A CROSS-CULTURAL STUDY OF MOTOR DEVELOPMENT IN THE WESTERN CAPE

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SUMMARY

Despite conflicting evidence regarding advanced motor behaviour in black African infants, very few comparative studies have been published. Reliable developmental norms for local populations are essential for the early identification of developmental disabilities. In this study the sample consisted of 681 black and 741 white infants drawn proportionally from the Child Health Care Clinics in the northern areas of greater Cape Town.

Babies were sampled in specified age-intervals between the ages of 16 and 1170 days. Variables studied were sex, birth-ranking, weight-percentile at the time of testing, marital status of the mother, parents' education and occupation, family size and family income. The demographic characteristics of the sample were compared with those of the population as a whole, based upon the 1980 census.

The testing instruments were the gross and fine motor-adaptive sections of the Denver Developmental Screening Test, supplemented by another 21 items representing reflex reactions or specific components of movement. These supplementary items were pre-tested for inter- and intra-observer reliability.

The percentage of children responding to the different tests at different ages was determined by probit analysis or, where more appropriate, by non-parametric logistic regression. Differences between the black and white South African infants were subjected to further statistical analysis, as was the contribution of the different variables to the attainment age.

Comparison of the performance of the South African infants with the Denver norms showed that both black and white babies were in advance of the Denver children on the majority of fine motor items. The black infants were also considerably advanced in gross motor behaviour; the white infants less markedly so. In the very few (3) items in which the Denver children excelled, doubts exist regarding either scoring criteria or cultural suitability.

Comparative analysis of the two South African samples identified certain consistent developmental trends. The black infants performed better on basic grasping patterns whereas the white infants were advanced in manipulative skills. The black infants were advanced on gross motor behaviour in the first year but were overtaken by the white group on learned gross motor skills in the second and third year, with the exception of items requiring physical strength.

Very little correlation could be shown between motor achievement and socio-economic factors. Differences appear to be largely due to child-handling practices and experiential learning, but ethnic characteristics may well play a role in the advanced early gross motor development of the black infant. Heavier infants also performed better in both groups, indicating nutritional influences.

The clinical implications of the findings are discussed and recommendations made for implementation and for further research.

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INTRODUCTION

Over a period of almost 50 years the results of more than 20 studies have been published with conflicting evidence for and against the existence of so-called African infant precocity. Those reports purporting to demonstrate this have been criticized for defects of measurement and design, and in particular for the fact that comparisons have been made with test norms rather than by investigating comparative samples of black and white infants.

Those of us working in developmental assessment units in this country have gained the impression that not only black babies but also white babies develop in advance of the established developmental scales most widely used. In particular, the continued use of the Gesell schedules is open to question. Standardization of the Denver Developmental Screening Test on children outside the United States has also shown significant differences in performance in different countries. The importance of early identification of developmental disabilities has been established. In order to make this identification it is essential to have reliable and valid developmental norms for the indigenous population.

The developmental scales in current use assess the presence or absence of certain gross and fine motor abilities without paying any attention to the manner in which these activities are performed. Each of these abilities, or milestones, is however achieved by the integration of specific components of movement acquired at earlier ages. Many of these so-called milestones in fact display a developmental course involving different combinations of components of movement over a period of weeks to months. The physiotherapist working with developmental disabilities requires a detailed knowledge of these components of movement, both in order to detect developmental abnormalities and in order to establish or re-establish motor control.

This study has been designed to investigate the performance of white and urban black South African infants on an established developmental scale, the Denver Developmental Screening Test, as well as to standardize the ages of acquisition of specific components of movement by the two ethnic groups under consideration.

In this study the coloured group has been excluded because of the impossibility of controlling variables in the ethnic background.

HYPOTHESES

1. Both white and urban black infants in the Western Cape achieve the items on the gross motor and fine motor-adaptive sections of the Denver Developmental Screening Test at earlier ages than those standardized for Denver infants.

2. Significant differences exist in the ages of acquisition of gross motor and fine motor-adaptive functions between these groups of white and urban black infants.

3. These differences are due to environmental factors rather than to genetic factors.

4. The acquisition of specific components of movement occurs over a sufficiently consistent time-span for these components to be standardized for use in physiotherapy evaluation of infants with suspected motor disturbances.

Chapter 1

LITERATURE REVIEW

1.1 AFRICAN STUDIES

Over a period of nearly fifty years, about twenty published articles have appeared with conflicting evidence for and against the existence of so-called African infant precocity. Those reports purporting to demonstrate precocity have been criticized for defects in design and measurement; in particular for the fact that comparison has been made with test norms rather than investigating comparative samples. Only one worker, Theunissen,[1] investigated comparative groups of black and white infants in Africa. Falmagne[2] compared black African infants with white Belgian infants. Both these studies were performed in South Africa, both are unpublished theses and neither, unfortunately, can be traced for study. They are reported on by Warren[3] and will be discussed later. There do not appear to be any published studies on the development of white babies in Africa.

The earliest published report on the development of black infants is that of Langton[4]. He states himself that the study was only an incomplete, preliminary survey of the Munyoros of Uganda and that conclusions should not be drawn. The number of children studied is not stated but was apparently very small. He recorded only the earliest and latest ages at which crawling, standing alone and walking were acquired. Crawling was acquired between the ages of 6,5 and 12 months, all infants stood by 17 months (the earliest age is not recorded) and walking was achieved between 10 and 17+ months.

Theunissen's study[1] is reported on by Warren[3]. Theunissen selected 66 black and 66 white infants between the ages of 2 and 57 weeks. The black families were described as urbanized or semi-urbanized and the whites as "fairly middle class". Using the Gesell schedules he found a marked similarity in the rate of development for the two groups.

Faladé[5,6] reports on a study of 101 Senegalese children, again using the Gesell schedules. The study was largely cross-sectional although 75 of the children were tested each month for five months. She found these infants to be advanced in all items of both gross and fine motor performance in the first 12-15 months. The greatest precocity appeared at between 36 and 40 weeks. There followed a second, brief period in which prehension and locomotor-related skills such as running and climbing steps were advanced, followed by an abrupt arrest of development and apparent apathy. The age at which this occurred was not noted, but Faladé ascribed the apathy and failure to develop to gastrointestinal disorders including kwashiorkor. Interestingly, development accelerated later, particularly with respect to equilibrium.

Probably the best known reports on the development of African infants are those of Geber and Dean[7,8,9,10]. Geber's study arose from observations made in 1954 when she compared a control group of healthy African infants with a group of children who were suffering from kwashiorkor. She subsequently tested 183 children in the Kampala district of Uganda over a period of three years, using the Gesell schedules. The socio-economic level ranged from that of rural labourers to that of theological students, but did not include any highly educated or wealthy groups. Several different tribes were represented. In reporting on the results of this study, Geber and Dean[8] remark particularly on the advanced gross motor development in the younger infants. They found that this motor precocity was accompanied by advanced adaptive, language and personal-social behaviour, particularly in the first year of life. Unfortunately the developmental quotients obtained are given in terms of "usual score" followed by the range of values and it is not clear whether this "usual score" represented the mean developmental quotient or not. It was found that this initial precocity was maintained, although at a slightly decreased level, until weaning at about two years. Thereafter there was a gradual decline, the few children retaining advanced performance after three years nearly all being the children of students at the theological college, which provided a nursery school. In a later study[10], 60 Bagandan infants in a much higher socio-economic group, whose way of life resembled that of many white families, were studied. Although they found advanced motor development in the first two years, this was not as pronounced as in the lower socio-economic groups studied earlier. However, the decline seen in the poorer groups after two years of age did not occur.

It was felt that the early motor precocity could largely be attributed to the mother's handling during the first two years, when she not only carries the baby everywhere on her back, stimulating his postural responses, but also lavishes love and attention on him[7, 10]. Equally important, she breastfeeds him throughout the early period, ensuring adequate nutrition. After two years of age the child is virtually ignored, being expected to keep quiet unless he is helping around the house. He is summarily deprived of his mother's milk and very often may be sent away to live with a relative. It is at this stage that kwashiorkor often develops, a finding that ties in with Faladé's observations[6].

There can be no doubt that the use of Gesell's developmental quotients may be misleading, especially in the younger infants where a very small advance in behaviour results in a very high developmental quotient. The apparent decline in performance could in part be due to the decreased effect of this in the older age-groups. Cobb[11] points out that development begins at conception. After computing the developmental quotient for adaptive ability using the age from conception instead of the age from birth he was able to show that the developmental quotient for the younger infants was not as high as that shown by Geber, and that it remained almost constant over the first five years. Cobb considered that genetic factors undoubtedly played a role in the African infant's advanced motor behaviour, and Geber and Dean's studies on newborn infants[8,9] would appear to support this supposition. They tested 107 newborn infants, 82 of whom were less than 48 hours of age, using the method of André-Thomas and Saint-Anne Dargassies[12]. They found a lesser degree of physiological flexion, a much greater degree of head-control and less primitive reflex activity than seen in the newborn white child. They also commented on the alert expression, open hands, mouthing and fingering. Within the first 48 hours after birth they observed behaviour normally seen at 4 weeks of age and in some instances at 8 weeks.

The findings of other workers (Faladé[5], Akim, McFie and Sebigajju[13], Vouilloux[14], Ainsworth[15], Massé[16], Kilbride et al[17]) would appear to support Geber's observations, at least as far as the existence of initially advanced motor development and the possible reasons for any decline are concerned. There certainly does not seem to be grounds for

Warren's[3] outright condemnation of Geber's work which appears to be based upon other authors' misinterpretation of Geber's findings. Geber herself commented on the lack of suitable test material for the older children and on the necessity for a more detailed study.

Geber also tested 16 black infants between the ages of 8 and 21 months in Johannesburg. Unfortunately no separate results are given for this group.

Kilbride et al[17] conducted a study of 163 rural Bagandan infants between the ages of one and twenty-four months. They took into acccunt the criticism of Geber and Dean's earlier studies and concentrated on eliminating these errors in their own research design. They chose to take their sample from Bagandan infants specifically in order to validate (or otherwise) Geber and Dean's findings. They used both the original California Infant Scale of Motor Development (Bayley, 1935)[18] and the revised Bayley Infant Scale of Motor Development (Bayley, 1965)[19]. They found that their sample showed advanced motor behaviour, although not as advanced as that in Geber and Dean's sample. They also found that the motor behaviour was less advanced on the revised Bayley scale than on the original one. On the 1935 scale, 95,79% of infants were graded as above average and 4,2% as average. On the revised scale 75,46% were found to be above average, 23,31% to be average and 1,23% to be below average. To avoid the doubt raised by Geber's use of the term "usual score" they computed the mean, median and mode scores for their sample. They also corroborated a decreasing developmental motor quotient (DMQ) with increasing age, but found that at 24 months of age the Bagandan infants still demonstrated DMQs of over 100. Analysis of variance showed no differences by sex or birth order. They also supported Geber's proposal that child-rearing practices contributed to the different rates of development in earlier and later infancy. The recommendations which they made were as follows:

"1. A longitudinal study from infancy through preadolescence of the motor and mental development of Baganda children, including information for each child on genetic constitution, mother's prenatal care, child's nutritional and medical history and childrearing practices, enabling controlled comparisons to be made.

2. The examination of similarities and differences between those Baganda infants who show a decreasing rate of development with age and those who do not.
3. The development of mental and motor performance norms for Baganda infants as a whole so that doctors can successfully evaluate an individual child's current health and developmental progress in relation to other infants from similar genetic and cultural backgrounds.
4. Testing and comparing African populations other than the Baganda, in order to determine whether early precocity and subsequent decreasing rate of development are present among other African infants".[(17)]

Unfortunately no researchers have taken up these recommendations in the intervening 14 years, neither with the Baganda nor with any other racial group in Africa.

Kilbride et al's study has been reported on out of chronological order because it related to Bagandan infants. Of interest in this study is that they compared their findings on Bagandan infants with those of Bayley[(19)] on American black and white infants. They found that Bagandan infants were significantly more advanced than American white infants at each level, as well as American black infants at all levels during the first year.

As has been mentioned previously, Falmagne[(2,20)] tested 78 black infants in Johannesburg and compared them with 105 white Belgian infants. Their ages ranged from 1-6 months only. 11 Motor items and 9 "perceptual or sensorimotor responses to stimuli" were tested[(3)]. No details of these items can be traced, but Warren[(3)] alleges that "a few items that Geber singled out as examples of remarkable precocity in African infants" were included. The two groups of infants were compared on each item at each month of age. Warren avers that 42 of these comparisons show the white babies to be advanced as against only 37 for the black babies. However, he states that "on the perceptual and sensorimotor items alone, 22 comparisons favor (sic) Europeans, 15 Africans", so that presumably on the motor items 22 comparisons favoured the black infants and 20 the white babies. Warren did admit that the range of items tested did not constitute a comprehensive baby test.

Griffiths[21,22] conducted a study of the growth and development of urban black infants in Johannesburg, under the auspices of the National Institute for Personnel Research. 1216 Infants of one year and under were tested between 1957 and 1960. Motor development was tested in a cross-sectional sample of 480 of these infants by a team led by Liddicoat, who has reported separately on her findings[23,24]. The testing schedules used were devised by Dr. Katherine Cobb, a Carnegie Research Fellow working with the National Institute for Personnel Research. The schedules were mainly Gesell-based but included items from other current infant tests. The ultimate aim was to produce a developmental scale specifically for use with urban black infants. If 50% or more of babies in a particular age group could perform a particular item, that item was considered to be normatively characteristic. Results showed that motor development was advanced throughout the first year as compared with the Gesell norms for white babies[25] and with Dekaban's findings[26]. These advances were not, however, as great as those found by Geber and Dean. Griffiths queries the accuracy of the ages of Geber's babies, but also suggests that the Johannesburg babies, being from urban families, may more closely approximate Geber's group of babies from a higher socio-economic population who had shown a lesser degree of precocity[21]. Liddicoat[23] compares six selected motor items for the same urban black infants with norms derived from various established infant scales for white babies (Table 1). In a separate publication referring to the same study[24] the results are presented in the form of percentile graphs. It is interesting to note that graphs are also given for vanishing responses such as the asymmetrical tonic neck reflex posture and the use of pivoting for locomotion. Difficulties were experienced in finding sufficient items at each monthly age-level in each of the four developmental fields. This was particularly so in the 7-12 months age-group. In this age-group the authors also experienced resistance by the infant and refusal to co-operate, despite the discarding of white coats and the replacement of the original white examiner by a black one.

Liddicoat[27], in the course of assessing the effects of maternal antenatal decompression on infant mental development in 210 white Johannesburg babies noted that 60,5% of nine month-old infants could pull to stand at their mother's laps, although only 44,1% used the pincer grasp at this age. No conclusions could be drawn from this since the number of infants involved was small and, having been subject to antenatal decompression, cannot be considered representative of the white population.

