relative locations of 2 D and 3 D patterns effects the number of comparisons made between them was that more alternations occurred between horizontal patterns than between vertical patterns especially for the youngest mongols and the oldest normals. In view of the predominance of horizontal scans in young babies (Chapter 2, section II.C.1,a) it is perhaps not surprising that in the present experiment horizontal movements of the eyes occurred more often than vertical movements.

One final comment about this measure is that the age II children made more alternations than the age I children. This replicates the finding in experiment 4 using the same patterns (Chapter 7, section III.B.3). There is therefore some support for the suggestion made in the discussion to experiment 4 (Chapter 7, section IV) that the absence in experiments 1 and 3 of a development towards more extensive scanning with increased age may depend in some way on the patterns to be looked at.

III.B.4. Repetitions

This was the total number of times on each of the two trials in the same condition and axis that the child made repeated fixations of the same pattern. The most suitable transformation of the data was $\sqrt{(X + 0.5)}$ and Table 88 summarises the means and standard deviations for each cell of thesetransformed data.

From this table it can be seen that the normal children tend to make more repetitions than the mongol children. Second, more repetitions tend to occur to patterns arranged vertically than to those arranged horizontally. This last feature

is especially obvious for the age I mongols and the age II normals.

The analyses carried out on these data and which are summarised in Table 89 confirm these observations. The Group effect is significant when total visual fixation is ignored ($F = 4.2$, df 1/28, $p < .05$) and when it is controlled ($F = 4.5$, df 1/27, $p < .05$). These confirm that the normals make more repetitions than the mongols. However the two analyses of covariance with the covariates of C.A. and M.A. indicate that the group effect is due to the difference in the ages of the two groups. The Group effect was nonsignificant when C.A. was controlled ($F = 2.3$, df 1/27, n.s.) and when M.A. was controlled ($F = 4.0$, df 1/27, n.s.).

The Axes effect was significant showing that more repetitions occur to vertical patterns than to horizontal patterns ($F = 21.5$, df 1/199, $p < .001$) and that this difference remains when total visual fixation is controlled ($F = 19.4$, df 1/198, $p < .001$).

There were two significant second order interactions. One was between Groups, Ages and Axes ($F = 8.2$, df 1/199, $p < .01$) which retains its significance when total visual fixation times are controlled ($F = 7.1$, df 1/198, $p < .01$). This interaction is shown in Figure 19 a and b for the data unadjusted for total visual fixation and adjusted for total visual fixation respectively. When the differences between the means were examined by Tukey's HSD test it was found that when total visual fixation was ignored and when it was controlled, the mongol age I children made fewer repetitions to the horizontal patterns than they did to the vertical patterns ($p < .01$) and than the normal age I children did to the horizontal patterns ($p < .01$).

The other significant second order interaction was between Ages, Axes and Conditions ($F = 2.8$, df 3/199, $p < .05$) which was also significant when total visual fixation times were controlled ($F = 2.8$, df 3/198, $p < .05$). The interaction is shown in Figure 20 a and b for the unadjusted data and the data adjusted for total visual fixation times. The only significant difference between the means was shown by Tukey's HSD test to be that at age II more repetitions occurred in Condition 3D-2D when the patterns were vertical compared to when they were horizontal ($p < .05$). However this difference was only significant when total visual fixation times were ignored.

Table 88: Means and Standard Deviations for Repetitions. The data were transformed $\sqrt{(X + 0.5)}$

Horizontal Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	2.80	0.87	3.26	0.38	3.12	0.41	3.15	0.49	3.08
3D-3D	2.92	0.49	2.83	0.36	3.72	0.40	3.18	0.68	3.16
3D-2D	2.75	0.49	2.89	0.56	3.38	0.50	2.93	0.44	2.99
2D-3D	2.79	0.49	3.24	0.38	3.40	0.71	2.96	0.52	3.10
Means of Totals	2.82		3.06		3.40		3.05		3.08
	2.94				3.23				

Vertical Axis

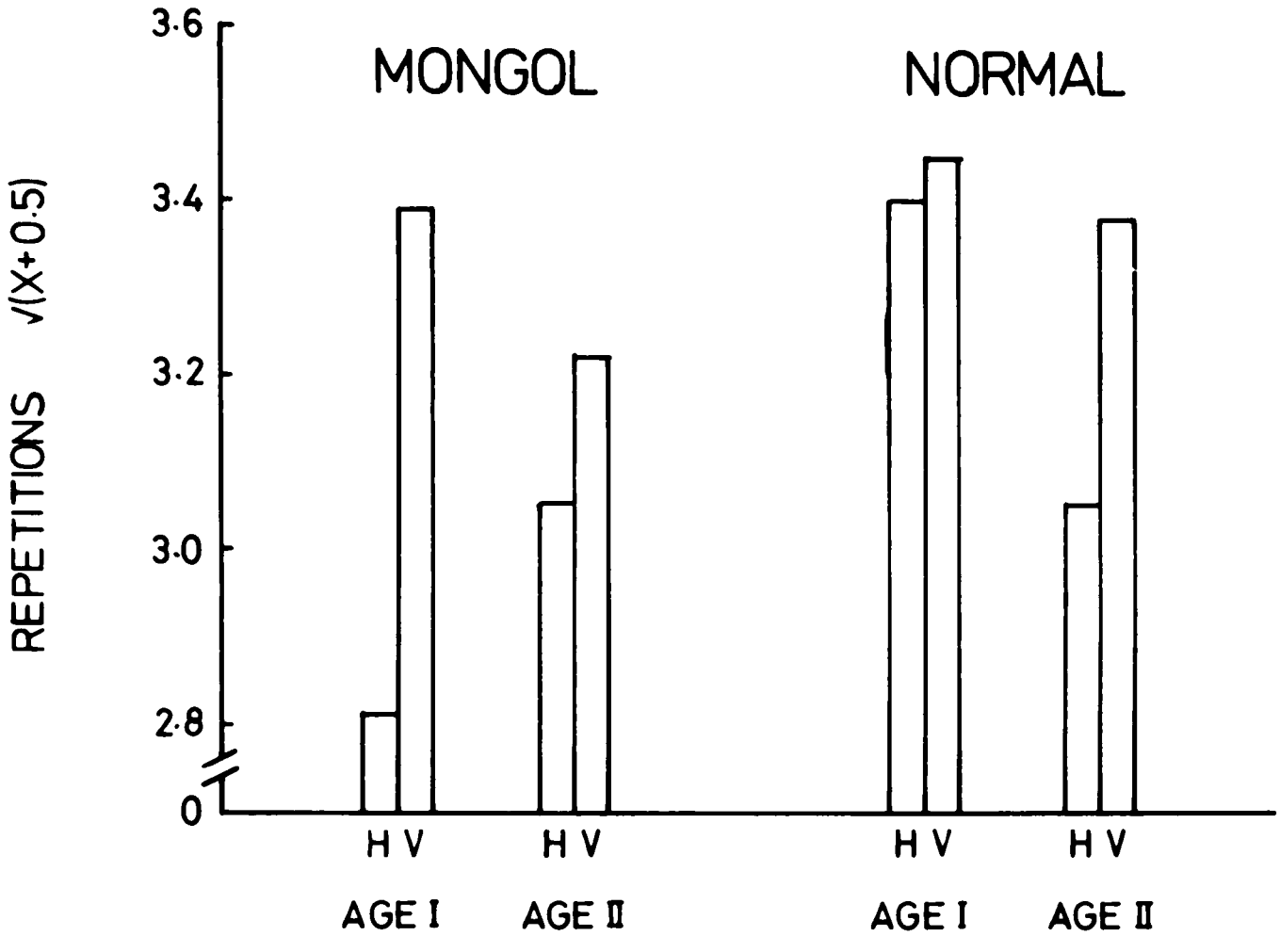
Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	3.10	0.36	3.11	0.49	3.52	0.35	3.24	0.42	3.24
3D-3D	3.39	0.79	3.21	0.32	3.41	0.64	3.37	0.66	3.34
3D-2D	3.50	0.66	3.43	0.34	3.15	0.75	3.62	0.24	3.42
2D-3D	3.56	0.60	3.15	0.26	3.72	0.59	3.30	0.62	3.43
Means of Totals	3.39		3.23		3.45		3.38		3.36
	3.31				3.42				

Table 89: Analysis of variance for repetitions (transformed $\sqrt{(X + 0.5)}$) and adjusted F ratios for analyses of covariance with covariates of total visual fixation (not transformed), C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (T.V.F.)	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	2.60	4.2^{x}	4.5^{x}	2.3	4.0
Ages (A)	1	0.46	0.7	1.4	1.0	1.0
GxA	1	0.98	1.6	0.0	1.0	1.5
S.W.G.	28	0.62				
Total Subjects	31					
Axes (As)	1	4.96	21.5^{xxxx}	19.4^{xxxx}		
Conditions (C)	3	0.15	0.6	0.4		
GxAs	1	0.55	2.4	1.4		
GxC	3	0.14	0.6	0.6		
AxAs	1	0.06	0.2	0.4		
AxC	3	0.33	1.4	1.6		
AsxC	3	0.28	1.2	0.8		
GxAxAs	1	1.88	8.2^{xxx}	7.1^{xxx}		
GxAxC	3	0.15	0.6	0.8		
GxAsxC	3	0.39	1.7	1.9		
AxAsxC	3	0.63	2.8^{x}	2.8^{x}		
Final Residual	199	0.23				
Grand Total	255					

Figure 19: Groups by Ages by Axes interaction for repetitions (transformed $\sqrt{(X + 0.5)}$)