TABLE 1 : PERFORMANCE OF BLACK JOHANNESBURG INFANTS IN COMPARISON WITH THE ESTABLISHED INFANT SCALES FOR WHITE INFANTS.*

African Infants			Other Series (White Infants)		
Item	Mos.	Wks.	Author	Item	Age
Sits alone for at least 10 seconds	$4\frac{8}{13}$	20	Bayley (1936) Gesell and Amatruda (1947) Griffiths (1954)	Sits alone momentarily Sits erect Sits alone for a short time	5,7 mos. 28 wks. 8 mos.
Stands at mother's lap	$6\frac{6}{13}$	28	Gesell and Amatruda Griffiths	Standing, holds rail, full weight Can stand, holding to furniture	36 wks. 11 mos.
Pulls to standing unassisted	$8\frac{4}{13}$	36	Gesell (1940) Bayley Kuhlmann (1944) Griffiths	Pulls to standing unassisted do. do. Pulls self up by furniture	40 wks. 10,6 mos. 11 mos. 11 mos.
Cruises at rail, lap, furniture	10	41	Gesell Griffiths	Cruises Sidesteps round inside cot or playpen, holding rails.	48 wks. 12 mos.
Stands alone for at least 5 seconds (47,5 per cent of sample at 12 months stood alone for 10 seconds or longer)	12	52	Bayley Griffiths	Stands alone (few seconds) Stands alone	12,5 mos. 13 mos.
Grasps pellet, thumb opposite (between thumb and top joint of forefinger)	$8\frac{10}{13}$	38	Bayley Gesell and Amatruda Griffiths Cattell (1940)	Fine prehension with pellet Neat pincer grasp Thumb opposition complete do.	9,3 mos. 48 wks. 11 mos. 11 mos.

*Reproduced from Liddicoat, R. (1969) Development of Bantu children (Letter to the Editor), Develop. Med. Child Neurol., 11,6,821:822.

Poole[28] studied the effects of "westernization" on the development of 90 Nigerian infants of the Yoruba tribe. The main differences between the rural "unwesternized" and urban "westernized" groups lay in the annual income of the families and the educational level of the mothers. The urban families were mainly professional and in nearly half these families the mothers had their own professional status and returned to work (curtailing breast-feeding) whilst the baby was still very young. Only 10 items were tested (6 locomotor, 2 manipulative and 2 language items). These were selected mainly from the Griffiths Developmental Schedule[29]. Although the results showed a trend in favour of the rural infants, this was not statistically significant. Testing was done by an unspecified number of Yoruban assistants and there does not appear to have been any attempt to establish reliability within and between observers. Poole's study also excluded babies of under 5 months of age, the very age-groups in which other studies have found black infants to show the most advanced motor performance.

One of the only two longitudinal studies of black African infants was conducted by Leiderman <u>et al</u>[30] on 65 periurban Kikuyu infants using the Bayley Scales of Infant Development[31]. Testing was done by a single observer, following training on 10 non-study infants during which inter-observer agreement on the two final infants reached 85%. The infants were tested at 2-monthly intervals on between 4 and 8 occasions, although the age at earliest testing is not recorded. The Kikuyu infants performed significantly better than the United States norms on 20 items in the motor scale (mean motor score 129,5) and on 38 items in the mental scale (mean score 108,4). They also performed better on both scales than did United States black infants as reported by Bayley[19] and by Walters[32]*.

The relationship between test performance and selected social and demographic variables was also computed. They found that the economic status of the family and the number of modern amenities present in the home showed the highest correlation with the mental test score (significant at the 5% level), whereas the number of individuals aged

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*These studies are discussed in Section 1.2

over 40 years showed the only significant correlation with the motor score. It was felt that these findings corroborated the precocity found by both Geber and Kilbride, but did not substantiate Geber's finding that motor development was more advanced in the lower socio-economic classes. They considered, however, that environmental factors contributed at least 25% to the rate of development.

An interesting longitudinal study in support of this was conducted by Super[33] on Kenyan infants, this time on rural Kipsigis. The Bayley[31] scales were again used to test 64 infants monthly for their first year of life. Additional observations were made randomly once a week in order to ascertain the babies' way of life, and the mothers were interviewed about child-rearing practices. Super found an uneven pattern of motor development in which the infants were considerably advanced in their acquisition of sitting, standing and walking - whereas they were slower in prone development. He found that this was directly related to the deliberate daily practice of sitting, standing and walking; there are even special words for the teaching of sitting and walking. It was also noted that where early standing was practised, the primitive standing reflex was retained until integrated into mature standing. A group of 18 urban infants, whose care was more westernized but whose mothers still practised sitting and walking with their infants, were able to sit and stand later than their rural counterparts but still earlier than an American sample. In preliminary studies on 12 other racial groups in East Africa it was found in all instances that advanced motor skill was directly related to the practice of that particular activity. In the Teso tribe, for instance, 93% of the mothers admitted to teaching their babies to crawl, and the age at which crawling was achieved was about $5\frac{1}{2}$ months.

Super's opinion has, however, been opposed by two more recent studies. Keefer <u>et al</u>[34] studied 15 Gusii newborns, comparing them with 15 American white infants. Each infant was tested three times using the Neonatal Behavioral Assessment Scale, the Gusii infants at 2, 5,5 and 10 days mean and the American infants at the mean ages of 2, 6 and 10,5 days. They found that the most striking difference between the two groups was in general motor tone, the Gusii infants showing more tone and more controlled modulation of tone, necessitating an adjustment to the motor tone scale used. Gusii infants also showed better motor maturity, had fewer startles and tremors, were less irritable (despite more frequent changes of state) and showed better self-consoling than the American infants. Both groups performed well, however, and there was no evidence of general motor precocity in the Gusii. The authors felt that the differences which were present were genetic in origin and that, contrary to Super's opinion, both genetic and environmental influences must be considered responsible for differences observed in older infants.

This view was supported by a study by Hennessy et al[35] who analysed the gait of Gusii infants aged between 13 and 69 months. Although the developmental patterns related to speed, stride length and cadence paralleled those observed in American children, the Gusii children showed a progressive decline in walking cadence, achieving adult ranges at a younger age than their American counterparts. They considered that this potential had been evidenced in the newborn abilities noted by Keefer et al[34]. Since mild malnutrition was present in the Gusii, nutritional level could not be considered responsible, nor could practice of skills or free exploration of the environment contribute since neither were characteristic of the Gusii tribe.

The chief antagonists of African infant precocity are Knobloch[36] and Warren[3], who criticize Geber's results in particular. Knobloch's argument is, however, based upon the results of studies of Negro infants in Newhaven and Baltimore in the United States, hardly part of the African continent. On the grounds of these studies she proposes that Geber has misinterpreted the behaviour exhibited by the Baganda infants. She states that paediatricians who have not been trained to use the Gesell Developmental Schedules "on any consistent or intensive basis" exhibit "a constant tendency to interpret the behaviour at an unduly high level"[36].

Warren[3] in his review article considers that out of the 14 studies which he reviewed only the two which failed to show any differences in the rate of development are worthy of consideration. These are those of Theunissen[1] and Falmagne[2]. As mentioned earlier, neither of these studies can be traced and since the only author who has commented on them is Warren himself, no conclusions can be drawn. Warren is a psychologist and most of his criticism is directed at "defects of measurement and design". He quite rightly suggests that future studies should involve comparative samples of black and white infants rather than mere comparison with test norms. He states "It is also argued that infant differences by social milieu afford the most sensible basis for the necessary introduction of independent variables into this research area, and that improved techniques of assessment should be applied, both in the neonatal period and beyond".

Neither Knobloch nor Warren have themselves performed a comparative study on African infants.

Although the majority of studies so far carried out on the African continent appear to indicate advanced motor behaviour in black infants, in particular with regard to gross motor development, it must be admitted that this is still not proven. The early studies in particular were poorly designed (or not designed at all) and as yet there have been no published reports on studies of truly comparative samples.

Table 2 gives a summary of the results of the African studies.

TABLE 2 - AFRICAN STUDIES

Date published	Authors	Country	Sample size Black	Sample size White	Test	Ages tested	Comparable variables	Non-comparable variables	Conclusions
1939	Langton	Uganda	Not stated (very small)	-	3 items	Earliest and latest ages of acquisition noted	-	-	Not drawn
1948	Theunissen	South Africa	66	66	Gesell	Monthly intervals from 2 to 57/52	Urban families	Socio-economic background. Education of parents	Similar rate of development in both groups
1955	Faladé	Senegal	101	-	Gesell	Monthly but mainly X-sectional	-	-	Blacks advanced c/f norms in all gross and fine motor items for first 15 months; some temporary decline later
1957/1958	Geber Geber and Dean	Uganda	243	-	Gesell	Monthly intervals birth to 3 years	-	-	Blacks advanced c/f norms in first 2 years of life, declined thereafter. Group of higher socio-economic babies showed rather less precocity but no decline
1959, 1962	Falmagne	South Africa and Belgium	78 (S.A.)	105 (Belgium)	20 items	Monthly intervals from 1-6 months	Urban families	Black infants from Johannesburg townships; white infants from middle class Belgian families	Equivocal
1962, 1969	Griffiths	South Africa	480	-	Gesell - based but adapted	Monthly intervals from birth to 12/12	-	-	Advanced c/f norms throughout first year
1969	Poole	Nigeria	90	-	10 items based upon Griffiths Developmental Schedules	Only from 5 months	-	-	Found rural infants to be slightly advanced over "westernized" infants of same tribe (not significant)
1970	Kilbride, Robbins and Kilbride	Uganda	163	-	Bayley 1935	1-24 months cross sectional	-	-	Advanced motor behaviour c/f norms, decreasing towards end of second year. More advanced when scored on 1935 scale than or revised (1965) scale

Date published	Authors	Country	Sample size		Test	Ages tested	Comparable variables	Non-comparable variables	Conclusions
			Black	White					
1973	Leiderman, Babu, Kogia Kraemer and Leiderman	Kenya	65	-	Bayley, 1969	Earliest age not recorded. Tested at 2/12 intervals for 4-8 occasions	-	Compared with U.S. negro studies of Bayley, 1965 and Walters, 1967	Kikuya infants significantly more advanced than U.S. norms on 20 items in motor scale and 38 in mental scale. Also advanced c/f Bayley's and Walters' negro samples
1976	Super	Kenya	64	-	Bayley, 1969	Monthly intervals for first year of life	-	-	Considerably advanced over U.S. norms in sitting, standing and walking but slower in prone development. Related directly to practice of these activities.

1.2 STUDIES OF BLACK (NEGRO) AND WHITE INFANTS OUTSIDE AFRICA

1.2.1 Comparative studies

The earliest comparative study of white and negro infants is that of McGraw[37]. Her primary aim was to assess intelligence. Working in an era when negroes were, in her own words, described as an "inferior race" she compared 60 black and 68 white "Southern" infants. Her infants were selected in a "random and haphazard manner" - a justifiable description of a method which involved approaching households which had diapers hanging in their backyards as well as "baby pick-ups" at the local Ten-Cent Store! They ranged in age from 2 to 11 months. The sample was drawn from a town in which college education was available for both blacks and whites and it was felt that this sample showed a bias towards the better educated parents in both groups. A rather strange feature of the test situation was that the baby was usually examined in isolation, without the company of the mother, nurse or other family member. At the time at which this study was conducted McGraw did not consider Gesell's tests sufficiently developed to constitute a "scale". After reviewing several tests designed for use with infants under one year she eventually selected the Vienna Baby Tests, which had been standardized on 20 children at each monthly age level. These tests gauged the behaviour of the baby in relation to five different functional aspects[38], viz:

1. the child's control of his own body as well as his co-ordinated responses to external stimuli.
2. the development of manipulative ability.
3. the establishment of social contact.
4. the early development of memory and imitation.
5. the setting of goals and achievement of objects (sic).

Interpretation of results was on the basis of the percentage of children who passed the test at a given age. McGraw gives (in what she describes as a free translation) a meticulous description of the criteria for each test as well as the method of determining a developmental quotient. She also offers very valid criticism concerning defects in the design or interpretation of the tests. Unfortunately the number of infants tested by her in each age-group was rather small, ranging from a minimum of 3 to a maximum of 11, with a mean of 6,4. She found that the mean developmental quotient for the white infants (D.Q. 105, standard deviation 17) exceeded that of the black infants by 13 points, the mean developmental quotient for the blacks being 92 (standard deviation 16). She noted in both groups that the higher developmental quotients occurred in the lower age-groups. Except at the four-month level, the percentage of items passed by white children exceeded at each age-level the percentage passed by black children. Only 20 of the 100 test items were passed by a larger percentage of black babies than white babies, and a further 2 tests by an equal percentage of black and white babies.

It must be remembered that this study was primarily concerned with assessing intellectual traits and only included 10 tests of gross motor performance, although 29 items involved aspects of fine motor development.

Comparison of height and weight for the two groups revealed that the white babies of both sexes were consistently taller and heavier than their black counterparts. The black babies also were considerably below their own norms for weight, and this gap increased with age. McGraw did not, however, consider that the possible difference in nutritional status accounted for the differences in performance , since underweight white babies performed better than overweight black babies. The degree of under- or over-weight was not, however, reported.

Fifteen years passed before the next comparative study of negro and white babies appeared. Pasamanick[39] criticizes McGraw's rejection of the role of nutritional factors in performance and in his own study he recorded the socio-economic status of the infants' families in detail. He compared 53 black babies with three separate groups of white babies - 57 illegitimate babies living in foster homes, 22 illegitimate babies living in an institution and 20 babies from superior homes. For each group he recorded the occupations of both natural parents (where known), their years of schooling, the number and age of siblings, the baby's birth-weight and maturity and any other relevant details of the perinatal history. He recorded a relatively high number of perinatal problems amongst the black babies and their mothers - a total of 22 complications being present in the 48 mother/baby combinations for whom records were available. There were only 2 recorded problems between the three white groups together. The housing situation of the black infants was classified as good, fair or poor - 20 infants being housed in "good" housing (all but one in a public housing project) and 26 in "bad" housing, i.e. slum dwellings. The geographical origin and degree of pigmentation of the black babies and their motners was also recorded, the latter being classified arbitrarily into black, dark brown, light brown and very light brown; it was recognized that children under one year of age are lighter than their eventual adult colour.

The infants in the study were examined at only two age-levels - at six weeks and again at 40 weeks. Thirty of the 53 black babies were not examined at these specific age-levels but were examined initially at any age under one year and then again, if possible, approximately 6 months later. The infants' performance was measured on the Gesell schedules.

It was found that,over the five aspects of behaviour tested, there was no difference between the overall development of white and black infants. The only racial difference was in gross motor development where the black infants achieved consistently higher quotients. Within races, females were found to be more advanced than males, particularly in the black group. Infants living in poor housing conditions did not do as well as those living in better conditions, and the effect of environmental deprivation showed clearly in the poor performance of the institutionalized group of white infants. One finding that has been duplicated in other studies is that children with pre-school siblings did not perform as well as only children. No differences could be ascribed to the parental schooling, regional origin or degree of pigmentation.

At the time at which the study was made, New Haven negroes were enjoying relatively good socio-economic levels as a result of the employment offered by the wartime defence factories. The birth-weights for the black infants approached or exceeded those of the white infants in the study and the heaviest infants (black females) showed the highest average developmental quotient (113). One finding similar to that in some of the African studies was that the rate of development slowed slightly in the third half-year of life, although at that stage it still exceeded that of the first half-year.

Seven years later Knobloch and Pasamanick[40] published further observations of 44 of the same group of 53 negro infants. Four of the children seen refused to co-operate fully and were excluded. The socio-economic status of the families had deteriorated slightly. The average age of the infants at this examination was 24,4 months. The group of children still could be equated overall with the Gesell norms, showing a distinct and significant acceleration in gross motor development but a significant lag in language ability, although this was still at an average level. There were no significant differences related to sex, pigmentation, parental education or regional origin. Those children who had been heavier at birth were advanced in all fields except fine motor behaviour, being significantly advanced in adaptive behaviour at between the 2% and 5% levels. When birth-weight and weight at time of testing were correlated, those children who were heavier on both occasions showed the highest level of adaptive behaviour, being significant at the less than 1% level over infants who were below the median weight at birth and below average weight at time of testing. The difference between those children who were heavier on both occasions and those who were above median weight at birth but below average weight at time of testing was also significant at the 1% and 2% level.

The authors concluded that the average New Haven negro child of between 18 and 31 months of age developed equally to his white counterpart, the only racial characteristic being a definite acceleration in gross motor development in the black child. They felt that their subjects' adequate nutritional status was the main factor contributing to their development. They found no evidence of a downwards trend in development (as suggested in their previous study) but felt that a further study was indicated in order to elucidate whether adverse environmental circumstances could exert a negative effect on development, particularly in view of an apparent (but not statistically significant) correlation between parents' occupation, housing and development.

Scott <u>et al</u>(41) compared two groups of black infants with a group of white infants studied by Aldrich & Norval(42). This cannot be considered a strictly comparative study, since Aldrich's infants were from a different State and since there were essential differences between the designs of the two studies, not least of which the intervening period of almost a decade. Both studies, however, utilized the same 12 "neuro-muscular steps" as criteria. These were mainly gross motor characteristics: smile, vocalization, head-control, hand-control, roll, sit, crawl, prehension, pull-up (to stand) walk with support, stand alone, walk alone. Although it is reported that the subjects were seen at monthly intervals, the same subjects were not seen at all monthly intervals and the parents' report of the date of first occurence of a particular characteristic was accepted. A total of 708 black babies was used to obtain the 250 records for each of the 12 characteristics. The black babies came from two widely differing socio-economic backgrounds, those seen in private practice being regarded as comparative with Aldrich and Norval's white sample. Scott et al found that the development of their entire sample was in advance of the earlier white sample after the first 8 weeks of life, although the black and white infants from private practice had a similar course until the black infants showed an acceleration in development after 30 weeks. The group of black infants from poor socio-economic backgrounds were considerably advanced in motor development from the 8th to the 35th week of life, after which their developmental course approximated that of the black infants from better backgrounds (whose development was now accelerating). Without producing any details concerning child-care methods, the authors felt that the accelerated motor development of the infants from the low socio-economic group was due to "greater permissiveness in daily care as practiced (sic) by the mothers or mother-substitutes in the lower socio-economic classes".

In an extremely detailed study, Bayley[19] uses a revised version of her original mental and motor scales[43, 18] to make comparisons by sex, birth-order, race, geographical location and education of parents. In all, 1409 infants aged between 1 and 15 months were tested across 10 different States. On the basis of the parents' education (compared with the 1960 census) the sample was held to be representative of the whole United States. Approximately 55% of the infants were white and 42% black.

No differences could be found between any variables apart from consistently higher scoring on the motor scale by the negro babies. In no items on the motor scale did whites surpass blacks by as much as 0,5 months. On the other hand, blacks surpassed whites by more than 0,7 months on 11 of the 60 motor items. These included indicators of midline arm and hand-use (2 items), antigravity control (4 items) and locomotion (5 items). Bayley could find no clear explanation for this motor advantage.

She postulated a genetic factor and a generally high muscle tone in addition to the relative lack of restriction on black infants as noted by previous workers.

Two years after Bayley's article, Walters stated: "The paucity of recent investigations, conflicting results of other studies and their lack of statistical treatment and proper controls, and the age-old controversy of the superiority of the races make a comparative study of Negro and white development a vital area of research." (Walters,[32]). In the 17 years since this statement was made, not one truly comparative study has been published. Walters' own study was carefully designed to control as many variables as possible. In her own words: "The hypothesis was that, when influencing variables were controlled, there would be no differences between Negro and white infant development". Unfortunately her samples were small (51 black and 57 white) and were only tested at three age-levels (12, 24 and 36 weeks), but the two groups were carefully controlled, especially for socio-economic background, weight and height. Each sample was divided into high and low socio-economic groups.

The babies were tested on the Gesell schedules. In the two high socio-economic groups the negro group was found to be significantly advanced in total development and in personal-social behaviour at 24 weeks. The high socio-economic negro group was also superior to both low socio-economic groups, the greatest difference being between the two negro groups. Overall, the total negro samples showed higher mean scores than the white sample for all test areas at 12 weeks but not thereafter. The only significant difference between the two low socio-economic groups was that the white group performed better in adaptive behaviour at 24 weeks. Although the groups had appeared well-matched for all variables, Walters concluded that racial characteristics probably did not account for these differences. She felt that the marked superiority of the high socio-economic negro group was probably attributable to those very characteristics which had enabled the parents to achieve such high status in spite of relatively adverse conditions.

The most important comparative study, that of Frankenburg et al[44], contrasted the developmental status of 1189 children from a cross-section of Denver's ethnic and occupational groups with that of 1055 children whose parents were unskilled workers. In the second group there were approximately equal numbers of white, black and "Spanish surname" children. The Denver Developmental Screening Test was used to assess the children, who ranged in age from 2 weeks to 6,4 years.

The only comparison between black and white infants was made within the sample from unskilled families and showed few significant differences. The black group was advanced on five items of early development whereas the white group was advanced on five items occuring after the first two and a half years of life. The differences were more marked between the black and Spanish surname infants, with the blacks excelling at 13 items (all but one appearing at less than 16 months of age) and the Spanish surname infants excelling at only four, occurring between 20 months and 4,7 years. All differences were significant at the $p < 0,05$ level and six items favouring blacks were significant at the $p < 0,01$ level. Within the unskilled sample, therefore, black infants appeared to be more advanced in early development, particularly in gross and fine motor-adaptive items.

Comparison of 910 white children from the initial "cross-sectional " sample with the 349 white children from the "unskilled" sample showed that, in general, infants from the unskilled sample scored higher in early items (mostly for age-levels under 20 months) whereas children from the cross-sectional sample scored better later on. There were significant differences ($p < 0,05$) for 23 items in favour of the unskilled group and for 16 items in favour of the cross-sectional group.

The six comparative studies of American black (negro) and white children are summarized in Table 3. One of these studies shows white babies to be more advanced, but disregards the poor nutritional status of the black babies in that particular sample. Four studies show black (negro) infants to be more advanced, particularly during early development. One study was equivocal. Of the four studies showing advanced development in black infants, two showed infants from better socio-economic backgrounds to be more advanced in early development, whereas one showed infants from poorer socio-economic backgrounds to be more advanced.

TABLE 3 - COMPARATIVE STUDIES OF AMERICAN BLACK (NEGRO) AND WHITE INFANTS

Date published	Authors	Black	White	Test	Ages tested	Comparable variables	Non-comparable variables	Conclusion
1931	McGraw	60	68	Vienna baby	Monthly intervals from 2-11 months	Both groups recorded as being amongst the better educated in the community	Black babies considerably lower in both birth weight and weight at time of testing	White advance over black at all age levels except 4 months
1946	Pasamanick (Also Knobloch and Pasamanick 1953)	53	99	Gesell	Two only - 16/52 and at 40/52	Relatively good socio-economic levels both groups. Good nutrition both groups.	Housing Three widely differing white groups: environmental deprivation one group; another group fostered. High incidence perinatal complications amongst black (42%)	No overall differences Blacks consistently advanced on gross motor development, maintained over 2 years. Girls more advanced than boys. Poor housing (blacks) and institutionalization (whites) retards devel. Heavier children advanced.
1955	Scott, Ferguson Jenkins and Cutter (Aldrich and Norval, 1946)	708 (but only 250 for each 12 items tested)	(215)	12 items (mainly motor)	Monthly intervals (not all subjects at each monthly interval)	Black group from P.P. considered comparable with white group	Blacks from two widely-differing socio-economic backgrounds; whites from different state and several years earlier	Black sample advanced overall; blacks from poor socio-economic background advanced over other black group from 8th - 35th week, thereafter similar
1965	Bayley	Approx. 42% of 1 409	Approx. 55% Of 1 409	Bayley (revised)	Monthly intervals from 1-15 months	Not documented between groups - entire group comparable to findings 1960 census	Black parents had fewer years of education. Other factors not docuemnted	Blacks scored consistently higher on motor scale
1967	Walters	51	57	Gesell	3 only - 12/52, 24/52 and 36/52	Groups well-matched on all major factors	-	Blacks overall significantly advanced in total behaviour at 12/52 and motor behaviour 24/52. Black high socio-economic group most advanced; black low socio-economic group least advanced.
1975	Frankenburg, Dick and Carland	352	349 ("Anglo")	D.D.S.T.	Cross sectional testing from 2 weeks to 6,4 years	Fathers in both groups classified as unskilled workers	Not recorded	Little significant difference - blacks more advanced on a few early items, whites on a few later items.

A comparative study by Pollak & Mitchell[45] has not been included in the above chart since the study was performed in England. They examined 25 black West Indian, 25 Cypriot and 25 white babies at 1, 3 and 9 months of age, using Gesell[25] and Sheridan[46,47] scales. All babies attended the same general practice and their fathers were in social classes IV and V. They found the West Indian babies to be highly significantly advanced in gross motor development at one month of age, in both postural control and in hand-opening. This advance had, however, disappeared by 3 months and did not reappear. The social behaviour of the white and Cypriot infants was superior throughout and these two groups were also advanced in language and adaptive development by nine months of age. They considered that the early motor development of the black infants was possibly due to ethnic differences, but felt that their lower achievement in language and adaptive items might be due to lack of stimulation.

1.2.2 Non-comparative studies

Curti et al[48] applied the Gesell schedules to one-, two- and three-year old black Jamaican children. They tested 26 infants at 12 months, 21 at 24 months and 21 at 36 months. Although these infants stood and walked earlier than the Gesell norms, their overall performance was poor, with only 39% scoring higher than the Gesell norms at 12 months, 10% at 24 months and 38% at 36 months. Their poor developmental progress was ascribed partly to the very poor socio-economic conditions and levels of nutrition which were prevalent at the time, but also to the unsuitability of man of the Gesell test items. Most of the children showed a considerable scatter of abilities and the authors concluded that the Gesell schedules were not a valid indication of the "intelligence" of Jamaican negro infants.

Williams and Scott[49] postulated that early motor development is not a racial characteristic but is related to the way in which the infant is handled and cared for. On the premise that child-rearing practices varied with social class, they selected 54 babies from infants seen in private practice and 50 babies from infants seen at hospital or district clinics. The weekly income of the parents of the former group was £45,00 or above. Apart from income, the two groups also contrasted strongly as regards occupation, education and housing conditions. The mean birth-weight for the higher socio-economic group was 209g heavier than that for the lower socio-economic group. The infants ranged in age from 4 to 18 months at the time of the first examination, 91 of the original 104 babies being seen for a second assessment between three and six months after the first one. The first assessment, made in a clinic setting, covered (after an initial interview) the gross motor items on the Gesell schedules. The second assessment was made in the baby's home setting and consisted of a detailed interview with the mother followed by observation of mother/child interaction.

The original Gesell record forms for the gross motor items were also scored by two independent examiners, and the developmental quotient was computed according to the usual Gesell formula.

The results showed a significantly higher rate of motor development for the babies in the lower socio-economic group, the difference applying to both younger and older infants. Despite this, the child-rearing practices which showed a significant correlation with the level of motor development were, with one exception, not significantly correlated with the socio-economic rating. Table 4 summarizes the findings:

TABLE 4 - INFLUENCE OF CHILD-REARING PRACTICES, DERIVED FROM WILLIAMS AND SCOTT[49]

Child-rearing practice	S-E group	Significance level	Motor devel.	Significance level
Flexible feeding schedule	low	.03	-	-
Prolonged breast-feeding	low	>.05	-	-
Flexible sleep routine	low	.01	-	-
Discipline only when needed	low	.019	-	-
Little mechanical restriction	low	.01	-	-
Reaching out/inter-play encouraged	low	.016	enhanced	.05
Permissiveness	-	-	enhanced	.05
No restriction play area	-	-	enhanced	.05
Left to develop at own rate	-	-	enhanced	.01

Although there were no other statistically significant correlations, the trend towards greater permissiveness and flexibility and fewer restrictive practices, noted in the lower socio-economic group, appeared to foster those attitudes which encouraged gross motor development.

14 Items from the Gesell gross motor schedule together with 2 language items were used in a longitudinal study by Grantham-McGregor and Back[50] to assess 252 black Jamaican infants at ages 6 weeks, 3 months, 4 months, 5 months, 6 months, 8 months, 10 months and 12 months. Between 230 and 244 infants were assessed at each age-level. The majority of the infants came from poor socio-economic backgrounds and unsettled families. They were stratified for birth-weight into two groups - those with birth-weights of over 2,5 kg and those under 2,5 kg. The total sample was significantly advanced in comparison with the Gesell norms for gross motor behaviour and, on the 2 items tested, were at least equal as regards language development. The age at which walking commenced was earlier than those ages given by Hindley _et al_[51] in their study of infants from five different European countries.

The infants with birth-weights of less than 2,5 kg were significantly slower than the heavier infants in achieving 11 of the 16 items (10 of them gross motor), but were equal to the Gesell norms. It was also noted that, of all the babies walking by 12 months, significantly more had a weight above the 50th percentile at the time of testing. The overall nutritional status of the whole sample was felt to be relatively poor, the 50th percentile falling below the 25th percentile for North American infants at 12 months.