a) Total visual fixation not controlled



b) Total visual fixation (raw data) controlled

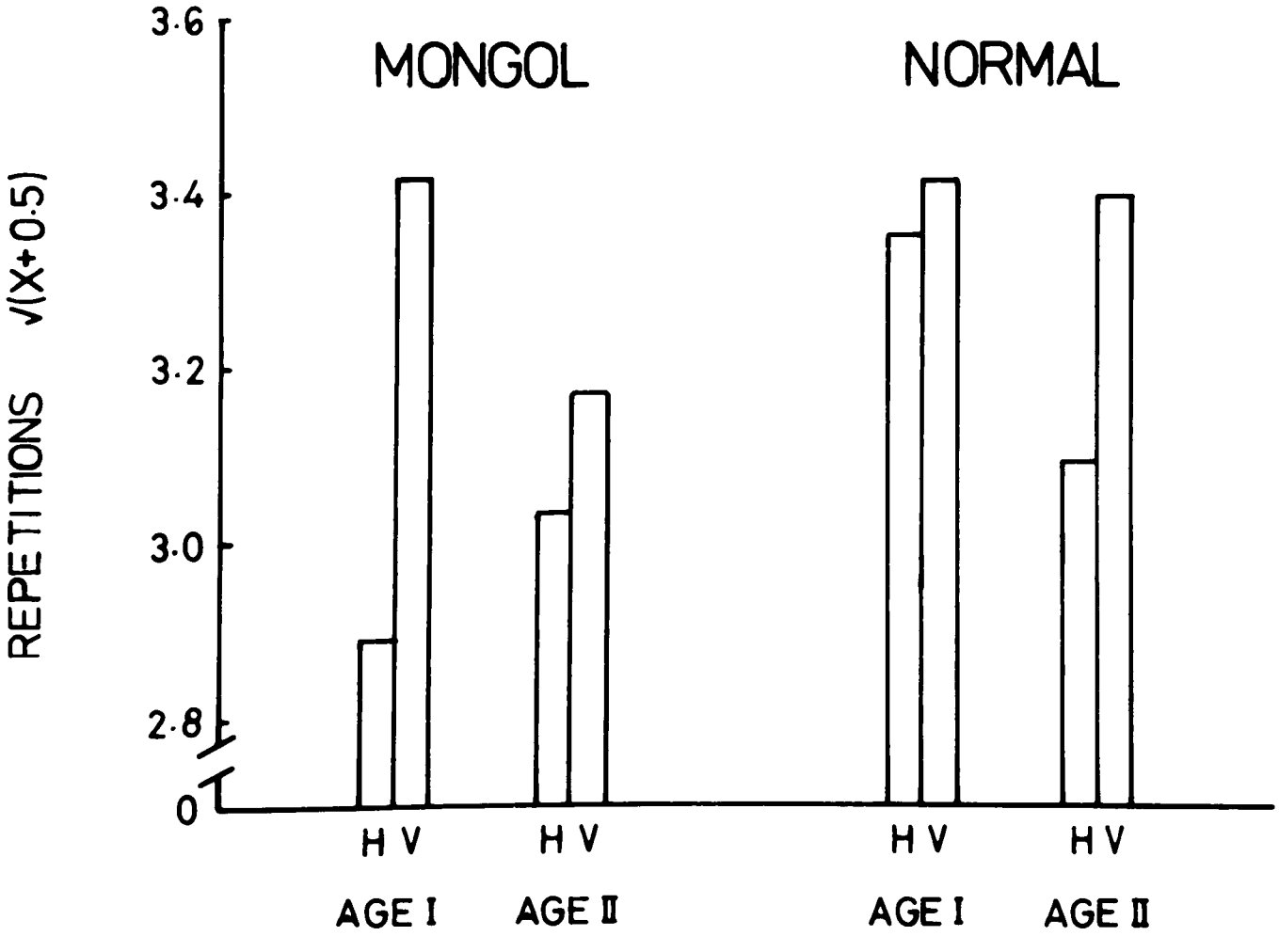
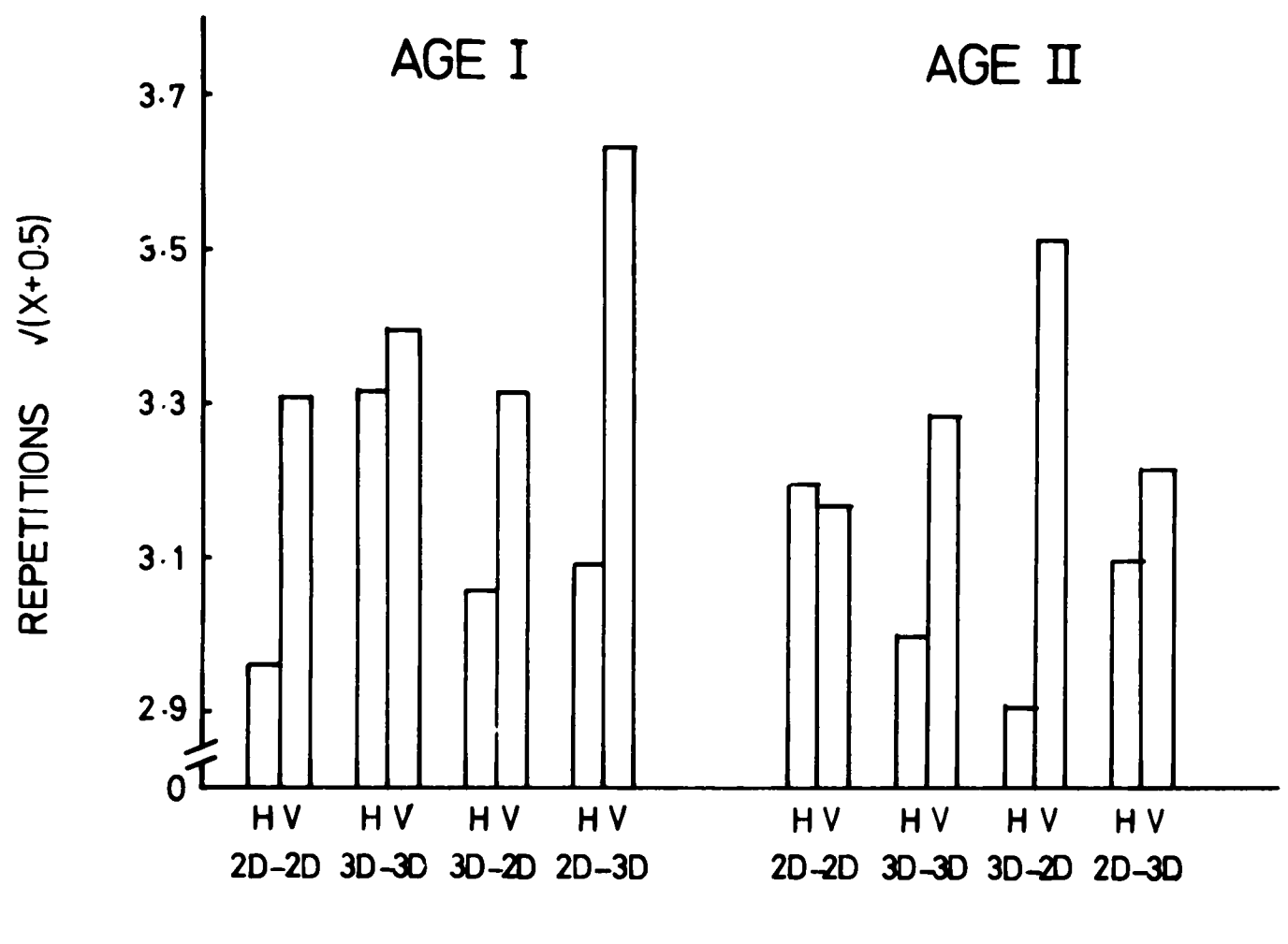
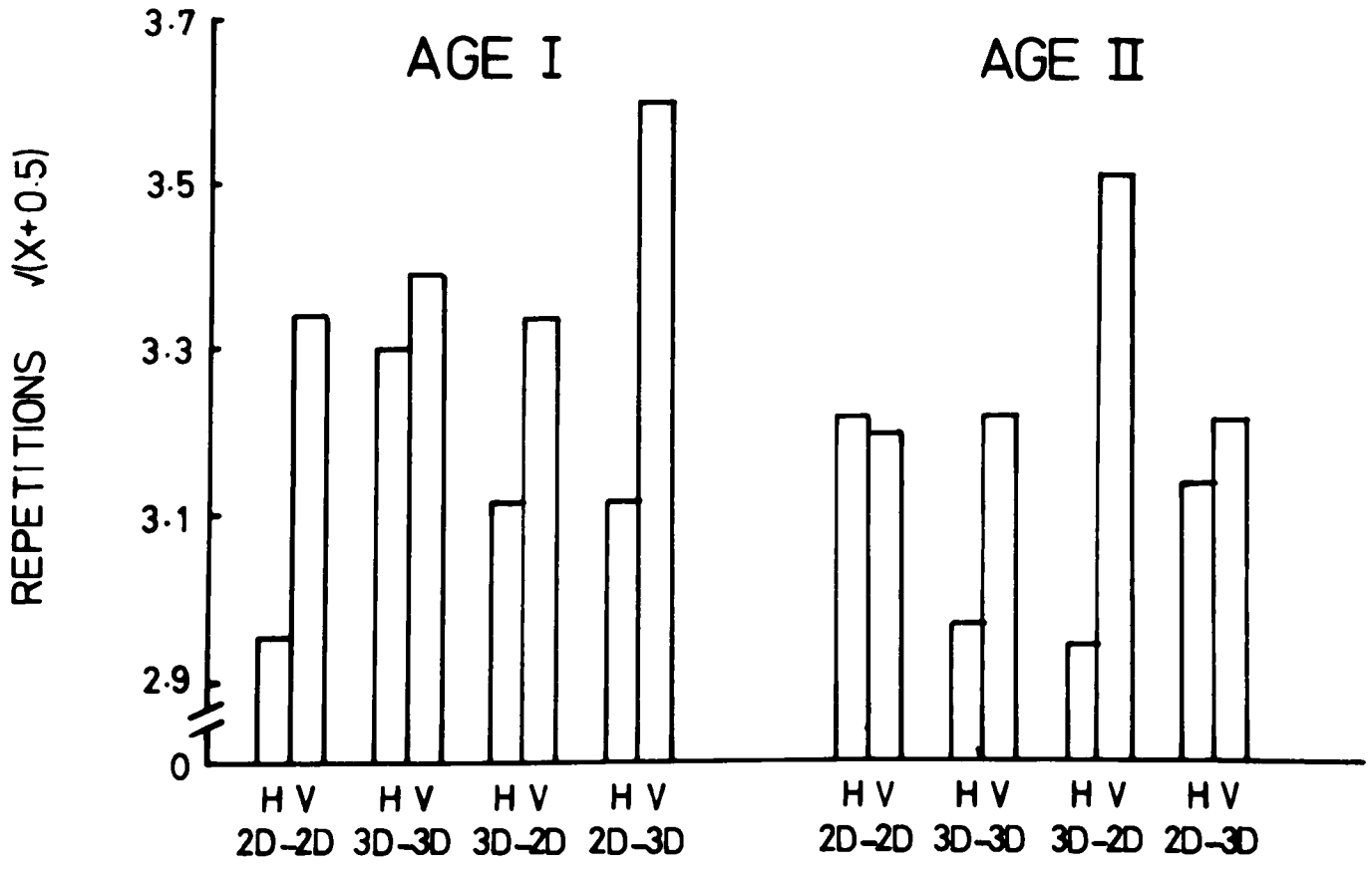


Figure 20: Ages by Axes by Conditions interaction for repetitions (transformed $\sqrt{(X + 0.5)}$)

a) Total visual fixation not controlled



b) Total visual fixation (raw data) controlled



We are now in a position to consider the way in which the children in this experiment move their eyes when they look at the patterns. If horizontal eye movements are more common than vertical eye movements, it would be predicted that more repetitions and fewer alternations would occur to vertically arranged patterns, and that the converse would occur with horizontally arranged patterns. This was found in the present experiment and was particularly noticeable for the mongol age I and normal age II children. This should not be taken to mean that these two groups of children scanned the patterns in the same way. Although they were similar in terms of the number of repetitions, the normal age II children made more alternations than the mongol age I children. Therefore the older normal children were scanning the patterns more extensively.

III.B.5. Time to Fixate the First Pattern

This was the mean of the times taken by each child to begin to look at a pattern on the two trials of the same axis and condition. The most suitable transformation was $\frac{1}{(x + 1)}$ and Table 90 gives the means and standard deviations for each cell of these transformed data.

From this table it seems that there are no consistent differences in the mean times taken to fixate the first pattern. This is confirmed by the analyses which are summarised in Table 91 and which indicate that none of the F ratios reaches significance.

In experiments 3 and 4 a consistent finding was that the normal children were quicker to begin to look at the patterns than the mongols. There was no indication of this in the present experiment. However there was a major difference between this experiment and the previous ones, and this involved the way in which the patterns were displayed.

The differences between the ways in which the patterns were displayed in this experiment and in the previous experiments was outlined in section II.B. In previous experiments the presentation of the patterns was accompanied by a rotation of the back and base of the box, whereas in the present experiment the patterns were displayed on small panels which were rotated in the back of the box. It seems possible that when only a small movement is associated with the presentation of two patterns as in the present experiment, the normal children respond in the

Table 90: Means and Standard Deviations for the Time to Fixate the First Pattern. The data were transformed $\frac{1}{(x+1)}$

Horizontal Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.49	0.21	0.60	0.09	0.55	0.08	0.58	0.13	0.55
3D-3D	0.53	0.18	0.50	0.22	0.52	0.10	0.59	0.05	0.54
3D-2D	0.50	0.23	0.62	0.11	0.57	0.04	0.57	0.08	0.56
2D-3D	0.63	0.12	0.53	0.17	0.56	0.06	0.51	0.19	0.56
Means of Totals	0.54		0.56		0.55		0.56		0.55
	0.55				0.56				

Vertical Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.48	0.18	0.59	0.14	0.48	0.11	0.57	0.09	0.53
3D-3D	0.51	0.11	0.56	0.14	0.56	0.03	0.53	0.12	0.54
3D-2D	0.51	0.08	0.51	0.16	0.53	0.13	0.55	0.12	0.53
2D-3D	0.47	0.12	0.56	0.13	0.48	0.16	0.53	0.08	0.51
Means of Totals	0.49		0.56		0.51		0.54		0.53
	0.52				0.53				

Table 91: Analysis of variance for the time to fixate the first pattern (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.002	0.1	0.7	0.0
Ages (A)	1	0.070	1.5	0.0	0.6
GxA	1	0.009	0.2	0.0	0.2
S.W.G.	28	0.047			
Total Subjects	31				
Axes (As)	1	0.046	3.4		
Conditions (C)	3	0.002	0.1		
GxAs	1	0.000	0.0		
GxC	3	0.010	0.7		
AxAs	1	0.016	1.2		
AxC	3	0.025	1.8		
AsxC	3	0.008	0.6		
GxAxAs	1	0.001	0.1		
GxAxC	3	0.005	0.3		
GxAsxC	3	0.004	0.3		
AxAsxC	3	0.028	2.0		
Final Residual	199	0.014			
Grand Total	255				

same time as the mongol children. On the other hand when there is a large movement this may act as a signal to the normal child, but not to the mongol child that something is about to happen. This is of course pure speculation but might be worth following up.

III.B.6. Time to Fixate the Second Pattern

This was the mean of the times taken by each child to look at the second pattern on the two trials for the same axis and condition. The most suitable transformation was $\frac{1}{(x + 1)}$ and Table 92 gives the means and standard deviations for each cell of these transformed data.

From this table a number of points are worth noticing. First, the normal children seem to look at the second pattern in a shorter time than the mongol children. Second, the age II tend to respond more quickly than the age I children. Finally the second pattern is looked at in a shorter time if the patterns are arranged horizontally compared to when they are arranged vertically.

The analyses which are summarised in Table 93 confirm the last two observations. However the Group effect is nonsignificant ($F = 2.5$, df 1/28, n.s.) unless C.A. is covaried out ($F = 6.8$, df 1/27, $p < .025$). This means that the normal children look more rapidly at the second pattern than the mongol children but only when the differences in the C.A.s of the groups are controlled. In other words mongol children are not slower than normal children of the same M.A., but are slower than normal children of the same C.A.

The Ages effect was highly significant ($F = 13.8$, df 1/28, $p < .001$) confirming that the age I children take longer to look at the second pattern than do the age II children. This effect becomes nonsignificant when C.A. is controlled ($F = 1.1$, df 1/27, n.s.) and when M.A. is controlled ($F = 0.0$, df 1/27, n.s.). Therefore the age effect is due to the difference in C.A. and M.A. of the age I and age II children rather than any other difference.

Finally the Axes term is significant ($F = 19.1$, df 1/199, $p < .001$) showing that the second pattern is looked at more quickly if the patterns are horizontal rather than vertical.

This measure did not produce the group difference which was found in

Table 92: Means and Standard Deviations for the Time to Fixate the Second Pattern. The data were transformed $\frac{1}{(x+1)}$

Horizontal Axis

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.22	0.19	0.34	0.12	0.32	0.06	0.40	0.07	0.32	
3D-3D	0.22	0.14	0.31	0.14	0.24	0.12	0.38	0.06	0.29	0.29
3D-2D	0.26	0.19	0.28	0.13	0.23	0.09	0.35	0.08	0.28	
2D-3D	0.24	0.15	0.29	0.11	0.26	0.13	0.33	0.14	0.28	
Means of Totals	0.24		0.31		0.26		0.36			
	0.27				0.31					

Vertical Axis

Group	Mongol				Normal				Means of Totals	
Age	I		II		I		II			
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.		
2D-2D	0.14	0.10	0.29	0.10	0.20	0.11	0.33	0.12	0.24	
3D-3D	0.17	0.15	0.27	0.09	0.18	0.13	0.34	0.13	0.24	0.23
3D-2D	0.14	0.16	0.23	0.11	0.21	0.10	0.30	0.15	0.22	
2D-3D	0.20	0.10	0.27	0.11	0.21	0.12	0.28	0.15	0.24	
Means of Totals	0.16		0.27		0.20		0.31			
	0.21				0.26					

Table 93: Analysis of variance for the time to fixate the second pattern (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.109	2.5	6.8^{xx}	3.9
Ages (A)	1	0.598	13.8^{xxxx}	1.1	0.0
GxA	1	0.007	0.2	1.0	0.4
S.W.G.	28	0.043			
Total Subjects	31				
Axes (As)	1	0.217	19.1^{xxxx}		
Conditions (C)	3	0.010	0.8		
GxAs	1	0.000	0.0		
GxC	3	0.005	0.5		
AxAs	1	0.009	0.8		
AxC	3	0.014	1.2		
AsxC	3	0.006	0.5		
GxAxAs	1	0.002	0.2		
GxAxC	3	0.006	0.5		
GxAsxC	3	0.005	0.4		
AxAsxC	3	0.001	0.1		
Final Residual	199	0.011			
Grand Total	255				

experiment 4 and to some extent in experiment 3. It is possible that this can be accounted for by the fact pointed out in the previous section, that the presentation of the patterns was associated with less movement in this experiment than in experiments 3 and 4.

However this experiment did confirm the age difference found in experiment 4. There was also a difference between the axes. This is not surprising in view of the measures of alternations and repetitions (sections III.B.3 and III.B.4). These indicated that the children made fewer alternations between, and more repetitions of vertical patterns than horizontal patterns. Since an alternation must occur in order for the child to fixate the second pattern, it would be expected that the time to fixate the second pattern would be slower for vertical patterns than for horizontal patterns.

III.B.7. Average Fixation Length

This was the mean of the average fixation lengths to each pattern presented in the two trials for each axis and condition. These data were most suitably transformed by $\frac{1}{(x + 1)}$. Table 94 gives the means and standard deviations for each cell of these transformed data.

It should be noticed from this table that the normal children tend to make shorter fixations on average than the mongols, especially when the age II children are compared. Second, horizontal patterns receive shorter average fixations than do vertical patterns.

The analyses are summarised in Table 95 and confirm that the normal children make shorter average fixations than the mongol children ($F = 12.2$, df 1/28, $p < .01$). When the data were adjusted for C.A. the effect was reduced but still significant ($F = 5.3$, df 1/27, $p < .05$) whereas controlling for M.A. had little effect ($F = 11.8$, df 1/27, $p < .01$).

There was no Groups by Ages interaction as suggested from the table of means. However there was an Age difference ($F = 4.7$, df 1/28, $p < .05$) which showed that the age II children made shorter fixations than the age I children. This effect was removed by controlling for C.A. ($F = 0.8$, df 1/27, n.s.) and for M.A. ($F = 1.5$, df 1/27, n.s.). Thus when the C.A.s or the M.A.s of the two

Table 94: Means and Standard Deviations for Average Fixation Length. The data were transformed $\frac{1}{(x+1)}$

Horizontal Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.39	0.07	0.39	0.05	0.37	0.05	0.46	0.06	0.40
3D-3D	0.39	0.09	0.37	0.03	0.41	0.05	0.43	0.06	0.40
3D-2D	0.40	0.04	0.40	0.06	0.40	0.07	0.47	0.07	0.42
2D-3D	0.38	0.07	0.41	0.05	0.40	0.05	0.46	0.04	0.41
Means of Totals	0.39		0.39		0.39		0.45		0.41
	0.39				0.42				

Vertical Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.35	0.04	0.36	0.03	0.40	0.03	0.44	0.05	0.39
3D-3D	0.35	0.04	0.35	0.06	0.38	0.05	0.39	0.07	0.36
3D-2D	0.37	0.03	0.35	0.05	0.38	0.05	0.43	0.05	0.38
2D-3D	0.33	0.06	0.36	0.04	0.39	0.05	0.41	0.05	0.37
Means of Totals	0.35		0.36		0.38		0.42		0.38
	0.35				0.40				

Table 95: Analysis of variance for the average fixation length (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.101	12.2^{xxx}	5.4^{x}	11.8^{xxx}
Ages (A)	1	0.039	4.7^{x}	0.8	1.5
GxA	1	0.030	3.6	4.1	3.6
S.W.G.	28	0.008			
Total Subjects	31				
Axes (As)	1	0.059	28.2^{xxxx}		
Conditions (C)	3	0.004	1.7		
GxAs	1	0.002	1.1		
GxC	3	0.000	0.2		
AxAs	1	0.002	1.2		
AxC	3	0.004	2.1		
AsxC	3	0.003	1.4		
GxAxAs	1	0.002	1.0		
GxAxC	3	0.003	1.5		
GxAsxC	3	0.001	0.7		
AxAsxC	3	0.001	0.3		
Final Residual	199	0.002			
Grand Total	255				

age groups are controlled there is no difference in their average lengths of fixation.

The only other significant F ratio was for Axes ($F = 28.2$, df 1/199, $p < .001$) confirming that longer fixations occur to vertical patterns than to horizontal patterns.

This measure failed to find any difference in the average length of fixation to the patterns in the four conditions. Experiments 3 and 4 both found that longer fixations occurred to a pair of patterns of which at least one was 3 D than to a pair of 2 D patterns. In order to account for this discrepancy it is necessary to examine more closely the results of experiment 4. From experiment 3 alone it was possible that longer fixations occurred to 3 D than to 2 D patterns because the 3 D ones could be touched but the 2 D ones could not. This influence of touch was apparently ruled out by the results of experiment 4 which found no interaction between Modalities and Conditions for the measure of average fixation length. However although there was no significant interaction an inspection of the mean fixation lengths in the four conditions for the two modalities (Table 70) shows that the difference between Condition 2D-2D and the other three is greater when the patterns can be touched than when they cannot. Although this was a nonsignificant tendency it seems possible that after all touch may have some effect on how long 2 D and 3 D patterns are fixated, and that the absence of any difference in the present experiment may be due to the fact that the children could not touch the patterns.

III.B.8. Length of the First Fixation to the First Pattern

This was the mean of the length of the first fixation to the first pattern on the two trials for each axis and condition combination. The data were transformed $\frac{1}{(x + 1)}$ and Table 96 gives the means and standard deviations for each cell of these transformed data.

It can be seen from this table that normal children tend to make shorter first fixations than the mongol children, particularly when the age II children are compared. The only other obvious feature is that the first fixation is longer if the patterns are vertical rather than horizontal.

The analyses essentially confirm these observations and are summarised in Table 97. These indicate that there was no Group effect unless C.A. was controlled ($F = 7.2$, df 1/27, $p < .025$) when the normal children made shorter first fixations than the mongol children. Therefore there was no difference between the fixation lengths of the children when M.A. was controlled. But there were differences when C.A. was controlled. This means that there are differences in the length of the first fixation for the normals and mongols when there are no C.A. differences, but that the fixation length difference does not occur when there are no M.A. differences.

The Age effect was significant ($F = 7.6$, df 1/28, $p < .025$) and showed that the first fixations of the age I children were longer than those of the age II children. This effect was removed by covarying out C.A. ($F = 0.2$, df 1/27, n.s.) and M.A. ($F = 0.0$, df 1/27, n.s.), confirming that the age difference accounted for the effect.

It was confirmed that first fixations are longer to vertical patterns than to horizontal patterns by the significant Axes effect ($F = 11.1$, df 1/199, $p < .01$).

The only interaction was between Groups and Ages ($F = 5.6$, df 1/28, $p < .05$) which was also significant when C.A. was covaried out ($F = 8.9$, df 1/27, $p < .01$) and when M.A. was the covariate ($F = 7.6$, df 1/27, $p < .025$). Tukey's HSD test was used to find the source of the interaction. In all three analyses the observation made from the table of means was confirmed. This was that the normal age II children make shorter first fixations than the mongol age II children. This difference was significant at the five per cent level in all three analyses. It was also found that the fixations of the normal age I children were longer than those of the normal age II children when the data were not adjusted for age differences ($p < .01$) and when they were adjusted for C.A. ($p < .01$). The difference was not significant when the data were adjusted for M.A.

No significant effects were found for this measure in experiment 4. However the present results repeat the finding in experiment 3 that the age I children make longer first fixations than the age II children.

Table 96: Means and Standard Deviations for the Length of the First Fixation to the First Pattern. The data were transformed $\frac{1}{(x+1)}$

Horizontal Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.55	0.10	0.52	0.15	0.48	0.10	0.66	0.11	0.55
3D-3D	0.50	0.16	0.51	0.12	0.44	0.09	0.58	0.12	0.50
3D-2D	0.48	0.17	0.48	0.09	0.40	0.13	0.56	0.17	0.48
2D-3D	0.46	0.22	0.47	0.13	0.52	0.14	0.62	0.08	0.52
Means of Totals	0.50		0.50		0.46		0.61		0.51
	0.50				0.53				

Vertical Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.37	0.12	0.46	0.13	0.46	0.14	0.55	0.18	0.46
3D-3D	0.47	0.16	0.47	0.14	0.39	0.18	0.60	0.19	0.48
3D-2D	0.44	0.20	0.41	0.12	0.47	0.18	0.50	0.12	0.45
2D-3D	0.40	0.15	0.43	0.10	0.41	0.16	0.50	0.23	0.43
Means of Totals	0.42		0.44		0.43		0.53		0.46
	0.43				0.48				

Table 97: Analysis of variance for the length of the first fixation to the first pattern (transformed $\frac{1}{(x+1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.123	3.3	7.2^{XX}	4.0
Ages (A)	1	0.286	7.6^{XX}	0.2	0.0
GxA	1	0.210	5.6^{X}	8.9^{XXX}	7.6^{XX}
S.W.G.	28	0.038			
Total Subjects	31				
Axes (As)	1	0.214	11.1^{XXX}		
Conditions (C)	3	0.018	0.9		
GxAs	1	0.007	0.3		
GxC	3	0.011	0.5		
AxAs	1	0.002	0.1		
AxC	3	0.009	0.5		
AsxC	3	0.021	1.1		
GxAxAs	1	0.020	1.0		
GxAxC	3	0.005	0.3		
GxAsxC	3	0.014	0.7		
AxAsxC	3	0.011	0.5		
Final Residual	199	0.019			
Grand Total	255				

III.B.9. Length of the First Fixation to the Second Pattern

This was the mean of the lengths of the first fixation to the second pattern on the two trials for each condition in each axis. The data were transformed $\frac{1}{(x + 1)}$. The means and standard deviations for each cell of these transformed data are summarised in Table 98.

From this table it can be seen that the normal children tend to make shorter first fixations to the second pattern than do the mongol children. The mongol children, but not the normal children, tend to make shorter first fixations to the second pattern when the patterns are arranged horizontally compared with when they are arranged vertically.

The analyses, which are summarised in Table 99, essentially confirm these observations. The Groups effect is significant ($F = 11.6$, df 1/28, $p < .01$) showing that these fixations of the normals are shorter than those of the mongols. The effect remains when M.A. is covaried out ($F = 11.3$, df 1/27, $p < .01$) but is nonsignificant when C.A. is controlled ($F = 2.5$, df 1/27, n.s.). Thus the difference in the fixation lengths of the children is accounted for by the difference in their C.A.s.