In a further study concerning the same sample[52], full developmental assessments using the Gesell schedules were given to 66 of the infants at one year of age. Sixty-two of the infants were negro. There were approximately equal numbers of male and female infants and the mean weights at the time of assessment were 9,9 kg for boys and 9,4 kg for girls. Although the sample was divided into 2 socio-economic groups, the higher socio-economic group were lower middle or working class and the division was made largely arbitrarily on the grounds of the standard of housing, the higher socio-economic group living in "above-average" housing consisting of a housing unit with an inside bathroon and kitchen and not more than 3 people per room. The whole sample was more advanced than the Gesell norms, particularly in gross motor behaviour. Females also excelled over males in most items of gross motor behaviour. A further observation was that first-born infants were slightly more advanced than later-born infants in all areas of development, again consistently so in gross motor behaviour ($p < 0,05$). The infants in the higher socio-economic group performed better than those in the lower socio-economic group in both language and fine motor behaviour ($p < 0,01$ and $p < 0,05$ respectively). Once again, heavier infants performed better although the overall means are again low compared with the percentiles for North American children.

In these 4 studies which compare negro infants with Gesell's norms for white babies, one study(48) found that black Jamaican infants did not perform as well as white infants except in standing and walking. Curti pointed out, however, the extremely poor socio-economic conditions and nutritional levels prevailing at the time of her study. The remaining three studies show negro infants to be advanced in developmental behaviour, particularly in gross motor development. Favourable circumstances for an advanced rate of development appear to be adequate nutrition (as reflected in the heavier babies) and the more permissive practices observed in the lower socio-economic groups. In the one study in which infants in a "higher" socio-economic group excelled(52) the division was arbitrary and the infants in this group may well merely have enjoyed better nutrition.

1.3 STUDIES IN OTHER COUNTRIES

For the purpose of this survey, studies carried out in other countries have been divided into two sections, those utilizing the Denver Developmental Screening Test and those utilizing other scales of infant development. The latter will be discussed first, since the former will form an introduction to the choice of the Denver Developmental Screening Test for the present study.

1.3.1 Studies from other countries (excluding the use of the D.D.S.T.)

These will be discussed under the country in which the study was performed.

Western Europe

Only one study could be traced which used standardized scales other than the D.D.S.T., that of Francis-Williams and Yule(53) who used the revised Bayley Infant Scales(19) in an exploratory study with 300 English infants drawn from various industrial cities and the so-called home counties, i.e. the counties around London. 10 Male and 10 female infants were tested at monthly intervals from age 1 to 15 months. They found the performance of this sample to be virtually identical with that of Bayley's infants, the only possibly significant differences being that the American sample tended to excel over the English sample in development from prone, whereas the English sample was quicker to achieve hand-use in the midline in supine. This observation was also made by Holt(54) in a study of posturally-induced variations in early motor development, and will be discussed in more detail in Chapter 5. No differences related to sex or to socio-economic status were noted, but only children performed better on the mental scale than those with siblings.

Neligan and Prudham(55) report on an attempt to establish valid norms for four basic milestones in over 3000 infants born in an industrial English city during 1961. The milestones were sitting unsupported, walking unsupported, single words and sentences, and were carefully defined. The date of acquisition of each milestone was, however, only checked retrospectively by the health visitor from the mother's report, although the health visitor would confirm at her visit that the milestone was indeed present. Results were expressed in terms of percentiles, the 50th percentile for each milestone being achieved as shown in Table 5. When compared with the Denver percentiles (Frankenburg and Dodds[56]), these results show that this particular sample is rather slower on the acquisition of the two gross motor items, but possibly slightly advanced in the acquisition of the two language items.

TABLE 5 : NORMS FOR 4 BASIC MILESTONES IN AN ENGLISH SAMPLE (NELIGAN AND PRUDHAM,[55]).

Item	Neligan and Prudham	D.D.S.T.
Sitting unsupported	6,4 months	5,5 months
Walking unsupported	12,8 months	12,1 months
Single words - females	12,3 months	12,8 months
- males	12,4 months	
Sentences - females	22,9 months	-
- males	23,8 months	

The most striking feature of the distribution for each item was the marked skewing which resulted in the age difference between the 50th and 97th percentiles being almost double that between the 3rd and 50th percentiles. This skewing is also evident in the Denver Developmental Screening Test[56]. Apart from the sex differences as regards language, the only other significant findings were that children from the lower socio-economic classes walked earlier ($p<0{,}001$) and that first-born children spoke sentences earlier ($p<0{,}001$ for boys and $<0{,}01$ for girls).

In a follow-up article Neligan and Prudham[55] showed that the use of 3 of the 4 milestones (excluding single words) could be predictive in identifying retarded development. Advanced development could not be predicted accurately due to the skewness of the cumulative percentile distributions.

On the European continent, the most detailed and meticulous study is that of Touwen[57] who studied a carefully selected group of 50 Dutch infants at 4-weekly intervals from 2 weeks of age until they walked unsupported. In particular he wished to address two unanswered questions:

1. Does the development of a specific motor ability mean that it will always be present in that child from then onwards, or may the child still revert to a former motor behaviour under normal conditions?

2. What is the inter-relationship between the different motor phenomena throughout their developmental course?

His findings in this respect are discussed in Chapters 2 and 5. Only some of the results of the study are discussed here, being those related to locomotión in prone, sitting up, sitting unsupported, walking unsupported and voluntary grasp.

Of the 50 infants, 27 were boys and 23 girls. They were all born to Dutch social class II (parents being scientists, physicians, teachers, etc.) and were at low risk as defined by Prechtl's optimality concept[58].

Development through the stages of locomotion in prone showed considerable variation, with not all the infants performing all stages in the normal course of development. There was, however, a close correlation between the acquisition of mature crawling (on hands and knees) and the acquisition of walking unsupported. Active participation in sitting up also showed wide variations, but again there was a highly significant correlation between the age of sitting up without help and the age of walking unsupported. Touwen compared his results with those of Neligan and Prudham[55] and found that the dates of acquisition of sitting unsupported and walking unsupported by the Dutch children were considerably delayed. Dutch girl infants also walked later than Dutch boy infants. It was felt that this difference might in part be due to methodological differences in the treatment of the data, but Hindley's analysis of longitudinal studies of five European samples[51,59] also showed very significant differences between countries in the ages of acquisition of walking unsupported. Infants in Stockholm and Brussels walked considerably earlier than those in London, Paris and Zurich ($p < 0,001$). Hindley's studies showed no difference by social class.

Eastern Europe and the Middle East

Pikler[60] studied 736 infants in an institution in Budapest. Her study is interesting in that although the infants were unrestricted as regards space, clothing and availability of toys they were never placed in any other position than supine and did not have toys put into their hands or hung within reach. They thus did not experience the prone position until they were able to roll from supine to prone, and did not experience sitting until they were able to attain the sitting position unaided. The author compares the ages at which certain milestones occurred with the ages at which these were noted by other workers. She claims that the Budapest infants were not delayed in the achievement of these milestones but this would not appear to be a true representation. Those items appearing in at least 5 of the developmental scales quoted by Pikler are shown in Table 6.

TABLE 6 : COMPARISON OF MOTOR DEVELOPMENT ADAPTED FROM PIKLER[60]

Item	Mean ages of attainment in weeks						
	Pikler	Brunet-Lezine	Bühler	Gesell	Illing-worth	Schmidt-Kolmer	Schelo-vanov
Supine to prone	25	32		24	28	21	18
Crawls*	46		39	40	44	28	30
Sits up from prone	47		47	44	40	32	33
Stands up alone	51	41	47	40	36	49	41
Starts walking	70	62	69	65	56	58	49

In Israel, Kohen-Raz[61] studied 361 infants aged between 1 and 27 months, raised either in a Kibbutz or in an institution or in their own home. He found that both the Kibbutz and home-reared infants equalled Bayley's[62] norms for white American infants on the motor scale and exceeded them on the mental scale. The institutionalized infants were significantly retarded on both mental and motor scales. Among the motor items, eye-hand

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*Creeps on hands and knees or hands and feet on level ground.

co-ordination and walking showed less cross-cultural and intra-cultural variation than equilibrium and fine motor co-ordination.

In a study of rather doubtful design, Özelli[63] used the Bayley[31] scales on a small Turkish sample of 90 infants, testing at 3, 6, 9 and 12 months only. He concluded that the rate of development of his sample was equivalent to the United States norms and found no differences between infants of rural and urban background.

India

The 1970's saw a proliferation of studies on the development of Indian infants, not all of the same quality. The earliest study of those which could be traced is that of Phatak[64] who studies 278 infants longitudinally from the age of 1 to 30 months, using Bayley's[62] scales. The infants were of upper middle-class and/or educated parents. The ages at which 50% of the babies tested achieved a specific item were computed and compared with the Bayley norms. The Indian babies achieved about 46% of the items on the motor scale and 38% of those on the mental scale earlier by 15 or more days than the American sample. 7% of the motor items and 10% of the mental items were attained 15 days or more later than the American sample. In a rather more in-depth longitudinal study of 219 children between 1 and 30 months, the infants were classified by nine workers as accelerated, average or retarded in development. The 23 accelerated and 20 retarded babies were analysed in relation to several independent variables, but only the educational level of the parents was found to correlate significantly (and positively) with the rate of development, and then only after 8 months of age (Phatak [65]).

Kandoth et al[66] conducted a cross-sectional study of 700 Indian children from birth to 5 years of age, using the Gesell schedules. Their sample was mainly from the lowermost socio-economic group (59%), with 61% of the fathers' being unskilled labourers and 68% of the mothers' being illiterate. The 50th percentile for weight and height of the sample corresponded to the 25th percentile of the national standard (Indian Council for Medical Research, 1969), and to less than the 3rd percentile of the American standard. In scoring the Gesell items, they recorded the ages at which 25%, 50%, 75% and 90% of the children achieved each behaviour, rather than working out the developmental quotients. For this reason they compare their results with the Denver norms (Frankenburg and Dodds,[56]) rather than with the Gesell norms, but in their comparisons they only use the 25th and 90th percentiles. From these they conclude that their sample compares well as regards motor and personal-social behaviours but shows definite delays in adaptive and language functions, which they attribute to illiteracy and poor social conditions. On closer analysis there are discrepancies in the data given in their different tables and comparison with the Denver norms shows delays of over one month on most of the comparable items on the motor and personal-social scales at each of the 25th, 50th, 75th and 90th percentiles. Frankenburg and Dodds[56] considered that a difference of one month in the age of attainment of any test item in the first year at the 50th and 90th percentile should be regarded as noteworthy.

Das and Sharma[67] conducted a longitudinal study of 100 infants from an upper socio-economic group from birth to 5 years. They selected 10 motor, 7 adaptive, 8 language and 6 social behaviours, not all of which were well-defined. The mean ages of attainment were listed in months and the medians are not given. The authors state that their study supports the superiority of Indian over western infants in all four areas of development, but do not give comparative data. It is difficult to make accurate comparisons with standardized tests since the data is insufficient, but by comparison with the Denver norms it would appear that the Indian infants are slower on all motor items except the first one, the difference increasing directly with age. A similar position exists for the adaptive and social items; the language items cannot be compared as they are so dissimilar. The authors also aver that boys were significantly ahead in motor development after the age of three years, but fail to point out that they only tested two items after three years of age. On the other hand they aver that the girls' better performance on language and social items is statistically insignificant, although the girls were advanced over the boys on 7 of the 8 language items by differences of between 1,8 months and 4 months.

Purohit et al[68] performed a longitudinal study of 199 infants from birth until 6 months of age, checking for the appearance of five items normally attained in the first 3 months, 5 normally attained between 3 and 6 months and 5 normally attained between 6 and 9 months. In the first quarter their babies performed similarly to the Illingworth norms[69] but in the second quarter 62,5% of the babies were considered to be advanced. There is no statistical analysis. Development during the first quarter appeared to be favourably influenced by higher socio-economic levels and better maternal education. Development throughout was positively related to higher weights at birth and at the time of testing.

The most recent Indian studies are those of Bhandari and Ghosh[70,71]. In a longitudinal study of gross motor development only they followed 123 urban infants from birth to one year of age, using 30 tests from the Illingworth schedule[72]. In contrast to Purohit they found that their sample of Indian infants were advanced in the first three months of life but lagged behind thereafter. When developmental quotients were calculated at the age of one year according to the Gesell formula, 69,91% scored developmental quotients of 90 or above whilst 30,09% scored less than 90. Only 13,01% had a developmental quotient of 110 or above. When compared with the Denver percentiles, the Indian sample lags behind in the performance of most test items at the 25th and 50th percentiles but performed better at the 90th percentile. At one year there was no statistical difference between the sexes, although there had been a significant difference in favour of the boys ($p < 0{,}001$) on some of the earlier items[70].

Bhandari and Ghosh[71] analyse their sample's performance in relation to socio-economic factors. In this study fine motor-adaptive, personal-social and language-speech performance were also assessed on the Illingworth[72] schedules. They found that gross motor, personal-social and language-speech behaviours were enhanced when the father's occupation was skilled work, business or clerical work, whereas the level of maternal education enhanced adaptive and personal-social development. The development of children in the higher income groups was significantly better in the adaptive, personal-social and language-speech areas ($p < 0{,}001$); it was also better in the gross motor area but this was not significant. Gross motor, adaptive and language-speech development was advanced in first-born children, and the authors ascribe this to the better nutritional status of the first-born child in the low-income groups.

These two studies by Bhandari and Ghosh(70,71) are the most meticulously designed and best documented of the Indian studies and their results would appear to carry the most weight. Their findings in relation to socio-economic background and nutritional status support those of Purohit. In this respect it is interesting to note that the 50th percentile for weight in Indian children falls below the 10th percentile on the American standards (Indian Council for Medical Research, 1968), so that the nutritional status of many Indian babies may be low. This relationship between socio-economic background and nutritional status is the most probable reason for the discrepancies in the results of the various Indian studies.

American continent and islands

Smith *et al*(73), in an early study criticized by later workers, studied the age at which walking was achieved by 727 Hawaiian children (of seven races) and compared this with that for three groups of United States children.* Walking was defined as the "first step alone" - a definition open to misinterpretation. Apart from the Haoles in the Hawaiian sample, the other Hawaiian children were of a much lower socio-economic group than the three United States samples. The quite large group of 565 Californian children were all classified as gifted (I.Q. $\leq$ 140 on the Stanford-Binet scale). Records of the age of walking were derived retrospectively, by questionnaire or from clinic records, and not by direct observation. The median age of walking, excluding a few atypically late walkers, was 12,71 months, with a mean of 13,25 months. This was similar to that of the gifted Californian children (median 12,79 mean 12,94) and considerably earlier than the other two United States samples (median 13,54). Children of the Haole group walked earliest (median 12,06);

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*Two of these groups were the subjects of study by previous workers(74,75).

those of Portuguese origin latest (median 13,00). This latter value is deceptive though, caused by the inappropriately late walking of Portuguese boys (median 14,17) as compared with Portuguese girls (median 12,53). In all racial groups girls walked earlier than boys by approximately two weeks. Calculating the mean difference between racial groups of the same sex as 0,44 and the probable error of random difference as 0,46, the authors concluded that there was not a significant difference between racial groups.

In order to exclude differences in socio-economic background only the Haole group of Hawaiian children were compared with two of the United States groups - those from Iowa and from California. The Haole children walked approximately 6 weeks earlier than the Iowa children, with the Californian children falling almost midway inbetween. The authors concluded that these differences were due to climate, children from warmer climes being less restricted by clothing. They postulated relationships between annual temperature, sunlight and growth. They also conceded differences by socio-economic background and intellectual level.

Hindley[76], in a reappraisal of the Smith et al data, criticized reliance on the mother's long-term recall of the date of walking for the Haole group, and felt that they should be excluded from comparisons. He also criticized the use of medians to establish differences. Hindley utilized the logarithmic translation of ages of onset used in his own study[51] to render a more normal distribution, and then subjected the data to an analysis of variance technique. With the Haole group excluded, Hindley's results agreed with those of Smith et al which failed to show any significant racial differences. With the Haole group included, however, (as in the original study) this method of re-working the data did show significant racial differences in favour of the Haoles. The differences between sexes, again excluding the Haoles, became highly significant ($p < 0,001$). On the basis of his own study[51], and that of Dennis and Dennis[77], Hindley rejected the hypothesis that children from warmer climates walked earlier.

In another study, Peatman and Higgons[78] evaluated the development of sitting, standing and walking in 349 infants in the New York City area, all considered to have optimal paediatric and home care. All observations were made by the paediatrician himself in the course of his routine care, so that not all children were seen at each age-level and the study combines cross-sectional and longitudinal observations. Sitting, standing and walking were carefully defined and walking required the child to stand up and walk at least 6 feet unaided. The mean ages of attainment were found to be 7,1 months, 10,9 months and 14,5 months respectively. Even in 1940, therefore, American infants were performing in advance of the Gesell schedules[79]. The authors considered that the accelerated development of their sample was due to good socio-economic conditions and superior paediatric care. They commented on the skewness of the distribution curves and found that all three milestones occurred earlier in girls than in boys.

A rather different study was that of Brazelton et al[80], who studied Zinacanteco Indian infants in Southern Mexico. The study was a three-part one, firstly looking at the newborn at birth and during the first week, secondly looking at mother-child interaction in the first nine months and thirdly studying developmental milestones during the first year. The study is reported in fine detail. The 5 newborns examined were scored on 43 items over 5 areas - spontaneous movement, elicited responses, passive movement, sensory responses and general assessment. They found a striking sensory alertness in the newborn period, coupled with quiet, non-tremulous motor behaviour. The low level of spontaneous movement and elicited responses persisted throughout the first week, being furthermore restricted by the type of swaddling used. The birth-weight of all the newborns is recorded as being under 5,0 lb., well below the United States median. Mother-child interaction in the first nine months was, with the exception of frequent breast-feeding, very limited in comparison to United States practice. Young infants spent most of their time with their faces covered, either swaddled beside the resting mother for the first month or covered by a shawl on the mother's back. Despite the swaddling effect of the abdominal binder and shawl, and the fact that the infants were not placed on the floor to play, their gross and fine motor development proceeded along normal lines, although they lagged consistently one month behind the United States norms as measured by the Bayley scales[19] and by the Knobloch-Pasamanick adaptation of the Gesell schedules[40]. Difficulties were experienced in administering the two chosen scales and a plea was made for the development of infant scales more applicable to cross-cultural research.

Of the six publications by Solomons and Solomons[81,82] or by Solomons H.C.[83,84,85,86], all but one refer to the same study, the date of which is not clear but would appear to be between 1972 and 1974. The subjects of the study were 288 Yucatecan infants. Like the Zinacantecos, the Yucatecans are descendents of the Mayan civilization, but are rather less isolated than the highland Zinacantecos and have a much greater socio-economic range. The infants were assessed on both the Bayley Motor Scale[31] and the Denver Development Screening Test[87]. The study was cross-sectional, 8 infants (4 boys and 4 girls) being assessed at each monthly interval from 2 weeks to 54 weeks. The sample was divided into three socio-economic groups (equal in size) on the basis of the type of health-care facility used.

The Bayley scores were subjected to analysis of variance and showed no differences by sex or socio-economic group. When compared to the United States norms[31] the Yucatecan infants were significantly advanced at 3 months ($p<0{,}01$) and at 4, 5, 6 and 8 months ($p<0{,}001$), the greatest degree of advancement being seen in the fine motor items. They levelled out at 10 months and by 12 months were delayed in comparison ($p<0{,}001$). Walking showed the greatest delay, although the 50% pass is perhaps misleading when it is remembered that only 8 infants were tested at each age-level. One infant walked at 8 months, 2 more at ten months, 1 more at 11 months and 5 of the 8 at 12 months. The Bayley norm is 11,00 months. The results according to the Denver Development Screening Test will be discussed in section 2.3.2.

Differences in child-rearing practices were considered to be the main factors responsible for the observed differences[82,83]. Infant toys were lacking, with the result that the babies appeared to discover their hands earlier and establish good eye-hand co-ordination. On the other hand, Yucatecan infants are rarely placed on the floor and, when they are, there is very little furniture on which they could pull themselves to standing, since the Yucatecans sleep in hammocks and the poorer families do not have chairs and tables.

Werner[88] summarized the findings of 50 cross-cultural studies covering infants in five continents. Most of these have been surveyed in the present study, either in this chapter or in chapter 5. She reached the following conclusions:

1. African infants showed the greatest early acceleration and Caucasian infants the least, with Latin American and Asian infants falling inbetween.
2. Within each group, "traditionally reared" rural infants showed greater acceleration than urban, "westernized" infants. This advanced motor behaviour lasted until weaning, after which a decline in language and adaptive behaviour occurred in the rural group.
3. In all groups, infants with a higher birth-weight showed more advanced behaviour.

Her first conclusion may be regarded as probable, but not yet proven because of the differences in both design and interpretation already discussed in this chapter. With regard to the second conclusion, different studies have rendered conflicting evidence and it seems likely that differences may prove to be due to nutrition or to child-rearing practice. The third and last conclusion can, on the basis of all the studies analysed so far, be regarded as valid.

The already standardized and well-known developmental studies which are accepted worldwide as developmental norms have not been surveyed in this chapter. They include the Bayley Infant Scales of Development[43, 18, 19, 31], the Gesell Developmental Schedules[79,25,40], the Griffiths Developmental Scale[29] and the Denver Developmental Screening Test[56,87,89].

1.3.2. Normative studies using the Denver Developmental Screening Test (D.D.S.T.)

Several meticulously designed studies have standardized the D.D.S.T. for use with other populations. Bryant et al[90] studied 668 infants in Cardiff, Wales (U.K.) between the ages of 2 weeks and 12 months. As with the Denver study, adopted children, twins and those with obvious handicaps were excluded, but the Cardiff study included pre-term and breech deliveries unless there was definite evidence of abnormality. The sample was drawn from babies born in 1970 and 1971. They took cognisance of sex, social class, parity, birth-weight and gestational age and felt that their sample was fairly representative of the Cardiff population as a whole. There was a slight bias towards the higher social classes, whereas illegitimate children, low birth-weight babies and premature babies were felt to be underrepresented. In analysing the results, the number of infants in each ten-day interval who passed each item was tabulated, and then fitted by regression with a logistic model. This provided estimates of the ages at which 25%, 50%, 75% and 90% of the subjects passed each test, and it was found that these percentiles compared realistically with the tabulated proportion of babies passing at each age. The ages at which 50% and 90% of the babies passed each test item were compared with the Denver norms.

The Cardiff infants appeared to be slightly slower than the Denver sample in gross motor function, being more than one month delayed on 5 items on the gross motor scale at the 50th percentile. On the other hand, this difference was only maintained on 2 items at the 90th percentile. One of these - "rolls over" - is an item which the present writer has observed to produce the greatest discrepancies in studies by various workers and its interpretation must be open to query (see Chapter 5). The other item in which the delay was maintained at the 90th percentile was the item "stands holding on". This is of interest in view of the fact that a related item - "bears some weight on legs" - was the only item on the gross motor scale achieved more than one month earlier by the Cardiff infants at both the 50th and the 90th percentile. The authors could not explain these findings.

All personal-social items were performed earlier by Cardiff infants at both the 50th and 90th percentile, although only 4 items at each level occurred earlier by more than one month. Language items show a similar trend, all items being passed earlier although with fewer items by more than one month. In the fine motor-adaptive field the Cardiff and Denver infants performed about equally, the only noteworthy delay being in the Cardiff infants' ability to pass a cube hand to hand.

In a separate article, Bryant and Davies[(91)] investigated the effect of three of their recorded variables - sex, social class and parity - on the achievement of the test norms. They showed that girls are significantly more advanced than boys at the 50th point, less so at the 90th point. This difference only applied when all areas of function were combined and there were no differences in the individual fields of behaviour. Similarly there was a significant difference on the total data only at both 50% and 90% points in favour of first-born over second-born children. This did not hold for any other comparisons of parity. They found no differences by social class and concluded that this factor was not relevant in the first year of life.

A follow-up study by Bryant et al[(92)] continued standardization of the D.D.S.T. from one to six years of age. Sampling was once again random and proportional to each planned age-group, although inadvertently more children were tested between the ages of 15 and 24 months than originally intended. The bias towards the upper socio-economic groups noted in the original study was avoided. Once again low birth-weight and short gestational age infants were slightly under-represented, but these differences only occurred in the tails of the distribution.

In combining the statistics for this and the previous sample, the authors reworked the original data, using a logarithmic translation of age in order to eliminate skewness of distribution. The greatest difference between Cardiff and Denver children was on the gross motor scale, where the Cardiff children achieved 21 of the 31 items later and only 3 earlier. There were no real differences in fine motor-adaptive function. The advanced language development noticed in the Cardiff infants during the first 12 months continued up to 24 months of age, whereafter the trend reversed for the 50% point but continued for the 90% point. A similar trend was seen with personal-social items, where the noted advancement at the 50% point reversed after 15 months, but continued throughout at the 90% point.

In this study of older children the authors found a striking relationship to social class regarding fine motor-adaptive and language scales from two years of age onwards, the lower socio-economic classes being slower in development. Girls remained slightly in advance of boys in a number of items from all fields, and first-borns showed quicker language development. The statistical significance was not calculated. On the basis of their results the authors have designed a modified recording form for use when testing Cardiff infants and children on the D.D.S.T.

In Canada, Barnes and Stark(93) standardized the D.D.S.T. on a rather small sample from a rural and semirural population. They studied 122 boys and 104 girls between the ages of two weeks and 6,4 years and concluded that the D.D.S.T. was valid for this population, without adaptation. The sample was stratified according to the occupation of the head of the family and, on analysis, the children of professional families (8% of the sample) scored significantly lower than the children of craftsmen (29% of the sample) in all four fields of behaviour ($p < 0,025$ for gross motor and $p < 0,05$ for the other areas). This finding was unexpected and the authors could advance no satisfactory reason. No differences were found by sex, again in contrast to the findings of previous studies.

In a more recent study, Pedneault et al(94) studied 368 3-month old and 371 6-month old French-Canadian babies in the Montreal area. On 4 of the 5 gross motor items at 3 months their infants surpassed either the Denver or Cardiff norms (one item each) or both the Denver and Cardiff norms (2 items). In each case $p < 0,05$. Of the 4 items on the fine motor-adaptive scale at 6 months they surpassed both Denver and Cardiff norms on 1 item, Cardiff only on one item and Denver only on one item, but fell below the Cardiff norm (falling on the Denver norm) in the final item. Again the differences were significant at $p < 0,05$. They found no relationship to sex, social class or parity and suggest that hereditary and cultural factors may influence the rhythm of development in the young infant.

Ueda[95,96] standardized the D.D.S.T. in a cross-sectional study of 1171 Tokyo children. The sample was representative of the Tokyo population as far as father's occupation was concerned, and was evenly distributed throughout the metropolitan area. Probit analysis was used to determine the percentage of children in each age group who had passed each item, and from this the ages for 25%, 50%, 75% and 90% passes were calculated. Differences between the age of passing by Tokyo children (A) and Denver children (B) were calculated by the formula (A-B/A x 100). In the gross motor section it was found that the Tokyo infants lagged behind the Denver children in the first 7 months but not thereafter. All but one of the items in which delay was noted involved development from prone and the delay was ascribed to the fact that Japanese children are never placed in the prone position. Only one item (copying a circle) showed significant delay in the fine motor-adaptive field.

In the language section the Tokyo infants turned to a voice significantly earlier, but 2 of the language items had to be adapted because of poor performance; this discrepancy was ascribed to cultural differences in language expression.

In comparing the Tokyo and Denver samples with a rural sample of 615 children from Okinawa, Ueda[96] found the Okinawa infants to be advanced over the Tokyo infants in 6 gross motor items in the first year, 3 at the 1% level and 3 at the 5% level of significance. In other areas during the first year there was little difference, but they were delayed in comparison to the Tokyo infants in all four areas of development after one year of age. In comparison with the Denver sample, the Okinawa infants were delayed in all 4 sectors, most noticeably so in the gross motor and language sectors.

The differences between the Okinawa and Tokyo samples were ascribed to the warmer climate in Okinawa, resulting in lighter clothing which might favour gross motor development, as well as to differences in socio-economic background favouring the earlier development of the Okinawa infants.

Two articles on the use of the D.D.S.T. with Ankara children have appeared recently. Yalaz and Epir[97] report on a well-designed and recorded study primarily intended to standardize the D.D.S.T. for use with urban Turkish children. A total of 1176 children were tested, with approximately equal numbers of each sex. Inadvertently four age-groups were over-represented - one, eight, eighteen and 30 months. The sample was not considered to be representative of the population as a whole since the selection had been planned to ensure that the educational and socio-economic background was similar for each child included in the study. Only one fine motor item and three gross motor items differed significantly from the Denver norms, but these were discounted as the differences lay mostly at the extreme ends of the curves. One item, pulls-to-stand, was discarded because there was a discrepancy of five months between the ages at which 25% and 90% of the children acquired this ability. The rationale for this is not quite clear because other Denver norms at a similar level have an equal or greater range.

Epir and Yalaz[98] give a further analysis of the above study in terms of sex and social class differences. There were no consistent gross or fine motor differences by sex. Although the differences in social class were small throughout the sample, the more advantaged children showed a consistently better performance after 10 months of age, particularly in language and fine motor items; this difference increased with increasing age. As a result of these differences the authors queried the validity of the D.D.S.T. for lower class Turkish children.

The study of Solomons and Solomons[82] on Yucatecan infants has already been mentioned, as well as the series of articles arising from the original study. Solomons[86] elaborates on the performance of the original 288 babies on the D.D.S.T., but deviates from the normal D.D.S.T. scoring procedure in that she only records the number of items passed by each child on each sub-test. However, age norms for individual items were derived by probit analysis. At the 50% pass point Yucatecan infants were advanced in comparison to both Cardiff and Tokyo infants on most of the items in the gross motor scale, and they performed similar to the Denver infants in the first year - being advanced on some of the earlier items but delayed towards the end of the first year. Similar results were obtained with fine motor-adaptive behaviour. There were few consistent differences on the personal-social and language scales. No differences were found by sex and only in the language sub-test did the higher socio-economic classes score higher[85].