The Axes effect was significant ($F = 7.8$, df 1/199, $p < .01$) and showed that longer first fixations are made to the second of two vertical patterns than to the second of two horizontal patterns.

There was a significant interaction between Groups and Axes ($F = 3.9$, df 1/199, $p < .05$). Tukey's HSD test was used to examine the differences between the means to find the source of this interaction. It was found that the mongol children made longer first fixations to the second of two vertical patterns than to the second of two horizontal patterns ($p < .01$). The mongols also made longer first fixations to the second of two vertical patterns than did the normal children ($p < .01$).

Table 98: Means and Standard Deviations for the Length of the First Fixation to the Second Pattern. The data were transformed $\overline{(x + 1)}$

Horizontal Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.43	0.11	0.42	0.13	0.49	0.05	0.53	0.13	0.47
3D-3D	0.39	0.14	0.43	0.13	0.43	0.10	0.46	0.09	0.43
3D-2D	0.43	0.09	0.48	0.10	0.45	0.12	0.49	0.16	0.46
2D-3D	0.44	0.12	0.46	0.13	0.46	0.14	0.51	0.11	0.47
Means of Totals	0.42		0.45		0.46		0.50		0.46
	0.43				0.48				

Vertical Axis

Group	Mongol				Normal				
Age	I		II		I		II		Means of Totals
Condition	M	S.D.	M	S.D.	M	S.D.	M	S.D.	
2D-2D	0.42	0.05	0.34	0.09	0.49	0.08	0.47	0.10	0.43
3D-3D	0.40	0.09	0.41	0.13	0.47	0.09	0.46	0.14	0.43
3D-2D	0.39	0.14	0.31	0.09	0.45	0.11	0.49	0.08	0.41
2D-3D	0.36	0.08	0.37	0.07	0.44	0.15	0.46	0.12	0.41
Means of Totals	0.39		0.36		0.46		0.47		0.42
	0.37				0.47				

Table 99: Analysis of variance for the length of the first fixation to the second pattern (transformed $\overline{(x + 1)}$) and adjusted F ratios for analyses of covariance with covariates of C.A. and M.A.

Source	D.F.	M.S.	F	ADJ.F (C.A.)	ADJ.F (M.A.)
Groups (G)	1	0.284	11.6^{xxx}	2.5	11.3^{xxx}
Ages (A)	1	0.005	0.2	0.1	0.4
GxA	1	0.011	0.4	0.4	0.4
S.W.G.	28	0.025			
Total Subjects	31				
Axes (As)	1	0.082	7.8^{xxx}		
Conditions (C)	3	0.003	0.3		
GxAs	1	0.041	3.9^{x}		
GxC	3	0.007	0.6		
AxAs	1	0.030	2.9		
AxC	3	0.005	0.4		
AsxC	3	0.015	1.4		
GxAxAs	1	0.002	0.2		
GxAxC	3	0.004	0.4		
GxAsxC	3	0.007	0.7		
AxAsxC	3	0.003	0.3		
Final Residual	199	0.010			
Grand Total	255				

III.C. Summary of Results

III.C.1. Similarities in the Visual Behaviour of the Mongol and Normal Children

Total Visual Fixation. Both the mongol and the normal children fixated the patterns in Condition 3D-3D for longer than those in Conditions 2D-2D and 2D-3D.

Number of Fixations. The age II children fixated the patterns more often than the age I children. Patterns which were presented along the horizontal axis were fixated more frequently than those presented along the vertical axis.

Alternations. The age II children made more alternations than did the age I children, and this was a characteristic of the mongol children when the patterns were vertical and of the normal children when the patterns were horizontal. More alternations were also made between horizontal patterns than between vertical patterns, particularly by the mongol age I and normal age II children.

Repetitions. More repetitions were made to vertical patterns than to horizontal patterns particularly by the mongol age I children.

Time to Fixate the Second Pattern. The age I children took longer to first fixate the second pattern than the age II children. All of the children took longer to look at the second of two vertical patterns than at the second of two horizontal patterns.

Average Fixation Length. The average fixation lengths of the age I children were longer than those of the age II children. Also the average fixation lengths to vertical patterns were longer than those to horizontal patterns.

Length of the First Fixation to the First Pattern. The results of this measure were similar to those of average fixation length. That is, the age I children made longer first fixations to the first pattern than did the age II children, and the first fixation of the first vertical pattern was longer than that of the first horizontal pattern.

Length to the First Fixation to the Second Pattern. This measure also showed that the second of two vertical patterns received a longer first fixation than did the second of two horizontal patterns, particularly when the children were mongol.

III.C.2. Differences in the Visual Behaviour of the Mongol and Normal Children

The measures of Total Visual Fixation and the Time to Fixate the First Pattern will be omitted from this section since they showed no differences in the responses of the mongol and the normal children.

Number of Fixations. The normal children fixated the patterns more often than did the mongol children.

Alternations. Overall the normal children made more alternations than the mongol children. However this depended on the ages of the children and the arrangement of the patterns. In particular, the normal age I children made more alternations when the patterns were vertical than did the mongol age I children. When the patterns were horizontal, the normal age II children made more alternations than did the mongol age II children.

Repetitions. The normal age I children made more repeated fixations of the horizontal patterns than did the mongol age I children.

Time to Fixate the Second Pattern. When the C.A.s of the children were controlled the normal children took less time to look at the second pattern than did the mongol children.

Average Fixation Length. The normal children made shorter fixations on average than the mongol children.

Length of the First Fixation to the First Pattern. The normal age II children made shorter first fixations of the first pattern than did the mongol age II children.

Length of the First Fixation to the Second Pattern. When the patterns were arranged vertically the normals made shorter first fixations of the second pattern than did the mongols.

IV. DISCUSSION

The aim of this experiment was to examine the ways in which 2 D and 3 D patterns are looked at when they are presented along a horizontal axis and when they are presented along a vertical axis.

There were many differences in the way in which horizontal and vertical patterns were looked at. The two most interesting measures were alternations and repetitions since these produced group differences. As predicted, all of the children compared horizontal patterns more often than vertical patterns and made more repetitions to vertical patterns than to horizontal patterns. This can be explained by a greater probability of horizontal scans than of vertical scans. Thus for the first time there is strong evidence for a difference in the visual responses of young children which is dependent upon the spatial arrangement of the patterns.

This experiment also provides some evidence which suggests that the spatial arrangement of patterns may have a different effect on the visual responses of mongol and normal children. This evidence was that the youngest mongols compared the vertical patterns even less frequently than did the other groups. This therefore is evidence that under certain conditions the young mongol can be shown to scan his environment less extensively than a normal child of the same mental age. This is an important finding which should be investigated further.

In some respects the effect of whether the patterns were arranged horizontally or vertically was the same for both the mongol and the normal children. As expected the second of two horizontal patterns was fixated more rapidly than the second of two vertical patterns. Also the vertical patterns were fixated for longer on average and for the first time than were the horizontal patterns.

One possible interpretation of these results could be that when the child looks at one of the horizontal patterns the other pattern falls within the range of his peripheral vision, and that when he looks at a vertical pattern the other vertical pattern falls outside the range of his peripheral vision. He may therefore look on average for longer at a vertical pattern because he is unaware of any other pattern to look at, whereas once he has investigated one horizontal pattern he will look

towards the second one. The second vertical pattern will only be fixated when he looks away from the other pattern in such a direction that the second pattern falls within the range of his peripheral vision. This interpretation is supported by a similar asymmetry which has been found in the visual fields of one and two month olds (Chapter 2, section II.B.5), and the present results may indicate a continuation of this. However there were no interactions between ages and axes which suggests that if the size of visual field accounts for the different responses to horizontal and vertical patterns, the size was similar for the two ages.

This fifth experiment provides some confirmation of the developmental trend from age I to age II which was observed in both the mongol and the normal children in experiment 4. In particular, the age II children make more fixations, especially alternations, and fixate the second pattern in a shorter time. These results are evidence that with the patterns used in experiments 4 and 5, but not with those used in experiment 3, the age II children scan more extensively than the age I children.

The last feature of the results to notice is that the only measure to find an effect of the four conditions was total visual fixation. This indicated, as in experiments 3 and 4, that two 3 D patterns are fixated for longer than two 2 D patterns. However, other measures such as the number of fixations, alternations and repetitions and the lengths of fixations failed to replicate the effects of the four different conditions which were found in experiments 3 and 4. There was no evidence for any difference in the way in which 3 D and 2 D patterns presented together are looked at when the 3 D pattern is to the left, or the right, or above or below the 2 D pattern.

There were differences between this fifth experiment and the previous two which may account for the present paucity of results involving the conditions variable. As has been pointed out, the apparatus was different as was the way in which the patterns were presented. Another difference was that no touching whatsoever occurred in this experiment, whereas the children in experiment 4 could touch the 2 D and 3 D patterns on half of the trials, and in experiment 3 the 3 D patterns could always be touched and the 2 D patterns could never be touched. Perhaps this means that after all touch docs have an effect on the way

in which 2 D and 3 D patterns are responded to visually, but that the effect was insufficient in experiment 4 to generate significant interactions between Modalities and Conditions. Only further more detailed experiments can untangle the crucial factor involved.

CHAPTER 9

Conclusions

I. INTRODUCTION

In Chapter 1 a search was made through much of the available literature on the development of people who were first identified by J. Langdon H. Down in 1866 and whose clinical and chromosomal anomaly is referred to as Down's Syndrome or mongolism, to discover if there was any evidence for particular deficits which might be worth researching in the young mongol person. The evidence indicated that the modalities of vision and touch might be two such areas and so in Chapter 2 the literature on the visual and tactile perceptions of the young normal child was examined. From this review it was clear that despite many years of research and numerous research projects, it is only recently that we are beginning to acquire a detailed picture of the way in which the young normal child perceives his world through the modalities of vision and touch. For this reason the aim of this thesis, which was to examine the ways in which vision and touch in the young mongol might be similar to and might be different from these abilities in the normal child of the same mental age, was ambitious. It is therefore encouraging that the results of the five experiments which were reported in Chapters 4 to 8 identified some interesting similarities and differences in the ways in which young mongol and normal children look at and touch patterns.

The results of the experiments were not limited merely to confirming the presence or absence in the mongol of abilities known to exist in the young normal child. They went further than this and provided more information on the way in which the normal child looks at and touches patterns.

In this final chapter it is intended to do several things. The first is to review the experiments and to attempt to bring together the results. The second point of this chapter is to indicate a difficulty with research of this nature which became apparent during the course of this thesis. Finally, as is not surprising with a venture into a new field such as this, the experiments which have been conducted have raised more questions than they have answered. Therefore the

final part of this chapter will consider the implications that the present results have for future research.

II. THE EXPERIMENTS

The experiments which have been described in this thesis were performed to provide answers to a number of questions concerning the visual and tactile abilities of young normal and mongol children. There were six main questions. The first three questions were about the way in which the children looked at patterns, and in particular the way in which they looked at two dimensional patterns, at three dimensional patterns and at patterns in different spatial arrangements. The next two questions concerned the tactile abilities, and specifically their perception of objects through touch and the amount of time which they spent manipulating different patterns. The final question concerned the nature of the relationship between touch and vision, and the effects of touch on visual behaviour.

In this section it is intended to consider each of these questions in turn and to look first at the general implications of the relevant results for developmental psychology and second to consider the significance of the ways in which the normal and mongol children responded differently from one another.

Question 1: How are two dimensional patterns looked at? It is clear that two dimensional patterns attract visual attention. However the amount depends on certain factors. In the present experiments one influential factor was whether or not two patterns which were presented together were different from one another or identical to one another. A pair of different two dimensional patterns attracted longer visual fixation than did two identical patterns (Experiment 1). On the other hand there was no difference in the amount of time for which a pair of two dimensional patterns was fixated when the patterns were either identical or different from one another in Experiment 3. However when the patterns were different in Experiment 1, they were different in colour and shape, whereas in Experiment 3 they only differed in shape. This must mean that the visual displays which attracted more visual attention than the others did so because the displays contained two patterns which were of different shapes and colours and in which there was therefore more variation in the patterns, compared either to a display

of two identical patterns or to a display of two patterns of different shape.

This simple interpretation is supported by two other results which were first that habituation occurred to repeated presentations of the same pair of two dimensional patterns, and second, that dishabituation occurred when the patterns were altered (both Experiment 1). When the same patterns are presented for a number of trials there is no variation between trials, but when the patterns are altered there is a change in what can be looked at.

In addition it is not just variation in the identity of the particular patterns which is important in maintaining fixation, but also the spatial relationship between them. This is shown by the fact that dishabituation occurred when the left-right positions of two different two dimensional patterns were reversed as well as when two identical patterns were replaced by two other patterns which were also identical (Experiment 1). This suggests that both mongol and normal children show more interest in displays which are variable and which change over time than in displays which are constant. This is not a new finding for normal children, but this is the first time that it has been demonstrated in mongol children of similar mental age to the normal children. It is therefore of importance since the spontaneous interest which a normal child takes in his environment may be a crucial factor in the development of his perception; it has now been shown that this is an area in which the mongol child may also exhibit a similar interest.

A reduction in visual interest to repeated patterns was accompanied by a decrease in the number of fixations, particularly alternations of fixation (Experiment 1). This further supports the interpretation that when there is no variation in a visual display, the display ceases to hold the child's attention, since with time he becomes increasingly less likely to compare the two patterns.

There was a difference in the number of fixations made to two dimensional patterns by children of different mental ages, with those of about 14 months making more fixations than did those children with mental ages of approximately 10 months (Experiment 1). This indicates that the older children moved their eyes more than the younger children did. There was no age difference in the number of comparisons which they made between the patterns and therefore no evidence that

the scanning of the older children was more extensive than that of the younger children.

However in Experiment 3 there was evidence of more comparisons being made between two dimensional patterns by children with mental ages of 13 months compared with children with mental ages of about $6\frac{1}{2}$ months, but only when the children were normal. This was the only difference which was found between the way in which the mongol and normal children looked at two dimensional patterns, and raises the possibility that the visual scanning of normal children may be more extensive than that of mongol children.

If this is a real difference it would indicate that as the normal child gets older there is an increase in the extent to which he scans a visual display. This may mean that with increasing age the normal child has the opportunity to collect more information about a visual display, since the older child moves his eyes about more than the younger child. On the other hand, there seems to be no corresponding increase with age in the eye movements of the mongol child. He may therefore have less opportunity as he gets older to gather information about the features of a visual display compared to the normal child. To this extent the young mongol child may be increasingly deprived of perceptual experience as he gets older.

Apart from this one difference the mongol and normal children responded to two dimensional patterns in the same way, and this means that the visual attention of both groups is dependent upon the amount of variation in a two dimensional display, whether it be variation within a trial or across trials.

The fact that there is very little difference in the way in which normal and mongol children look at two dimensional patterns suggests that their perceptions of such patterns may be extremely similar. They are both able to perceive when two patterns are identical to and when they are different from one another in both colour and shape. They are also aware of when a particular display of two dimensional patterns has already been presented and when the display has been altered. But the sign should not be forgotten that the mongols may be relatively less perceptually active than the normals as they get older.

Question 2: How are three dimensional patterns looked at? In all of the experiments in which three dimensional patterns were presented the children looked longer at these patterns than they did at two dimensional patterns (Experiments 3, 4 and 5). This means that some difference was perceived between the patterns, and that since the three dimensional patterns attracted more visual attention these patterns are of greater visual interest to the children than the two dimensional patterns. This differential fixation occurred regardless of whether or not the patterns could be touched, and raises the question of why the children showed greater interest in the three dimensional patterns.

One possibility is that they were aware that three dimensional patterns can be touched and that two dimensional patterns cannot, and that this controlled their visual interest. Another possibility is that there is more to look at when the pattern is three dimensional compared to when it is two dimensional. In addition to the shape which is common to both patterns, the three dimensional pattern has depth. The cues associated with this depth may not be interpreted by the child as indicating depth and therefore solidity, but may make the three dimensional pattern more interesting than the two dimensional one. Further experiments are necessary to separate these two possibilities.

In Experiment 3 both groups of children took a shorter time to begin looking at the three dimensional patterns than they took to begin to look at the two dimensional patterns. This was not found in Experiments 4 and 5 which suggests that it may have nothing to do with the fact that the patterns were three dimensional and two dimensional. There is an explanation of these results which does not depend on whether the patterns were two or three dimensional. This explanation is based on the fact that in Experment 3, but not in Experiments 4 and 5, the three dimensional patterns were presented nearer to the child than the two dimensional patterns. This means that any lateral movement of the child's head would result in greater displacement of the three dimensional patterns across the retina than of the two dimensional patterns. Therefore the more rapid visual orientation to three dimensional patterns by all of the children may indicate that they are all sensitive to the greater movement which these patterns produce peripherally compared to the two dimensional patterns. This explanation is

Also - 30 patterns moved at a

supported by the absence of this result in Experiments 4 and 5 when the two and three dimensional patterns were presented at the same distance from the children.

Despite the fact that both mongol and normal children do perceive some differences between two and three dimensional patterns, Experiment 3 provided evidence that mongol and normal children do look in different ways at three dimensional patterns which can be touched. This was particularly noticeable at mental ages of about $6\frac{1}{2}$ months when the normal children made more fixations, and especially alternations of fixation, to three dimensional patterns than to two dimensional patterns; on the other hand, the mongol children made more fixations, particularly repetitions of fixations, to two dimensional patterns than to three dimensional patterns. Also the normal children made more alternations between three dimensional patterns than the mongol children did. This means that although both groups of children perceive some difference between two and three dimensional patterns the normals make more comparisons of three dimensional patterns than do the mongols. This difference may be of importance in determining what is perceived by the children and the way in which differences between visual displays are noticed. This raises the question as to why these differences occurred with the three dimensional patterns but not with the two dimensional patterns. A possible explanation for this will be offered when the effect of touch is considered in Question 6.

There is, however, some further support for the suggestion that because the mongol children make fewer comparisons between two three dimensional patterns than the normal children do, this may limit the mongol's ability to notice differences in visual displays of three dimensional patterns. The support comes from the results of the visual within-modal tasks of Experiment 2. It was found that the ability of the mongol children to select visually out of two three dimensional objects, which one they had seen before was inferior to that of the normal children. It is of course speculation that this poor performance by the mongol children is related to the way in which they make visual comparisons between three dimensional patterns. If this explanation is correct, it would predict that since mongol children have been shown to compare visually two dimensional patterns to the same extent as normal children, there should be no

difference in the ability of mongol and normal children to discriminate visually between two dimensional patterns. Clearly more research is required to establish reliably the nature of the relationship, if any, between the way in which patterns are compared and the ability of children to discriminate between patterns.

Question 3: How are patterns in different spatial arrangements looked at?

It has been reported by Aslin and Salapatek (1975) that one and two month old normal children are better at locating targets introduced along the horizontal axis than targets introduced along the vertical axis. This suggests a difference in the peripheral sensitivity along horizontal and vertical axes and this was proposed as an explanation of some of the results of Experiment 5. These indicated a marked effect of the way in which two patterns were arranged spatially, in that two patterns in a horizontal arrangement were scanned much more extensively by both mongol and normal children than were patterns in a vertical arrangement. It is argued that when one pattern is being fixated, the image of the second one may fall outside the boundary of peripheral vision when the patterns are arranged vertically but will fall within this boundary when the patterns are arranged horizontally.

The implications of these results are far reaching since our understanding of the way in which the young child perceives the real world through vision has been based on results from experiments in which patterns are presented either singly or in pairs along the horizontal axis. The present results indicate that such an approach may have serious limitations. Objects in the real world are organised along many different axes and it is a large and possibly unwarranted step to assume that results from experiments using one axis can be generalised to responses to objects in the real world. For example, in the real world there are people of many different heights. The present results indicate that mongol and normal children might be more likely to compare the features of two people of the same height standing several feet apart than to compare the features of two people of extremely different height standing side by side.

These results have indicated that horizontal and vertical arrangements of patterns have a similar effect on the way in which both mongol and normal children look at such arrangements. Thus, although in a different situation, they

extend the results previously obtained with two month old normals to older normals, and demonstrate once again that mongol and normal children may perceive visual patterns in a similar way.

However, in Experiment 5 there was some evidence that in a spatial sense the way in which mongol children look at patterns may not be quite the same as the way in which normal children look at patterns. At an average mental age of about ten months, normal children made more comparisons between the vertical patterns than did the mongol children, and these normal children made more repetitions to horizontal patterns than the same mongol children did. At an average mental age of 15 months the normal children made more alternations between two horizontal patterns than the mongol children did. If these observations can be confirmed in more detailed studies they must mean that at least at certain mental ages the mongol child may have a more limited size of effective visual field than the normal child has. Such a finding would be important in determining the most appropriate size and shape of a visual display for mongol children.

Question 4: What is perceived through the modality of touch? Experiment 2 was concerned with this question and since the results demonstrated marked differences in the tactile perception of the mongol and normal children, the abilities of the normal children will be discussed first.

Bryant et al (1972) reported that normal children of less than one year old could integrate information from the tactile to the visual modality with a pair of ellipsoids, but failed with a pair of cubes. This same pattern was found with normal children of about 12 months old (Experiment 2). However by a mean age of 16 months the normal children also showed this integration with the cubes (also Experiment 2). The suggestion tentatively proposed by Bryant et al (1972) to account for the failure of their normal children on the cross-modal task with the cubes was that "both objects in this pair had only straight contours, and that a straight-straight discrimination is a very difficult one either tactually or cross-modally". The present study does not demonstrate whether or not this explanation is correct, but has shown that whatever the difficulty is, it is still present at 12 months, but has been overcome by 16 months.

In contrast the mongols performed at chance level on the two cross-modal

tasks, which means that they certainly do not possess the same abilities as the normal children. The poor performance of the younger mongols with mental ages of about 12 months can be explained by their failure on the visual within-modal tasks, as can the older mongols chance level performance with the cubes. However the older mongols performed above chance level on the visual within-modal task with the ellipsoids. Therefore their failure on the cross-modal task with this pair is strong evidence that they have some form of tactile deficit. Unfortunately with the available procedure it was not possible to determine whether this was a failure of coding at the level of touch or of integrating tactile information with visual information.

Although a tactile deficit in the young mongol has only been implicated by these results, the finding is consistent with reports in the literature. These show that the ability of the adult mongol to make discriminations on the basis of touch is inferior to the abilities of normal children of the same mental age, normal adults of the same chronological age and other non mongol imbecile adults (Gordon, 1944; O'Connor and Hermelin, 1961; Knights, Hyman and Wozny, 1965; Knights, Atkinson and Hyman, 1967). Thus the present study has extended these reports by providing evidence that there is something wrong within the mongol's tactile system from a very early age. This means that throughout his life the mongol person will be deprived of information which the normal person obtains through the modality of touch.

This finding bears a direct relationship to the two final questions since these concern how much the children touched the patterns and whether the touching of patterns affects the way in which they are looked at. It seems possible that a child with some form of tactile deficit will react differently to patterns which can be touched compared to a child without a tactile deficit.

Question 5: How much do the children touch the patterns? Touching was allowed in two experiments (Experiments 3 and 4) and in both of these the older children touched the patterns more than the younger children did. This is consistent with the suggestion that as the ability to distinguish objects through touch increases with age, so more touching will occur. It would also be predicted that patterns which make a tactile impression will be touched more than those which do not; this was confirmed in Experiment 4 where it was found that a pair of three

dimensional patterns was touched for longer than a pair of two dimensional patterns.

The mongol children touched the patterns for less time than the normal children in Experiment 4, although there was no difference in Experiment 3. If this difference is a real difference, and its absence in Experiment 3 was an artefact of the procedure, this would be consistent with the mongol having some form of tactile deficit. If his perception of objects through touch is limited it would be expected that he would touch objects for less time than a child who is able to distinguish objects through the modality of touch, such as the normal child has been shown to be able to. The reason for this is that the mongol would obtain less information about the objects by touching them than the normal child would, and so he would not bother.

Question 6: What is the effect of touch on visual behaviour? The results of Experiment 4 indicated quite clearly that patterns which could be touched received much more visual attention than patterns which could not. There are two possible reasons why the opportunity to touch the patterns resulted in greater visual interest. The first is that the act of touching provides the child with additional information about the way in which the patterns can be distinguished visually and so he looks more. The second reason is that touch can be used as a way to direct visual attention, in the same way that an object which is placed in the hand will be looked at.

It has already been demonstrated that the mongol child has some form of tactile deficit and that he probably touches patterns for less time than normal children do. If the first reason was the explanation, the opportunity to touch the patterns should only have had an effect on the visual behaviour of the normal children since they do not have a tactile deficit. However, the effect was found for both groups and therefore the second reason seems a more likely explanation.

There is, however, a third possible explanation which is that the presence of the clear perspex screen which prevented the children from touching the patterns resulted in them paying less attention to patterns under these conditions, compared with when the screen was absent and the patterns could be touched. The present results cannot eliminate this possibility, but it seems an unlikely explanation since

the children paid little or no attention to the screen when it was in position, and did look at the patterns for some of the time.

The relationship between touch and vision is complex and certainly deserves more attention than it has received. In a cross-modal situation, when a visual choice between two objects must be made on the basis of previous tactile information, the mongol is definitely inferior to the normal child. On the other hand, when touch and vision can occur at the same time, the opportunity to touch a pattern results in greater visual regard of that pattern in both normal and mongol children.