1.4 CONSIDERATION OF THE D.D.S.T. FOR USE IN THE PRESENT STUDY

Previous studies of child development in African countries have used various established scales of motor and mental performance. These include the Gesell Developmental Schedules[79,99], the Bayley Infant Scales of Development[31] and the Griffith Developmental Scale[29]. Studies utilizing tests which are more related to mental performance only, or to specific aspects of non-motor performance (e.g. language development) are not discussed here. A few workers have used simple observation[4] or have developed their own test items[23,24].

The Denver Developmental Screening Test does not appear to have been used in any studies of motor development on the African continent although it has been used extensively in normative studies in other countries, including Great Britain[90,91,92], Canada[93,94], Japan[95,96], Mexico[85,86] and Turkey[97,98].

The Bayley Infant Scales of Development and the Griffith Developmental Scale may only be used by qualified psychologists and could not be considered for use in this study. In studies prior to 1971 the Gesell schedules appear to have been the most popular test norms for use with African populations. The Gesell schedules were used by Theunissen[1], Geber and Dean[8,9], Geber[7], Vouilloux[14], and Faladé[6]. Items based upon the Gesell schedules were used by Liddicoat[23,24]. Griffiths[21,22] also reported on the use of Liddicoat's items.*

In more recent years there has been criticism of the use of the Gesell motor schedules. Doudlah[101] points out that Gesell's original study was conducted in 1927 and consisted of a one-year follow-up of only five infants, which was considered by Gesell to be an "intensive longitudinal study". No information is available concerning the sampling procedure nor the selection of test items.

The infant's spontaneous behaviour was limited by positioning, by restraints and by manipulation of the environment by the examiner.

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*Liddicoat performed the tests of motor items for Griffiths' study.

Gesell's primary objective was, however, to study patterns of mental growth, and at the time of his study such manipulation was considered acceptable, as is shown all too clearly by Dennis' work[141]. The norms for the eventual Gesell schedules were determined from the performance of only 107 children[79] and have not been restandardized since first being published in 1938. In this respect it is noteworthy that Bayley deemed it necessary to revise her original (1935) test because of the acceleration of today's infants in gross motor, personal and social development[31, 142].

Warren[3] criticized the use of open-ended developmental quotient ranges in the interpretation of findings when using the Gesell schedules, and Cobb[11] criticized calculation of the developmental quotient on age from birth; he considered that the use of age from conception would give a more realistic developmental quotient. As early as 1941 Peatman and Higgons[78] found that well-cared for white American infants were performing better than the Gesell norms. At the other end of the scale, the validity of some of Gesell's items for less sophisticated populations has also been queried[8,48].

The Denver Developmental Screening Test was originally standardized on 1036 Denver Children[56]. It has been tested repeatedly for reliability, stability and validity over the last 16 years, involving a total of more than 20 000 children [87,89, 143,144]. In its present form the Denver Development Screening Test (D.D.S.T.) comprises 105 items arranged in four scales - gross motor, fine motor-adaptive, language and personal-social. Only the gross motor and the fine motor-adaptive scales were considered for use in the present study. In the revised D.D.S.T. (DDST-R) form the items in each scale are arranged chronologically and stepwise, resembling a growth curve. The DDST-R form was itself validated in a study designed to determine the agreement between the original DDST form and the DDST-R. A separate study conducted concurrently tested agreement between the scoring of individual items when these were scored independently and simultaneously by two workers. In all, 200 children representing six age-groups were examined. There was a mean of 97% examiner-observer agreement for the 105 items, varying from 93% for one item to 100% for 70 items. Using the full test, there was

100% agreement between the DDST and the DDST-R in classifying a child as normal or suspect[89].

The strict attention to proper validation made the DDST (now in its revised form, the DDST-R) an obvious choice for the present study, but this was not the only reason for its selection. Other aspects taken into consideration were as follows:

<u>Quantitative evaluation</u>

Adequate performance of the items in the DDST is strictly defined in the examiners' manual leaving little room for error, as has been shown by Frankenburg <u>et al</u>[145]. The high tester-observer reliability and test-retest stability of the DDST[144] make errors in scoring very unlikely, in contrast to the Gesell schedules where it has been shown that examiners without extensive experience of the administration of the Gesell examination consistently tend to interpret items at an unduly high level[36].

<u>Standardization for other populations</u>

Barnes and Stark[93] found the DDST to be valid for a Canadian rural and semi-rural population. Ueda[95], Bryant <u>et al</u>[92], Solomons[86] and Yalaz and Epir[97] standardized the DDST for Japanese, Welsh, Mexican and Turkish populations respectively, finding slight differences in performance which were discussed in Chapter 1. Pedneault <u>et al</u>[94] used the DDST with French-Canadian babies in a rather more limited study which is also discussed in Chapter 1. Frankenburg himself used the DDST for a cross-cultural study of Anglo, Black and Spanish surname groups in Denver[44].

<u>Efficacy as a screening instrument</u>

The DDST was specifically designed to aid in the early detection of developmental delay in young children[56]. During the initial study the DDST findings for 18 children were compared with the children's performance on the revised Yale Developmental Schedule (Provence, 1964). No child with a Yale Developmental Quotient less than or equal to 89 was judged normal by the DDST, and all children judged by the DDST to show serious delay had a Yale Developmental Quotient of less than 90. The gross motor schedules showed the closest correlation[56]. Subsequently 236 children were assessed with the DDST as well as with the Stanford-Binet Intelligence Scale, the Revised Yale Developmental Schedule, the Cattell Infant Intelligence Scale (Cattell, 1940) and the Revised Bayley Infant Scales of Development (Bayley, 1969). All of the correlations were significant at well beyond the p= 0,001 level. Correlation between each section of the DDST and each criterion test was highest in the gross motor and fine motor-adaptive schedules[144].

Despite these correlations, when used as a screening method the DDST averaged 21% over-referrals, i.e. it was not specific enough in identifying normal subjects. It was therefore revised[87] in order to reduce the number of over-referrals whilst retaining sufficient sensitivity to identify all the abnormal subjects. This revision encompassed three studies. The first two studies compared firstly the validity and secondly the stability of the original and revised methods of scoring. The revised, more conservative method reduced the number of over-referrals from 21% to 11% whilst only increasing the number of under-referrals from 2% to 3%. Re-testing after 7 days gave 97% agreement. After training health aides in the revised DDST a cross-validation study on a new sample of 246 children gave only 3,2% over-referrals and 0,4% under-referrals. In a recent study, Harper and Wacker[146] found under-identification of mental retardation in a group of 555 rural, disadvantaged, pre-school children. Since only the motor scales are being used in the present study I did not consider that these findings precluded the use of the DDST.

It was therefore decided to use the gross motor and fine motor section of the DDST-R in the present normative study.

Chapter 2

NORMAL MOTOR DEVELOPMENT

Changing concepts of normal motor development

Concepts of normal motor development have changed considerably over the last five decades. Earlier writers tended to represent development as a series of milestones, paying little attention to the manner in which these milestones were attained or to the exact components of movement involved. Most of the descriptions of normal development were based upon the studies which Arnold Gesell performed in the late nineteen twenties[99]. The limitations of these studies were discussed in Chapter 1. As late as 1983 Illingworth admits that he has based his writings on normal development "almost entirely on the work of Arnold Gesell"[100]. The gross motor milestones do at least represent the infants's spontaneous actions but the fine motor items used as milestones involve deliberate manipulation of the infant and his environment[101]. There is no information as to why specific fine motor/adaptive responses were selected as significant milestones of development. Particularly within the first year, the impression is given that specific milestones are attained at specific ages, given in weeks.

Sheridan made the first move away from this traditional concept of fixed milestones when she coined the phrase "stepping stones" and produced more detailed descriptions of the child's varied and spontaneous activities at each age.

Most recently attention has focussed upon the concept that normal motor development is a continuum of gradually evolving patterns, many items following a clear developmental course within any individual infant, although showing considerable variation between individuals as far as the ages of evolution of specific components of movement are concerned[103, 104, 105, 106]. The old concept that the reactions of a newborn infant were purely reflexive and that his movements only later became purposeful[107] has given way to the realisation that most movement patterns are meaningful at all stages of development, even in the newborn[108, 109, 110, 111].

In this chapter on normal motor development I shall highlight some of the more recent contributions to our understanding of motor phenomena in infancy, rather than reiterating sequences of development with which we are all familiar.

2.1 BEFORE BIRTH

Illingworth states "Development is a continuous process from conception to maturity. This means that development occurs in utero, and birth is merely an event in the course of development, though it signals the beginning of extraneous environmental factors."[100]

It is several years since Milani-Comparetti and Gidoni first postulated a meaningful interpretation of the motor reactions of the newborn[109]. They proposed that many of the movement patterns seen in the newborn are patterns which the newborn has developed in utero in readiness to take an active part in his own birth. They divided these patterns into two groups - those representing foetal locomotion, which enable the foetus to move around within the uterus and to assume the correct presentation for a normal birth, and those representing foetal propulsion, which enable him to take an active part in his expulsion during delivery.

They also identified two more groups of neonatal reactions - those necessary for survival and those representing early preparation for extrauterine life.

Although this interpretation of the reactions of the newborn initially met with some criticism, ultrasound studies of foetal movement have now demonstrated just how purposeful many foetal movements are[112, 108, 113, 114, 115]. The four groups of reactions can be analysed in more detail as follows:

2.1.1. Foetal locomotion

From the sixth week of gestation wormlike movements appear which become progressively more abrupt until, by the tenth week, the wormlike movements have ceased, being replaced by sudden jerks of the whole body into flexion or extension. The specific gravity of the foetus is slightly more than that of the amniotic fluid, so that at rest the foetus floats downwards to rest on the floor of the uterine chamber. Ultrasonic studies have shown the foetus to be capable of changing position by means of a series of repeated jumps at as early as 10-11 weeks of age[113].

By 12-13 weeks of age the head is turned frequently and extension movements of head and trunk are combined with frog-like swimming movements of the limbs. Rotation of the head and trunk allows the foetus to change position in utero without having to resort to the earlier abrupt jerks. Both symmetrical and reciprocal creeping movements are present by the 14th week and by the 16th week the hands are exploring the surfaces of the uterus and placenta. Foetuses of 14 weeks have even been seen to creep around intrauterine obstructions[112].

Remnants of these intrauterine exploratory and creeping patterns are seen in the newborn in the form of the placing reactions of the feet, primitive creeping and automatic walking. By these means the foetus, during the last weeks of pregnancy, manoeuvres himself until his head finds the area of the cervix where, by little rotatory movements, he eventually engages the pelvic inlet[108, 113]. With just such alternating head movements will a newborn baby nuzzle into his mother's neck when held upright against her[111].

2.1.2. Foetal propulsion

During labour the baby plays a very active part in his own birth, both by triggering uterine contractions and by providing a counterthrust which eventually assists in expelling him from the uterus. As the foetus grows, jumping movements in which the foetus moves freely within the intrauterine sac give way, at about 16 weeks, to extensor thrusts in which the head and feet press against opposite walls of the uterus. During these thrusts the arms are kept down and close to the body, as they would be during birth. These thrusts do not at this stage trigger uterine contractions, but at the end of pregnancy hormonal input from the foetus to the mother causes the uterine wall to respond to the mechanical stimulation from the thrusting foetus. The foetus even times contractions by ceasing to thrust when a prolonged contraction is threatening to result in anoxia[113]. In turn, the active thrusting phases of the infant are reinforced by pressure on the soles of the feet from the descending uterine vault and by pressure against the back of the head from the bony pelvic inlet. In the newborn, the remnants of the reactions needed for foetal propulsion can be seen in the form of the supporting reaction (primary standing), the Bauer reaction[116,117], the magnet response[117] and the head-thrust[100].

Once one accepts the concept of foetal locomotion and propulsion it is easy to understand why attempts to relate these two groups of reactions in the newborn to the future development of standing and walking failed so consistently.

2.1.3. Reactions necessary for survival

Sudden startle movements appear between the 12th and 13th week. These movements at first appear to be spontaneous but later occur in response to specific stimuli, appearing in response to mechanical pressure by the 14th week, to sound from about the 26th week and to a bright light shone on the abdomen from about the 29th week. The functional significance of the startle reaction to the newborn baby is thought to be its presence in the form of the Moro reaction at birth, triggering the initial inspiration. Continuous startle reactions would, in themselves, be detrimental to the well-being of the foetus and newborn baby, but from as early as the 14th week the foetus demonstrates the ability to habituate to repeated stimuli.

Further preparation for breathing is seen from about the 13th week with the start of expansion and retraction of the thorax and abdomen; the diaphragm joins in, in a movement-resembling hiccups, between the 20th and 24th week.

The newborn will need to be able to suckle in order to survive, and from the 12th week the hands approach the mouth frequently. Swallowing appears between 13 and 14 weeks and rooting and sucking of the fingers by the 15th week. By the 19th week swallowing can be seen simultaneously with "breathing" movements[112].

Other protective reactions can be seen during foetal development - the limbs move selectively away from mechanical pressure, the eyes open and close in response to light and, after 29 weeks, periods of sleep are interspersed with periods of activity.

2.1.4. <u>Competencies emerging in preparation for extrauterine life</u>

These include reactions to auditory and visual stimuli as well as early antigravity reactions. From the 27th week the foetus will turn his head towards the source of a loud auditory stimulus. From the 29th week, if a continuous light is applied to the abdominal wall, he will turn his head and open his eyes in a search for the source of light. These reactions increase in efficiency over the first few months of extrauterine life until the infant becomes skilled at locating and identifying auditory and visual stimuli.

Milani also interprets the early jumps of the foetus, seen up to about 20 weeks, as antigravity activity, enabling the foetus to change position in order to relieve excessive pressure on any body part. Although the specific gravity of the foetus is only slightly more than that of the amniotic fluid it is, as already mentioned, sufficiently so to cause the foetus to rest on the most dependent part of the uterus. Jumping in order to change position thus represents anti-gravity extension(113).

In summarizing intrauterine reactions, Milani discerns two completely different types of reaction within this complex motor repertoire. The first he terms Primary Motor Patterns (PMP) and the second Primary Automatisms (PA). Primary motor patterns develop between the 10th and 12th weeks of gestational age and appear to be genetically determined, providing a repertoire of spontaneous movement patterns which have no discernible functional meaning. The primary automatisms all have functional significance and are concerned with the foetus' adaptive responses to his environment, with his preparation for birth and for survival after birth, and with the acquisition of postural control. The acquisition of primary automatisms is dependent upon a process of interaction between the foetus and its environment, in the course of which the foetus integrates the genetically-determined primary motor patterns into functional activity(108). Because the foetus responds to the demands of his environment according to his genetic programming none of the primary automatisms are learned responses, although after the first performance learning may modify subsequent performances. (So-called "instinctive" mothering responses seen even amongst severe mental retardates(118) fall into this same group of epigenetically determined primary automatisms.)