Taken together the results are of great importance because although they have established some continuity between young mongol children and mongol adults vis à vis a tactile deficit, they have also demonstrated a way in which touch has the same effect for both mongol and normal children, namely as a way to direct visual attention. The importance of this latter result can be illustrated by considering a suggestion made by Carr (1975) concerning the education of mongol children. On the basis of evidence from adult mongols, Carr suggested that mongol children "should be taught as far as possible by visual methods, while stereognostic methods such as finger tracing (much favoured by Montessori trained teachers) should not be stressed". The present results, on the contrary, indicate that stereognostic methods may be of value provided that vision is also involved.

We are now in a position to consider a possible explanation for the difference in the way in which mongol and normal children look at three dimensional patterns which can be touched (Experiment 3). Two functions of touch have been suggested. One is to provide information about the tactile characteristics of objects, whilst the second acts to direct visual attention towards objects which can be touched. It has been argued that although touch functions in both of these ways in the normal child, in the mongol child touch may only function in the second way.

If this is correct it means that although touch will direct a mongol's attention towards an object, it will not provide him with so much information about the tactile characteristics of the object. On the other hand, the normal child will obtain tactile information about the shape of an object from touching it. Although pure speculation, it is possible that a normal child may visually compare

two three dimensional patterns more than a mongol child does, because touch not only directs the normal's visual attention towards the objects but in addition provides him with information about the shapes of the objects which further directs his visual attention towards making comparisons between the objects. This means that the function of touch as a director of visual attention is more complicated than it seemed at first, since it may also depend upon what is perceived through the modality of touch.

Much more research is needed to unravel the complex relationship which these experiments have indicated exists between vision and touch.

III. PERCEPTUAL DEFICITS AS A POSSIBLE CAUSE OF INTELLECTUAL RETARDATION

The aim of the experiments which have been described in this thesis was to see if there were any perceptual differences between mongol and normal children from very young ages. This stemmed from the evidence that the adult mongol has certain perceptual deficits, and the absence of any evidence concerning these deficits in the young mongol.

The main reason for looking for perceptual deficits in the young mongol was the possibility that a child with a perceptual deficit may be deprived of certain important experiences, and that this deprivation may lead to intellectual retardation. This is a feasible possibility if cognitive development is at all dependent on perceptual experience and there are many theoretical reasons for thinking that this might be so.

However there is an alternative to this possibility which is that perceptual deficits are the result rather than the cause of some basic handicap. This view holds that the child is born to be handicapped and the perceptual deficits are one aspect of his handicap.

One obvious way to distinguish between these two alternatives is by an intensive training programme designed to eliminate the perceptual deficits which are characteristic of the handicap at very early ages. Once the deficits have been eliminated, assuming that they can be, the two alternatives can be separated by examining the effect which the removal of the perceptual deficits has on

subsequent intellectual development. If there was no effect, in that the child is as retarded subsequently as another child who was not in the training programme, this would be evidence for the second alternative that the perceptual deficits are a result of the general handicap. On the other hand, if there is an effect such that the subsequent intellectual development of the children in the training programme exceeds that of a control group of children, this would support the first alternative that the perceptual deficits may caused the later cognitive retardation.

This has never been done but it is crucial. The present thesis has taken only the first necessary step which is to isolate certain perceptual deficits in the young mongol child. In particular it has been found that the mongol child does have some form of tactile deficit which indicates that the tactile deficit observed in adult mongols is present from extremely early ages. The second deficit which has been isolated in these experiments is that visually the young mongol is less perceptually active than the normal child in terms of the extent he moves his eyes when he looks at a visual display. This latter deficit may account for his poor visual discrimination of three dimensional objects.

The isolation of some perceptual deficits in the mongol child does not separate the two alternatives concerning the relationship between the perceptual deficits and the cognitive handicap. However, they provide an essential basis for the setting up of a training programme which should distinguish between the two alternatives.

Therefore the next step is to decide the nature of the training programme. From the evidence in this thesis, two deficits have been isolated and the training must be geared towards these. Both deficits seem to relate to the way in which the mongol child takes in information about the world around him. Any training programme must therefore be designed to make him increasingly aware of his environment and the consequences of his actions on the environment, through the modalities of touch and vision.

If such a training programme can eliminate the perceptual deficits which have been isolated in the young mongol, and if this results in greater intellectual development in the mongol compared to that of the mongol not included in the

programme, this would be of obvious practical value.

IV. A DIFFICULTY WHICH AROSE WITH THIS RESEARCH

A difficulty which was associated with this research and which was not fully anticipated at the outset was the time which it took to organise an efficient system for the notification of the births of mongol children, and the small number of these children who were available to take part in experiments at any one time.

The decision to work with young mongol children was made because they are usually identified clinically shortly after birth and this diagnosis can be confirmed or shown to be wrong by chromosome analysis. They therefore form a distinct clinical group and can be studied from an early age. This is a clear advantage of researching with such a group. However, one limitation is the relatively low incidence of mongolism which is estimated as between one and two per 1,000 births (e.g. Hall, 1964; Penrose and Smith, 1966; Stevenson, Johnston, Stewart and Golding, 1966a,b; Robinson and Puck, 1967; Jacobs, 1969; Mikkelsen and Stene, 1970; Uchida, 1970; Wahrman and Fried, 1970; Mikkelsen, 1971). The present annual birth rate in Oxfordshire is between 6,000 and 7,000 (Oxfordshire Area Health Authority, pers. comm.) and, therefore, between 6 and 14 mongols should be born each year in Oxfordshire. Of these children 16 per cent (between one and two mongols) would be expected to be dead by one year of age (Carr, 1975).

The number of mongol children available to take part in experiments is therefore fairly small unless either a much larger area than Oxfordshire is covered or the sample is taken from a more densely populated area. The small sample creates two related difficulties. One is that the same children often have to complete several experiments. The second is that if children of a particular age are required, especially of ages less than one year, the testing of the children will be extended over long periods in order to collect data from sufficient children at the right ages.

V. FUTURE EXPERIMENTS

The results of the experiments in this thesis demonstrate that it is possible to compare the visual and tactile responses of normal and mongol children who are of similar mental age. However it is clear from the answers to the six questions which have been considered that more experiments are required to confirm particular results and the speculations which have been made on the basis of some of the results.

One area for future research has already been mentioned and involves the design of training programmes to eliminate the perceptual deficits which have been found in young mongol children.

Another area for future research should be to investigate further the effect of touch in visual perception. When the child is touching an object, it is possible that he looks at it longer than an object which he cannot touch because some of the time he is watching his hands. One way of sorting this out might be to use the task devised by Harris (1972) which was discussed in Chapter 2, section III.A. In this task the children were familiarised to two objects of which only one could be touched. Following this familiarisation both objects were presented and both could be touched. An improvement on this would be to prevent the children from touching the objects when they were presented after the familiarisation. The latter condition in particular would indicate whether it is the touching of an object per se which affects the way in which it is looked at later. Such an experiment would bring a valuable addition to our knowledge about young mongol children.

The problem of the effect of touch in visual perception could also be examined by the use of more detailed measures of visual fixation such as the scanning technique which was outlined in Chapter 2, sections II.A.2 and II.C.1a. This technique allows precise analysis of where a child is fixating between saccadic movements of his eyes. Using this detailed method the ways in which mongol and normal children scan two and three dimensional patterns which previously they have either touched or not touched could be compared. If, as has been suggested, touch does function in the normal child to direct visual comparisons between three dimensional patterns, but does not function in this way in the mongol child, it might be expected that a normal child's scanning of a three dimensional

pattern would be effected by whether or not he has touched the pattern previously. On the other hand, the way in which mongol children visually scan a three dimensional pattern should not be effected by prior touching or no touching of the pattern.

However it may be necessary for touch and vision to be simultaneous for touch to direct visual comparisons at least in the normal child. If the previous experiments indicate no difference in the ways in which the mongol and normal children scan three dimensional patterns which they have previously touched or have not touched, it would be necessary to record the children's scanning of a three dimensional pattern at the same time as they touched the pattern . The child's scanning under such conditions could then be compared to his scanning without touching. It would be even more interesting if a method could be devised for recording simultaneously which parts of a three dimensional pattern a child looks at and touches from moment to moment, since this might provide valuable information about the relationship between vision and touch.

Another important set of experiments would be to examine in detail the way in which mongol and normal children scan pairs of two dimensional patterns and pairs of three dimensional patterns, and to see if there is any relationship between their visual responses and their ability to distinguish between different two dimensional patterns and between different three dimensional patterns. The present results would predict that mongol and normal children would scan and distinguish between two dimensional patterns in a similar way, but that differences would emerge between the groups when the patterns were three dimensional.

Studies of saccadic eye movements could also be used to follow up the differences which have been found in the way in which patterns in different spatial arrangements are looked at. Here there are many questions which need answering. For example, to what extent are the eye movements of young mongol and normal children ordered along a horizontal axis, and under what conditions will vertical movements occur? How does a child move his eyes around one pattern and from one pattern to another pattern?

Such studies would tell us much more about the function of alternations and repetitions than we know at the moment. If, as Ruff (1975) suggests, more

alternations occur between patterns which are similar than occur between patterns which are different, it would seem likely that the children may be comparing homologous parts of the two patterns. Only detailed records of saccadic eye movements can supply the data necessary to test this possibility. It is also possible that such a study would indicate further differences between mongol and normal children.

One of the consistent findings in this thesis was that the three dimensional patterns were fixated for longer than were the two dimensional patterns. It was pointed out that the factor directing this visual attention was unclear. It is possible that the children were responding simply to the cues which are associated with depth and which are absent in two dimensional patterns. Alternatively, it might be that the children responded with greater interest to the three dimensional patterns because they were aware that these patterns were solid and would provide tactile consequences.

A possible way to distinguish between these two alternatives might be to use the type of transfer task devised by Yonas (1973) and which was outlined in Chapter 2, section II.D. The experiment involved habituation to a real concave or convex surface under conditions of uniform lighting. The habituation trials were followed by a trial in which two photographs were presented. One was of a flat disk which was shaded at the top, and since light is assumed to come from above, the disk is seen as concave by adults. The second photograph was an inversion of the first and the disk was seen as convex. If the child prefers the photograph with a disk of apparently opposite curvature from the surface to which he habituated, this is evidence that the cues associated with the original real surface were responded to as depth cues. This is because in a situation with different cues which can also be associated with depth (i.e. shading), the child responds to the apparently novel curved surface. On the other hand, if there is no preference between the photographs or the preference is for the habituated curvature, it is most probable that the child habituated to the particular depth cues rather than to what they signified.

This type of experiment involving transfer should distinguish quite clearly between the two possible explanations for why the mongol and normal children paid more attention to three dimensional patterns than they did to two dimensional

patterns. It is therefore an experiment which should be performed.

One final suggestion for a future experiment concerns a possible design of a tactile within-modal task for use with very young children. The proposed design takes into account the observation that young children will not manipulate an object which they cannot see. Therefore the children must be able to see the objects when they are presented in the choice stage. A possible way to present the objects visually but still to make the task a tactile within-modal one might be to use two objects which when viewed from the front look identical. However, if their shapes were different at the back, the child would have to use touch to find out which one he felt before. The objects would have to be fixed onto the table so that they could not be removed by the child. It would not be possible to use reaching as a measure of choice behaviour; instead a suitable measure might be duration of manipulation, since if through touch the child recognises which object he has felt before, he might touch it for a different length of time than he touches the other. If this task proved to be successful it would provide a means of directly testing the tactile abilities of the young mongol child and the young normal child, and as such would be a valuable procedure.

It has been seen in this section that the results of the experiments which have been described in this thesis have raised many questions about the visual and the tactile abilities of young normal and mongol children. Thus one important outcome of these experiments is that they have indicated several appropriate directions for future research to take.

APPENDIX A

The Mechanisms Involved in Trisomy 21 and Mosaicism

This thesis has been concerned with the development of the perceptual abilities of young mongol children. In Chapter 1, section I.B, it was pointed out that the mongol is characterised by four types of chromosome abnormality, trisomy 21, translocation D/G and G/G and mosaicism. The mechanism involved in producing a translocation mongol is obscure unless one of the parents is a carrier of the translocation. However the mechanisms involved in trisomy 21 and mosaicism are fairly clear and will be described briefly in this appendix.

It was suggested as early as 1932 by Waardenburg that mongolism might be the result of nondisjunction during the formation of the gametes. The gametes in man, the ovum and the sperm, each contain 23 chromosomes. Therefore when an ovum fuses with a sperm the result is a zygote with 46 chromosomes which is man's normal chromosome complement. The gametes are produced by two successive divisions of a single cell. The normal way in which the gametes are produced is illusrated in the left hand diagram of Figure 21. Before the first division each chromosome divides into two chromatids and the homologous chromosomes pair up (Stage A). At this stage it is possible for two nonsister chromatids, both of an homologous pair to cross over (Stage B), but this is unimportant to the present discussion. The first division occurs when the nonsister chromatids of each pair separate and move to opposite poles of the cell (Stage C). The second division occurs when the chromatids separate (Stage D). The end result is four cells each with half the number of chromosomes of the original cell. When these gametes are fertilized, the zygotes produced will have a normal chromosome complement (Stage E). The formation of gametes involves meiotic division of the parent cell, in comparison to a mitotic division by which the daughter cells contain the same number of chromosomes as the parent cell had.

Trisomy may occur either as a result of nondisjunction during meiosis or at the first mitotic division of the zygote. Nondisjunction during meiosis implies

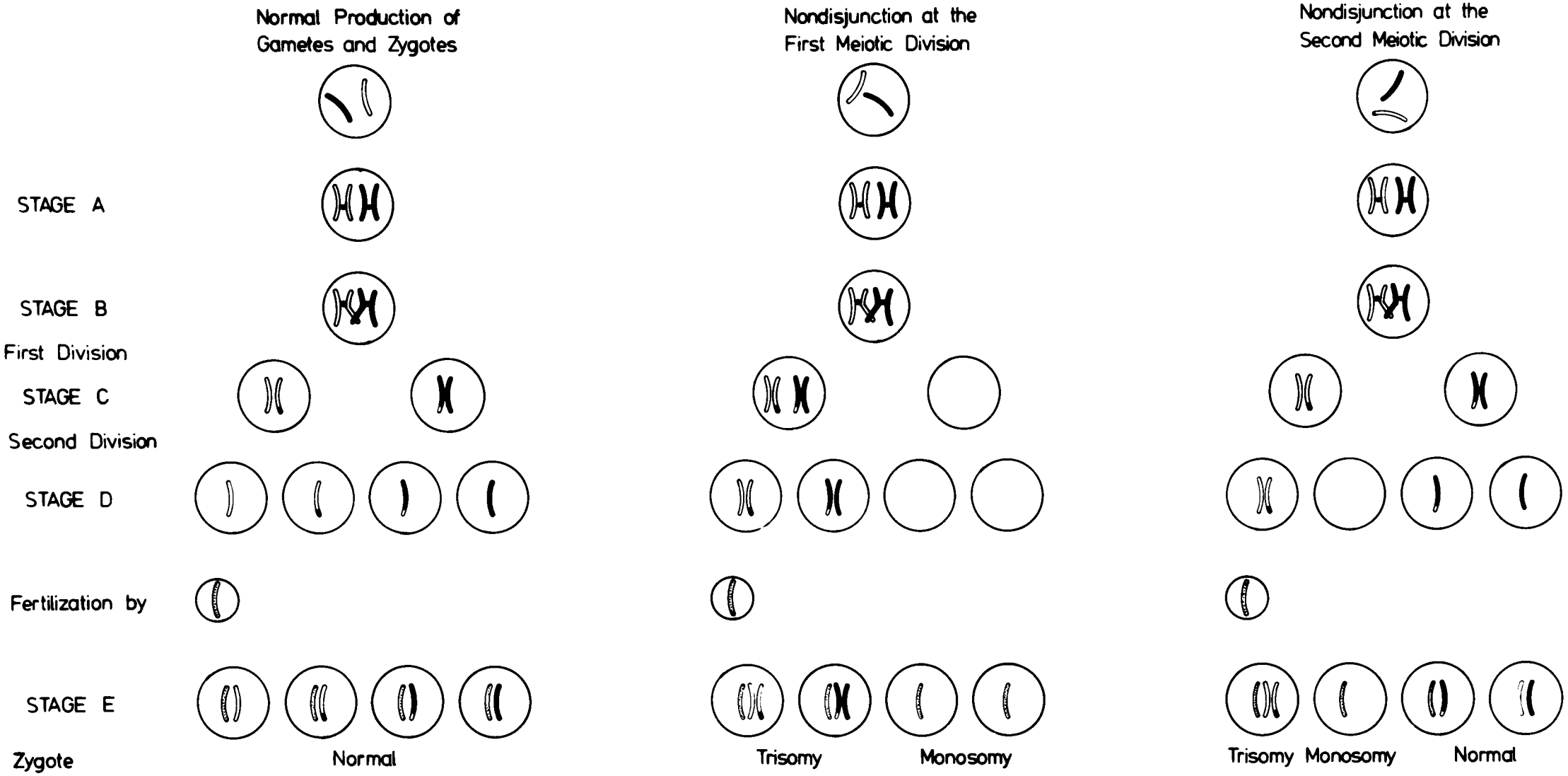


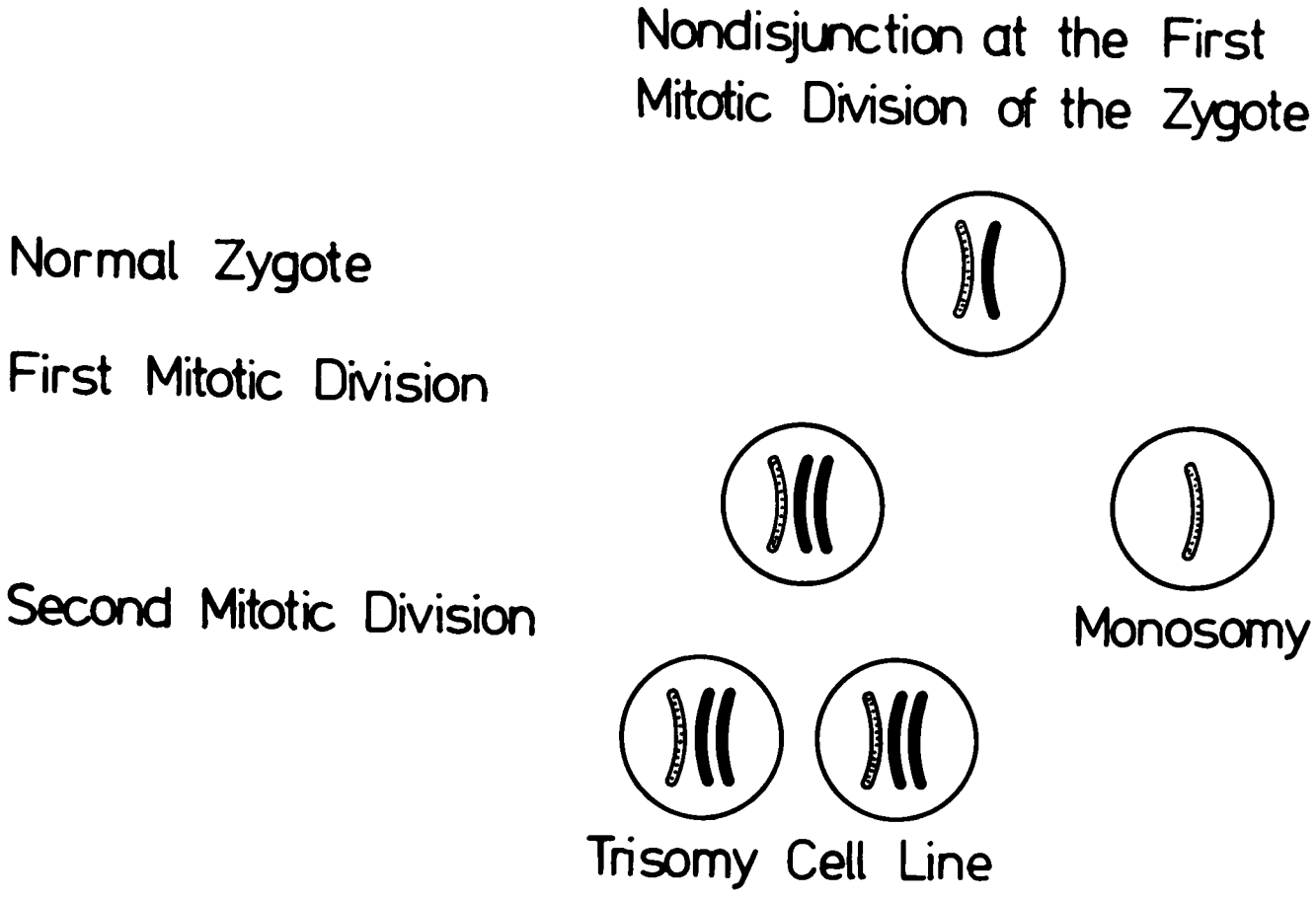
Figure 21: The production and fertilization of gametes illustrated for one chromosome pair

failure of homologous chromosomes to separate during the first of the two meiotic divisions or failure of the chromatids to separate during the second division. These are illustrated for a single chromosome pair in the middle and right hand diagrams of Figure 21.

Nondisjunction at the first mitotic division of the zygote is illustrated in the top half of Figure 22. In this case the monosomic cell line will most likely not be viable, and so the outcome will be a standard trisomy.

If nondisjunction occurs after the first mitotic division of the zygote, mosaicism will result in that more than one karyotype will be present. This is shown in the bottom half of Figure 22. The stage at which nondisjunction occurs after the first mitotic division will effect the proportion of normal to mongol cells, and the proportion can also vary in different parts of the same person.

Although the mechanisms are fairly straightforward, it is still not clear why nondisjunction does occur at all and what could be done to prevent its occurrence.



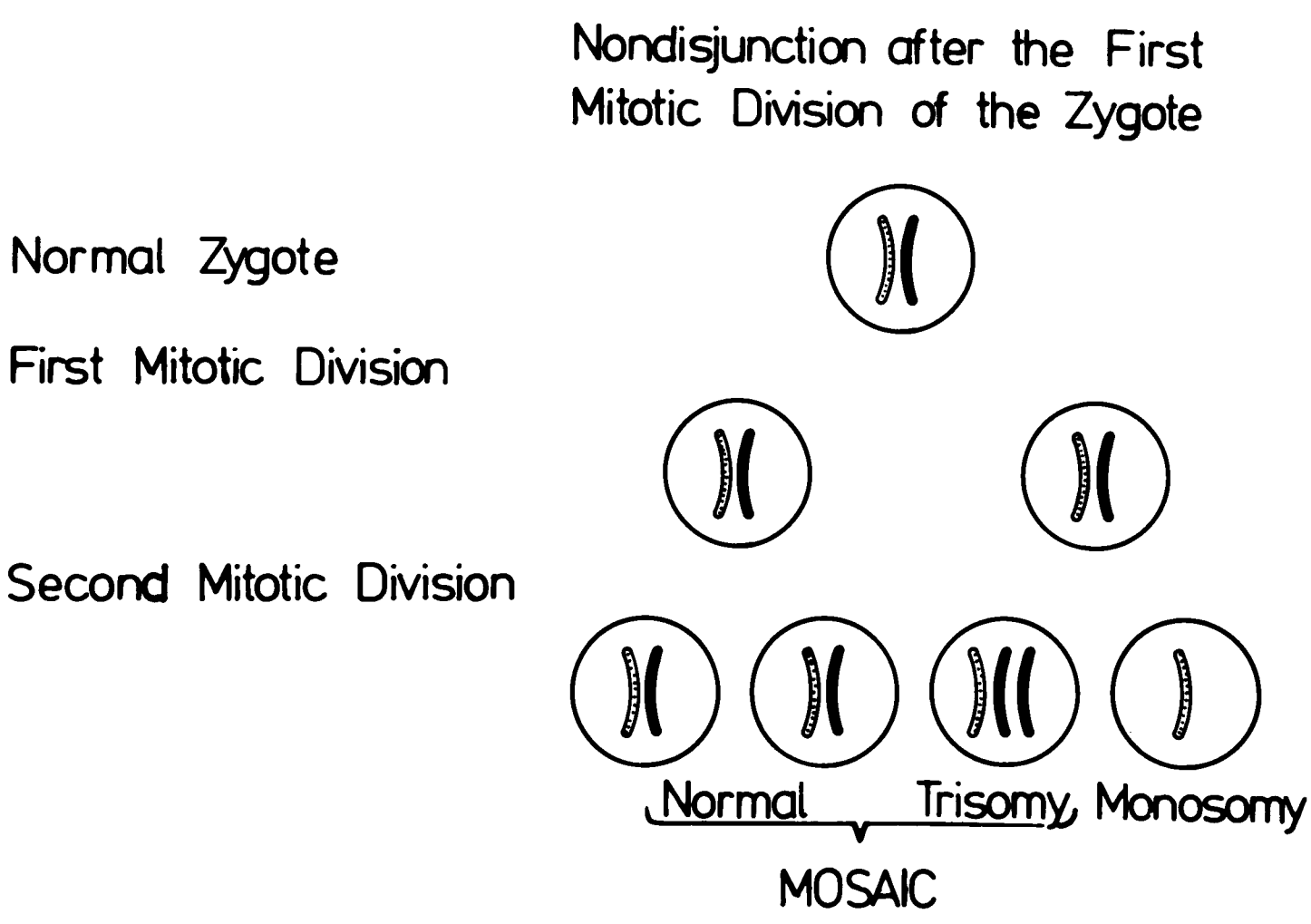


Figure 22: Nondisjunction at a mitotic division

APPENDIX B

Karyotype and Intelligence

In Chapter 1, section I.C, it was suggested that by studying mongols with a particular karyotype, it might be possible to reduce the variability within the group as a whole. An obvious measure to correlate with karyotype is I.Q./D.Q. and this is considered in this appendix. However, as will be seen, the literature is somewhat inconclusive as regards any relationship (Gibson, 1973), although several studies have reported higher I.Q.s than average for mongols with a translocation type of karyotype (Gibson and Pozsonyi, 1965; Johnson and Abelson, 1969; Finley, Finley, Rosecrans and Phillips, 1965; Rosecrans, 1971).