The primary automatisms form the basis for motor development, especially during the first year. Secondary automatisms (SA) provide later skills through learning. The earliest secondary automatisms seen are modifications of movement patterns as a result of cultural habits. Milani-Comparetti[119] considers that these are not recognisable until after six months of age, but this appears open to doubt in view of findings reported in Chapter 1[33].

Milani's concept of interaction between foetus and intrauterine environment develops into his important concept of dialogue between the infant, his caretaker and his environment after birth.

2.2 THE NEWBORN

The concept of interaction between the newborn and his mother and the newborn and his environment has also been stressed by Brazelton, who has made us aware of the vast repertoire of responses available to the neonate, enabling him both to explore his immediate world and to reject excessive stimulation. The Brazelton Neonatal Behavioral Assessment Scale[111] is a means of scoring such interactive behaviour.

Two important principles are stressed. Firstly that the state of consciousness of the infant largely determines the pattern of the infant's reactions, and frequent changes of state are characteristic of the newborn infant. Some reactions are state-specific and cannot be elicited unless the baby is in the respective state at the time of testing. Brazelton recognises 2 sleep and 4 awake states, defined along similar lines to the 5 states of Prechtl and Beintema[120]. The second important consideration is that every attempt is made to elicit the baby's optimum performance rather than his average performance. Both these aspects have been taken into consideration in the design of the present study.

In scoring infants on the Neonatal Behavioral Assessment Scale, the behaviour recorded on the third day is accepted as the mean, in order to allow for any immediate postnatal inco-ordination. Sixteen of the 27 reactions scored by Brazelton gauge the infant's ability to cope with disturbing influences from the environment. Four of these test the baby's ability to habituate to repetitive visual, auditory or tactile stimuli by shutting down his responses. Three reflect the infant's ability to console himself or be consoled after disturbance, whilst another "cuddliness" is closely related to this ability. One test records defensive movements in response to a cloth being placed over the face. The remaining 7 items in this category record more general aspects of the stability of the infant's responses to his environment - peak of excitement, rapidity of build-up, irritability, tremulousness, startles, lability of skin colour and lability of state.

The other major series of reactions scored relates to the newborn's ability to be attentive to his environment. The presence and quality of alert periods are scored, as well as five orientation responses to inanimate or animate objects. Smiling is also recorded. It is particularly in relation to this part of the examination that Brazelton stresses the importance of eliciting the infant's best performance. The series of films* made to illustrate the administration of the Neonatal Behavioral Assessment Scale show the astonishing alertness that can be present in the neonate, accompanied by the ability to follow even an inanimate visual object both horizontally and vertically - even to incorporating head movements in order to continue tracking.

The remaining four behavioural items scored concern postural tone and motor behaviour. Postural tone is scored during general observation and handling as well as during the manoeuvre of being pulled to sitting. (The degree of resistance and snap-back observed during passive movements of the limbs is assessed and scored separately on a different scale.) General motor activity and motor maturity are scored by observing the amount and quality of spontaneous and elicited movement.

In addition to these 27 behavioural items, 16 more classical, elicited responses are assessed, following the procedures of Prechtl and Beintema[(120)]. The responses tested are: plantar grasp, hand grasp, ankle clonus, Babinski, standing, automatic walking, placing, trunk incurvation (Galant), "crawling" (which includes all spontaneous responses to being placed in prone), glabella, asymmetrical tonic neck reflex, Moro, rooting, sucking, and two vestibular reactions in response to rotation - tonic deviation of the head and eyes, and nystagmus.

Brazelton's work has made evident the degree of competence possessed by the normal neonate as well as the wide variations in reaction across the range of normality. His work with neonates of other ethnic and cultural groups was discussed in Chapter 1[(80,34)].

Of interest to physiotherapists involved in the evaluation of infants is that, in addition to the scoring schedules, Brazelton requires a descriptive paragraph on each neonate assessed. In his own words:

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* Films available from the Educational Development Corporation, 10 Mifflin Place, Cambridge, Massachusetts 02138, U.S.A.

"This will be the paragraph which will help the examiner to remember the child later, and may be an important way of categorizing infants, or understanding the scores in the different categories and of understanding meaningful constellations of these categories." He also comments "Write a descriptive paragraph about the baby which includes the particular characteristics which are of interest in your study. This paragraph serves as a reminder of the unique characteristics of the baby which are not recordable elsewhere."[111] This is encouraging to those of us who have long since resorted to this method of recording, in addition to any other, having discovered that long lists of reflexes in no way provide an adequate picture of the postural and movement patterns seen during the course of normal development.

Casaer[121] has provided detailed observations of postural behaviour in newborn infants, again stressing the infant's behavioural interaction with elements of his environment, in this case primarily the force of gravity, rather than purely reflexive mechanisms. The infants were studied in different behavioural states[117] under well-controlled conditions, both lying free in their cots and whilst being carried in their mother's arms. The majority of the babies were aged between 4 and 8 days at the time of testing. The recording procedures were moderately intrusive, involving a thermistor taped to the nose and multiple surface electrodes connected to a polygraphic recorder. However, two observers were present at all times and the experiment was interrupted if the baby showed any discomfort. Postural changes were recorded by direct observation with descriptive notes, supplemented in most cases by either video- or time-lapse photography.

The postures noted, having been studied at over 4 days of age, did not always correspond to those observed in neonates by other workers. An example of this is Casaer's observations of the awake "newborn" in the supine position, who was usually seen lying with his face partially turned to the right side, arms in the expected position of flexion-adduction-medial rotation of the shoulder, flexion of the elbow and pronation of the forearm, but with the legs in a lesser degree of flexion so that the soles of the feet were flat on the surface of the cot, close to the buttocks, instead of the more usual newborn posture of flexion-adduction at the hips, flexion of the knee, and dorsiflexed feet held well clear of the surface. This observation would correspond with the decrease in physiological flexion which is usually evident by about the 5th day of life (122), but in that case it is puzzling that Casaer reported that the presence of extension-abduction movements of the hips was very rare and was only seen consistently in four infants in his study. I have seldom seen a newborn South African infant, awake and moving freely in supine, who did not kick his legs into extension-abduction at some stage during observation, even at ages younger than 5 days.

Casaer's studies also confirm that, although asymmetrical patterns are common, they are flexible and the newborn infant is never bound by the confines of the asymmetrical tonic neck reflex. This is in accordance with the findings of Touwen (103) and Paine et al (123) and the comments of André-Thomas (124) and Bobath (125).

Several manoeuvres were observed during which the newborn turned his whole body from supine to sidy-lying. The most commonly seen were in mass extension. In the former the head and trunk flexed, the limbs flexed and adducted and, due to the rounded back, the infant rolled to his side. In the latter the head was extended, the arms adducted and extended against the trunk and the knees extended, but with flexed hips so that the swing of the legs turned the infant onto its side.

The side-lying position appeared comfortable and stable, but even in this position antigravity activity was observed. The head would be raised laterally for a brief moment, the upper leg would be flexed and laterally rotated so that the sole was flat on the surface, and the head would be rotated back towards the midline, sometimes followed by the body so that the infant rolled back into supine.

Considerable antigravity activity was also seen in the awake, active newborn in prone. Head-lifting was always associated with movements of the whole body, although limb patterns varied. Head-lifting was usually asymmetrical, although if maintained for more than a couple of seconds the face was brought to the midline. Side-to-side head-turning was seen particularly when the infant was hungry, and was often associated with hand-to-mouth activity. Crawling movements were often sustained, resulting in forward progression; both symmetrical and crossed patterns were seen but Casaer does not analyse these in detail. At rest in prone the infant settled into the classical posture of flexion-adduction of the limbs, with the cheek in contact with the surface.

Casaer assumed that antigravity muscle activity must occur with changes of posture. In order to ascertain whether this activity continued during the maintenance of stable postures, or whether such postures were maintained by the visco-elastic properties of the tissues, the transition into sleep was observed in different positions. In all positions transition into State 2(117) was accompanied by a relaxation of the limbs and head in the direction of gravity. This was most evident in supine. Many movements occurred in State 2, each seemingly rendering the infant progressively less active. However, with the eventual transition into State 1 the infant tended to resume the postures seen when awake, implying a return of muscular activity even though the baby was deeply asleep.

It is not appropriate here to go into all the other aspects of Casaer's study, but two further observations are worthy of comment. Firstly it was noted that the newborn would repeatedly try to correct any accidental misalignment of body segments, if necessary using total body movements to do so. Secondly, newborns studied whilst resting in an inclined baby seat showed both more postural activity and longer periods of wakefulness. Both aspects were ascribed to the increased postural load in the more upright position, but I would suggest that they could also be due to the increased activity of the vestibular system in the more upright position, which has been demonstrated by several workers(126, 127).

Mihiudeen <u>et al</u>(128) videotaped 18 three-day-old neonates in three different positions - supine, prone and in an inclined baby seat. The babies were not restricted by any form of recording apparatus. They confirmed Casaer's observation of increased postural activity in the inclined position. They also identified a "neutral posture" which occurred repeatedly in each of Prectl's five normal states[(129)]. It corresponded to the "foetal" position of flexion-adduction of all four limbs, and was seen consistently as a transitional position inbetween postural changes when the baby was in States 2, 4 and 5. The neutral position predominated when the baby was in State 1 (deep sleep) and State 3 (alert but quiet). The neutral position was also the position resumed after elicitation of the Moro or Galant reflexes. Another interesting observation in this group of newborns was that the cervical spine was most often flexed to the right, as also reported by Casaer.

2.3 GENERAL PRINCIPLES IN THE DEVELOPMENT OF POSTURAL CONTROL

Before going on to a detailed analysis of the components of movement seen during the development of postural control, it is necessary to summarize some of the established general principles of motor development.

2.3.1. Development of postural tone

Relatively little seems to have been written about the development of postural tone in the infant, although there is agreement that there is considerable variation between normal infants(100,111). Considerable variations of tone between different ethnic groups have also been noted(80,9,130) and this was discussed in Chapter 1.

The normal, full-term infant shows physiological flexor activity - particularly at hips, knees, ankles, elbows and fingers. This is easily demonstrated by the degree of flexor recoil which occurs after these joints have been extended passively and released. It appears related to the elastic properties of the muscle fibres and is probably due to adaptive shortening of these muscles during the later months in utero when the baby is in a very flexed position. Breech-presentation neonates who have lain with their legs extended in utero show similar activity in the knee extensors. The increased physiological flexor tone in the limbs is not accompanied by any flexor control of the head or trunk; the newborn shows a head-lag when pulled to sitting and cannot maintain his head in midline in supine unless he is particularly active, as when suckling or crying.

The relatively high tone in the extremities as compared with the neck and trunk is not entirely passive, however; nor is it limited to the flexors. The strong patterns of movement seen in some of the primary automatisms(119) as well as the palmar and plantar grasp reflexes are evidence of higher active postural tone in the extremities at birth. Perhaps because the legs have been more active before and during birth, the postural tone is higher in the legs than in the arms.

These observations have led some workers to the conclusion that postural tone, as opposed to control of movement, develops in a distal-to-proximal and caudocephalic direction(131). I doubt whether this is in fact the case. The main factor influencing the development of postural tone is the force of gravity to which the baby is exposed after birth. It is the development of postural tone which enables the infant to maintain antigravity postures. We see the first signs of the development of postural tone against gravity in the newborn's ability to turn his head in prone and in his repeated attempts to right his head in the upright position. It is undoubtedly the effect of the righting reactions which act upon the head - the labyrinthine, body-on-head and (later) the visual righting reactions[132, 133] which trigger the initial development of postural tone and thus the control of movement of the head. During the first few months of life the development of postural tone and the control of antigravity postures proceed hand in hand in a cephalocaudal direction, accompanied by a gradual decrease in postural tone in the extremities as the original physiological flexion is lost and the infant, in some cases, passes through an astasic stage.

The development of extensor tone slightly precedes that of active flexor tone, as can be seen in the young infant's ability to raise his head in prone before he can do so in supine, but by between four and six months of age a balance between flexor and extensor tone has been achieved. The early predominance of extensor tone is probably due to the selective influence of the vestibular system on extensor motor neurones. As the development of extensor and flexor tone becomes more balanced we also see the proximo-distal spread of control, first to shoulder-girdle and hips - then to shoulders, to knees and elbows, and finally to hands and feet.

2.3.2. Development of patterns of movement

As postural control develops, so specific patterns of movement emerge. Two characteristics are evident throughout the development of motor patterns - competition of patterns and overlap of patterns[134, 135, 136].

Competition of patterns

The normal baby has, from birth, a tremendous repertoire of movement patterns and, although certain patterns are characteristic of certain stages of development, he is never limited to any one pattern at any stage. Throughout development he displays opposing patterns of movement, although he may occasionally practise a particular pattern more assiduously, especially when it is a new acquisition. This competition of patterns can be seen at all ages and culminates not only in a balance between flexor and extensor patterns but also in the ability to break up these patterns, selecting the different combinations of flexor and extensor components which are needed for skilled movements. The more complex motor skills also require the ability to dissociate the movements of one part of the body from those of another. The development of rotation is pre-requisite for this ability, and rotation is only possible once a balance has been achieved between flexor control and extensor control. Given this balance, controlled rotation becomes possible, realignment being brought about by a combination of the neck righting reaction and the body-righting-reaction-on-the-body. Control of rotation is also needed for the development of protective reactions (protective extension and equilibrium reactions).