Gibson and Pozsonyi (1965) compared ten cases of standard trisomy (mean C.A. 8.5 years) with ten cases of translocation (mean C.A. 8.1 years). On intelligence (Binet L-M) the translocations scored higher (I.Q. 43.5 ± 4.05) than the trisomies (I.Q. 40.1 ± 2.93), the difference being significant at the five per cent level.

A report by Johnson and Abelson (1969) supports Gibson and Pozsonyi's finding of higher I.Q. in translocations than in trisomies. This was a study of a larger number of institutionalised persons - 254 trisomies, 21 translocations and 18 mosaics. The translocations had the highest mean I.Q. (37.83 ± 12.47) and this was significantly different at the five per cent level from either the mean for 238 trisomies which was 32.11 ± 13.21 or the mean for the mosaics which was 28.94 ± 13.43. The last two groups were not significantly different from one another in I.Q. Unfortunately the ages of the mongols in this study were not reported, and therefore the possibility of age differences cannot be ruled out.

Two reports of an isolated translocation case (Finley, Finley, Rosecrans and Phillips, 1965, and Rosecrans, 1971) are consistent with the group studies of Gibson and Pozsonyi, and Johnson and Abelson. The mongol was a boy with a D/Partial G translocation karyotype. Stanford Binet I.Q.s are reported at C.A.s of five years two months, at six years two months and at six years nine months as 86, 82 and 85 respectively. At ten years seven months he had a

WISC verbal I.Q. of 86, Performance I.Q. of 68 and Full Scale I.Q. of 75. These I.Q.s are considerably higher than those found on average in the mongol population (Chapter 1, section II.C).

A study by Shipe, Reisman, Chung, Darnell and Kelly (1968) does not support Johnson and Abelson's finding of lowest I.Q. for the mosaic groups. However, Shipe et al's study was far less extensive in the number of mongols tested - 25 trisomies, three translocations and three mosaics - with the result that the observed differences between the groups could not be tested statistically. Thetrisomies had a mean C.A. of 72 months (S.D. 30 months, range 22 to 148 months); mean M.A. of 27.2 months (S.D. 10.8 months; range 7.2 to 55 months) and mean I.Q. 37.4 (S.D. 7.8; range 26 to 62). The three translocations had C.A.s of 85, 140 and 29 months; M.A.s of 42, 29, 19.2 months, and I.Q.s of 49, 28 and 66, respectively. The three mosaics had C.A.s of 39, 54 and 99 months; M.A.s of 18, 47, 54 months, and I.Q.s of 48, 86 and 52 respectively. The mosaics were on average chronologically younger than the translocations and this might account to some extent for their overall higher I.Q.s, although the small numbers prevent any relevant testing of this. It is of interest to see that although the mean C.A.s of Gibson and Pozsonyi's trisomy and translocation groups were 97 and 102 months, their I.Q.s were substantially higher than those found by Shipe et al (1968).

Johnson and Abelson comment that although they found the mosaics to have lower I.Q.s than the translocation mongols, this might be due to greater variability within the mosaic group. There is some small support for this in that although the mosaics only formed six per cent of the total sample, of the five mongols with an I.Q. greater than 60, one (20 per cent) was a mosaic.

Shipe et al also summarised the findings of several others on mosaic intelligence. It has been suggested by Reisman, Shipe and Williams (1966) that if one of the karyotypes in a mosaic is normal, their intelligence will vary directly with the proportion of normal cells, such that the greater the proportion of normal cells the more normal the intelligence. This proposition is supported by two of Shipe et al's mosaics - the child with an I.Q. of 86 at C.A. 54 months had 80 per cent of normal cells, whilst the child with an I.Q. of 48 at C.A. 39

months had only 10 per cent of normal cells. The third mosaic has been studied by Reisman, Shipe and Williams (1966) and has two abnormal cell lines - 60 per cent of trisomy 21 and 40 per cent of a probable 2/21 translocation. It had been suggested previously (Midgeon, Kaufmann and Young, 1962; Penrose, Ellis and Delhanty, 1960) that the presence of two abnormal cell lines results in the complete clinical picture of mongolism. However this particular mongol had a relatively high I.Q., as measured by the Stanford Binet Form L-M, of 52 at a C.A. of 99 months.

Of the other studies on mosaics summarised by Shipe et al, it was found that the mean I.Q. of nine mosaics with over 50 per cent of normal cells was 57, whilst the mean I.Q. of three mosaics with less than 50 per cent normal cells was 35. However, the picture is not as clear cut as this implies, since two of the nine mosaics had I.Q.s of 20 and about 14, although they possessed 93.7 per cent and 86.7 per cent of normal cells respectively (Richards, Stewart, Sylvester and Jasiewicz, 1965). Lindsten, Alvin, Gustavson and Fraccaro (1962) report the converse - a mosaic mongol with 63 per cent of abnormal cells by a blood cell count and 29 per cent of abnormal cells by a skin cell count who had an average Gesell I.Q.

This particular mosaic is included in a report by Rosecrans (1968) who collected together 31 cases who had been reported in the literature. In those cases in whom intelligence had been measured, the chromosomes had been counted in skin cells for two, in blood cells for ten and in both for eight. The percentage of abnormal skin cells (ten mongols) correlated significantly with I.Q. ($r = -.89$ $p < .001$); the percentage of abnormal blood cells (18 mongols) was not significantly correlated with I.Q. ($r = -.31$ $p > .1$); whilst a significant correlation ($r = -.68$ $p < .001$) was found between the percentage of abnormal cells and I.Q. when all the persons with cell counts and I.Q. were included. This supports the proposition that higher I.Q. tends to be associated with a low proportion of abnormal cells, but it does not offer any explanation as to why some mosaics do not follow this pattern.

All that can be concluded is that karyotype appears to play little or any role, although translocations are possibly favoured.

APPENDIX C

Social Development and the Mongol

The extent to which a mongol person developes socially is an important aspect of his development. However it was not considered to be directly relevant to the main purpose of this thesis, and therefore the question of whether or not the social development of the mongol is retarded has been delayed until now. If his social development is retarded it can be asked whether or not the mongol person behaves socially at a level corresponding to his M.A., and if factors which are known to affect his mental development also affect his social development.

In the majority of experiments to be described, one test of social skills, the Vineland Social Maturity Scale, has been used. This scale provides an assessment of social development in children over one year old.

Two experimenters have studied the social development of the mongol during the first year of life using scales other than the Vineland Social Maturity Scale. Dicks-Mireaux (1966, 1972) used the Gesell developmental scale and reported that the social quotients (abbreviated to S.Q.s) of 12 home reared mongols in 1966 and 21 home reared mongols in 1972 were below normal from 16 weeks, the earliest time of testing.

This is contrary to the findings of Fishler, Share and Koch (1964). They selected items from the Gesell scale and argued from their results that the mongol's social development is normal up to six months of age. Smiling first occurred in 71 mongols at a mean age of 2.9 months, range 1 to 11 months. The mean age for this in normals was reported as two months. Thirty mongols were first heard to laugh aloud at an average age of 4.8 months, range 2 to 12 months, compared to the standardised norm of four months. However, other personal-social items which develop in the normal child after six months of age were delayed in the mongol children.

Although Fishler et al (1964) argue that the mongol's social development is not retarded until after six months, they based their conclusions on only two

behaviours, smiling and laughing. In both of these the mean ages were older than the standardised norms. Since Dicks-Mireaux examined more behaviours, the evidence is in favour of the conclusion that social development is retarded from at least the age of 16 weeks.

Despite this disagreement on the early social development of the mongol, there is complete agreement that older mongols are socially retarded (Pototzky and Grigg, 1942; Centerwall and Centerwall, 1960; Dunsdon, Carter and Huntley, 1960; Shotwell and Shipe, 1964; Stedman and Eichorn, 1964; Shipe and Shotwell, 1965; Cornwell and Birch, 1969).

A number of these studies, in addition to those reported by Dicks-Mireaux (1966, 1972) have reported I.Q.s and D.Q.s as well as S.Q.s. This makes it possible to compare the rates of mental and social development. Dicks-Mireaux (1966, 1972) reported that there was no difference in the S.Q.s and D.Q.s of the mongol children at any time of testing from 16 to 78 weeks. This suggests that at least in the first year and a half social development proceeds at a similar rate to mental development.

In contrast to this the majority of reports find that at older ages social development is not as retarded as mental development. However there is disagreement as to the age at which this difference first appears. Ten institutionalised and ten home reared mongols with a mean age of 28 months, range 17 to 37 months, were found to have higher S.Q.s than D.Q.s by Stedman and Eichorn (1964), although none of these differences were tested statistically. On the other hand, Shotwell and Shipe (1964) and Shipe and Shotwell (1965) found that 25 home reared mongols had similar I.Q.s and S.Q.s at about two years of age, although by three and a half years their S.Q.s were greater than their I.Q.s. These same researchers also tested the I.Q.s and S.Q.s of 17 institution reared mongols at ages of about $1\frac{1}{2}$, 3, $4\frac{1}{2}$ and $6\frac{1}{2}$ years. At all of these ages the I.Q.s and S.Q.s of the children were extremely similar.

Cornwell and Birch (1969) have evidence on home reared mongols which is in conflict with that of Shotwell and Shipe (1964) and Shipe and Shotwell (1965). These researchers found no difference between the mean I.Q.s and S.Q.s of a group of 44 home reared mongols aged from 4 to 17 years until six years of age.

For seven mongols of four and five years old, the mean I.Q. and S.Q. were both 58. However for nine mongols aged six and seven years, the mean S.Q. was 59, but the mean I.Q. had fallen to 44.

This difference increased with age as shown by considering the percentage of mongols having I.Q.s and S.Q.s greater than 50 at different ages. At four and five years, six out of seven mongols tested (86 per cent) had I.Q.s and S.Q.s over 50. By the ages of six and seven years, seven out of nine mongols (78 per cent) had S.Q.s over 50, but only two (22 per cent) had I.Q.s over 50. At twelve years and over, three out of six mongols (50 per cent) still had S.Q.s over 50, whereas none had an I.Q. over 50.

The I.Q.s and S.Q.s reported by Cornwell and Birch (1969) were considerably higher than those found by Shotwell and Shipe (1964) and Shipe and Shotwell (1965) for their home reared mongols. Although the reason for the discrepancy between these studies is unclear, it is certainly the case that after the age of six years a mongol's S.Q. is greater than his I.Q. Centerwall and Centerwall (1960) reported that at a mean age of seven years, 32 institutionalised mongols who had been reared at home until the age of four years, had a mean I.Q. which was lower than their mean S.Q. The same was also found for 32 mongols who had been in foster placement until admission to the institution at four years.

Dunsdon, Carter and Huntley (1960) reported higher S.Q.s than I.Q.s for 15 out of 19 mongols aged from $5\frac{1}{2}$ to $18\frac{1}{2}$ years. The mean S.Q. was 55.42, range 32 to 80, and the mean I.Q. was 48.42, range 28 to 68. The social age (abbreviated to S.A.) had a range from 28 months to 135 months. Although the difference between I.Q. and S.Q. was not tested, it is in the same direction as found by Pototzky and Grigg (1942). They reported the mean S.A. of 21 mongols attending special schools to be three years four months above their mean M.A. The mean C.A. of these mongols was 21 years 7 months with a range from 7 years 11 months to 47 years. Their mean M.A. was 6 years 5 months with a range from 2 years 9 months to 10 years 8 months, and their mean S.A. was 9 years 11 months with a range from 3 years 8 months to 17 years.

The evidence reviewed so far indicates that although the social development

of the mongol is retarded, it is not as retarded, at least in the mongol over six years old, as his mental development is.

A final consideration in this section is whether the mongol's social development is more retarded if he is reared in an institution rather than at home. Three studies have made this comparison, and all have found that the home reared mongol is less socially retarded than the institution reared mongol. Stedman and Eichorn (1964) compared ten mongols institutionalised before five months of age to ten mongols living at home. They were matched in pairs for C.A., and had a mean C.A. of 28 months, range 17 to 37 months. For the home reared group the mean D.Q. was 52.1 and the mean S.Q. 75. For the institutionalised group the mean D.Q. was 37.3 and the mean S.Q. was 61.8. Thus the home reared mongols were superior in terms of D.Q. and S.Q.

The mongol who is reared at home for the first three or four years before admission to an institution has also been found to be superior in social development to the mongol who has been reared in some form of institution from birth. Shotwell and Shipe (1964) and Shipe and Shotwell (1965) reported this result for mongols aged about four and a half and six and a half years. Centerwall and Centerwall (1960) found the same result at the age of seven years.

It is therefore clear that although the mongol person is retarded in his social development regardless of his environment, a home environment produces less retardation than an institutional one does.

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