Overlap of patterns

The baby does not perfect one pattern of movement before going on to a more advanced one. Many so-called "milestones" in fact display an evolutionary course over several months, during which the components of movement are refined (see figs. 16 to 21 , Chapter 4). Even once perfected, the infant may revert to an earlier form of the same pattern at moments of stress or when attempting to superimpose a new skill. The infant also does not abandon creeping* as soon as he acquires crawling; he will also attempt standing before he has developed equilibrium reactions in sitting. When discussing the results of this study I shall try to analyse the relationship between the acquisition of some of the more advanced patterns of movement and the disappearance of earlier ones

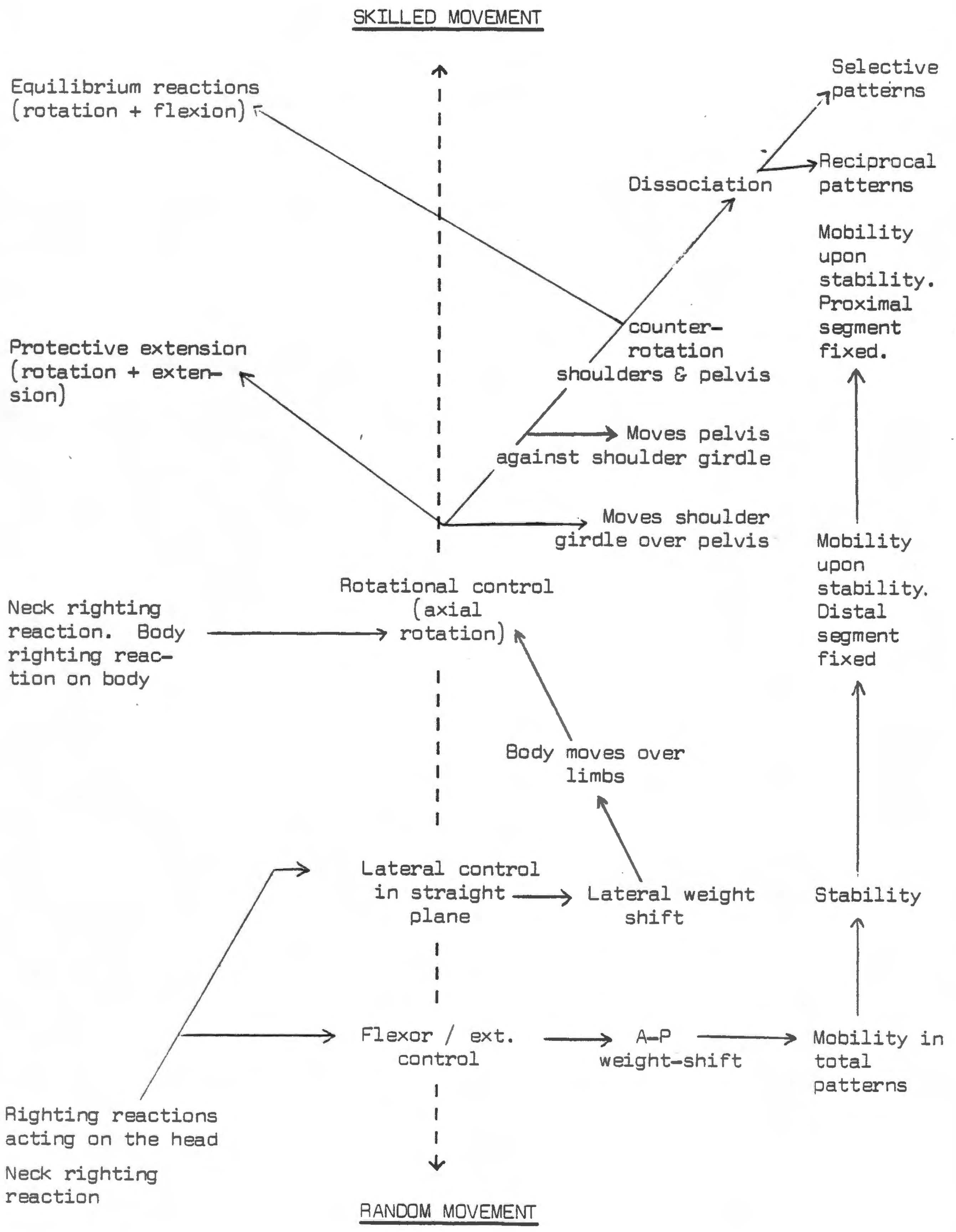
*Throughout this study the English terminology is used : creeping indicates moving forwards with the abdomen in contact with the floor, whereas crawling indicates raised on hands and knees.

The concepts of cephalocaudal and proximodistal development of control of movement are well known. Less well documented is the progression from control over movements in the sagittal plane (patterns of flexion and extension) to control over movements in the coronal plan (lateral flexion and lateral weight-shift). Lateral weight-shift in turn leads to diagonal patterns of movement and the development of rotation.

Rood[137] proposes yet another sequence in the development of patterns of movement - the progression from patterns characterized by mobility to those required for stability and thence to the different combinations of stability with mobility which are required for locomotion and skilled movement.

The hierarchy proposed on the next page is an attempt to depict the linkage between some of these sequences in the development of postural control and patterns of movement.

FIG. 1 : HIERARCHIES IN THE DEVELOPMENT OF SKILLED MOVEMENT AND POSTURAL CONTROL



2.4 COMPONENTS OF MOVEMENT

Mary Quinton, who first applied the concept of neurodevelopmental therapy[138] to very young babies, was also the first person to start analysing the actual components of movement involved in the attainment of the various developmental patterns commonly referred to as "milestones". Unfortunately she has never published her findings, but her work has been developed and built upon by others, notably by Bly[105, 106].

Bly[139] also points out that, in the course of development, most muscles undergo a process of elongation before they become functionally active. Elongation is brought about by gravity or by the action of antagonistic muscles. In the case of two-joint muscles, the muscle is first elongated over each joint separately; later over both joints simultaneously. It seems that the child establishes full mobility at given joint before achieving motor control over that joint.

I do not propose to discuss the components of movement involved in the development of every functional competence. As an illustration I shall follow the components involved in the development of control at the shoulder-girdle and shoulder[140]. Thereafter I shall analyse some of the specific developmental patterns included on the list of non-DDST items tested during this study (see Chapter 3).

2.4.1. Developmental aspects of shoulder control

The functions of the upper limb can be grouped under two headings, namely manipulative (including sensory functions and emotional expression) and weight-bearing (including protective). Although of prime importance in young children, the weight-bearing/protective function is of lesser importance in the adult with adequately developed equilibrium reactions. More important is that the failure to develop weight-bearing function appears to interfere with the later development of manipulative ability. The key to the development of all weight-bearing and manipulative abilities lies in the components of movement established at the shoulder-girdle and glenohumeral joint. These, in turn, are linked to the central control of flexion and extension against gravity. In this the righting reactions play the primary role although other influences are seen in the course of development. Initially the movements of the scapula and gleno-humeral joint are linked and the baby cannot move the one independently of the other in order to break up movement synergies. As control of the various components is established the ability to dissociate movements of scapula and humerus develops.

For the sake of simplicity, the term "adduction" of the scapula will be used to describe the combination of retraction and medial rotation, and the term "abduction" to describe the combination of protraction and lateral rotation.

In the newborn the scapulae are elevated in all resting positions; the baby apparently has no neck. In the prone position there is rather more abduction of the scapula as a result of the influence of the primitive tonic labyrinthine reflex. Casaer[121] describes strong, active mass flexion movements in the awake baby in which the scapula abducts and the humerus adducts and medially rotates. In supine there is relatively more adduction of the scapula, again secondary to the influence of the tonic labyrinthine reflex, with slightly less adduction and medial rotation of the humerus. The elbows usually do not rest on the surface and if the hand contacts the mouth sucking may occur, resulting in a tendency towards more abduction of the scapula with increased adduction and medial rotation of the humerus. Some active postural control against gravity is assumed, but it is uncertain whether prolonged maintenance of these postures is due to sustained postural activity or to visco-elastic properties. As the baby falls asleep in supine, the scapulae become more adducted and the arms fall into more abduction and lateral rotation.

As extension develops cephalocaudally there is progressively less elevation of the scapulae and the neck appears longer. Since extensor control develops slightly ahead of flexor control the scapulae become more adducted in both prone and supine, bringing the arms with them into abduction. The control required for weight-bearing starts to develop early. By three months of age extension has spread throughout the whole thoracic area and the baby can stabilise well enough with his scapulae in adduction in the prone position to start weight-bearing on his elbows with the humerus in abduction and medial rotation. As control of flexion increases there is more active depression and abduction of the scapulae in prone, bringing the humerus into more adduction and therefore more lateral rotation. By four months the baby has good control of either adduction or abduction of the scapula in prone but cannot dissociate movements of the scapula and humerus. When the scapula is adducted the humerus goes into abduction and lateral rotation (the swimming pattern) whilst when the scapula is abducted the humerus is drawn into adduction, the degree of lateral or medial rotation being dependent upon the position of the hands on the floor. As he starts to push up onto extended arms he initially reverts to stabilising with adduction of the scapula (and therefore with abduction and medial rotation of the humerus). As he pushes more strongly flexor activity increases, resulting in more abduction of the scapula and more adduction and lateral rotation of the humerus.

Once the development of extensor and flexor control becomes balanced, the baby starts to shift weight in preparation for reaching. At first he tries to stabilise with adduction of the scapula on the weight-bearing side and,until he learns to compensate with lateral flexion of the trunk on that side, he falls to the non-weight bearing side. Propping with lateral trunk flexion, adduction of the scapula and adduction of the humerus on the weight-bearing side is a perfectly normal pattern seen in early attempts to reach, but the baby will not be able to move his body freely over the supporting limb until he can stabilise his scapula adequately in abduction. As this control develops he extends his trunk on the weight-bearing side and, as he rotates his trunk on the supporting arm, the humerus becomes progressively more abducted and laterally rotated. This apparent dissociation is, at this stage, due to fixation of the distal segment rather than active isolation of components of movement.

Development of reach runs parallel but fractionally behind that of support. In supine the baby starts to reach forwards at about four months. At first flexor control is inadequate to allow abduction of the scapula and the shoulders rest on the ground. He reaches with medial rotation of the humerus. With increasing flexor control the shoulders begin to lift from the ground as the scapulae abduct against gravity. He can now reach with more adduction of the humerus and the medial rotation starts to decrease as he reaches towards the midline. Reaching in prone is first attempted without supporting on the opposite arm, and is performed with a lot of abduction and medial rotation of the humerus, without adequate fixation of the scapula in adduction. As weight-bearing ability on the supporting arm improves we see more rotation over the supporting arm and, for the first time, dissociation between the movements of the two scapulae. On the supporting side the scapula is stabilised in abduction whilst on the non-weight-bearing side it is stabilised in adduction, allowing reach in more lateral rotation. At this stage (at about six or seven months) if he attempts to reach in sitting he will revert to reaching in medial rotation since his trunk control in sitting is still inadequate and he has no point of fixation from which to control his scapula and glenohumeral joint.

Relationship to distal components

Whilst the baby is still weight-bearing on his elbows in abduction and medial rotation we see pronation of the forearm and ulnar deviation of the wrist; the weight is taken on the flexor aspect of the forearm and the hand is closed. As adduction of the humerus develops, bringing in more lateral rotation, the rotation of the forearm becomes more neutral and weight is taken along the ulnar border of the forearm and hand, allowing some exploratory raking with the fingers. Initial attempts at supporting on extended elbows achieve only partial extension as long as the shoulders remain in abduction and medial rotation, full extension only becoming possible once the humerus can be stabilised in adduction and lateral rotation (dependent, in turn, on stabilisation of the scapula in abduction). As adduction of the humerus increases, the point of weight-bearing on the hands moves from the ulnar side across towards the base of the thenar eminence. Initial weight-bearing is on flexed fingers, but as the baby brings his base of support in line with his shoulders, getting weight-bearing across the full width of the palm and putting stretch on the wrist and finger flexors, the fingers start to extend and the baby takes weight on an open hand. More important, the pressure on the thenar eminence brings the thumb out of the palm and into abduction in line with the palm, an essential preparation for the development of the use of the radial tripod in manipulation.

Development of the distal components of reach are similarly dependent upon the establishment of proximal components. Until flexor control is sufficiently established to allow good abduction of the scapulae in supine, the arms cannot be brought to the midline and reach is limited. As long as the humerus remains in medial rotation during reach, the forearms remain pronated. This pronation diminishes as the rotation of the shoulder becomes more neutral and by this stage the forearms supinate when the elbows are flexed, as when bringing a toy to the mouth. The mature pattern of reach in supine occurs when abduction of the scapulae is sufficiently strong to bring the shoulders off the ground; the humerus is now adducted and laterally rotated and the forearm is brought into supination. Only once this pattern has been established does grasp change from a palmar grasp to the use of the radial tripod. Reaching in the prone or prone kneeling positions involves adduction of the scapula, abduction and lateral rotation of the humerus, extension of the elbow and, as these components become perfected, supination of the forearm. Once again, the development of reach in supination depends upon the acquisition of proximal control; the baby initially reaches in pronation. It will be seen that the patterns of mature reach in supine and in prone differ in the combination of scapular and gleno-humeral components. In other words, the baby is eventually able to dissociate the movements of the scapula and humerus.

2.4.2. <u>Items from the list of supplementary (non-DDST) items included in this study</u> (See Chapter 3, Section 3.2.2.)

Items 3, 4, 5 and 9

These items represent stages in the development of flexor control against gravity.

In item 3 the infant has lost the initial physiological flexor tone of the newborn. The legs are now, under the influence of gravity, falling into more extension, abduction and lateral rotation, with the result that the feet come to rest on the supporting surface with the weight on heels and lateral borders of the feet. The resultant sensory input prepares the infant for later weight-bearing and for the development of the longitudinal arches of the foot.

Following upon this decrease in flexion (and comparative elongation of the flexor muscles) comes active control of flexion, seen in the loss of the initial head lag (item 4 - head in line with shoulders when pulled to sit). At this stage the scapulae may be elevated during pulling to sitting, for stability, but they remain adducted and there is no spread of flexion to the trunk or limbs. As flexor control improves, the infant starts to stabilize his scapulae in more abduction, enabling him to reach forwards from supine (see previous section) and flexion increases again in the legs - this time under active control. The legs now flex in more abduction and lateral rotation than in the newborn, although the pelvis is still tilted anteriorly. Until the scapulae are fully stable in abduction, the infant reaches towards his knees with internal rotation at the shoulder, as described above and in item 5 of the supplementary list.

As flexion against gravity is perfected, the scapulae are stabilised in abduction and the baby is able to reach forwards with more lateral rotation at the shoulder (see section 2.4.1). His pelvis now tilts posteriorly when he flexes his legs, with the result that he can now reach his feet with his hands (item 9).

<u>Items 7, 8, 11, 15, 16 and 19</u>

These items are all concerned with the development of arm-support and protective extension. The proximal components in this developmental sequence have already been discussed in section 4.1. In the parachute reaction (item 7) the infant switches from the adduction of the scapulae seen during the Landau reaction in ventral suspension [120] to abduction of the scapulae and forwards reaching with the arms when tilted suddenly forwards and downwards. At the same time the hands open; Touwen[103] has shown that this occurs independently of the visual placing reaction of the hands. When the parachute reaction initially occurs, the infant is not yet able to support his weight on the extended arms. Early weight-bearing on the arms (item 8) develops after the infant has become able to stabilize his scapulae in abduction when weight-bearing on the elbows. However, as noted above, the additional effort of extending the elbows causes him to revert to the earlier pattern of scapular adduction and humeral abduction. At the stage described in item 8, the elbows are not yet completely extended, the forearm is pronated and the hands are usually semi-flexed. As he regains the ability to stabilize his scapulae in abduction, the gleno-humeral joint reassumes more adduction and neutral rotation and the infant bears weight on extended elbows with open hands (item 11). Early attempts at supporting on all fours (item 15) are similarly accompanied by a short-lived return to the earlier pattern at scapula and shoulder before the mature pattern of arm-support is re-acquired.

Although abduction of the scapula is required for the mature pattern of forwards arm-support, stabilization in adduction is required for lateral and backwards arm-support. Early forms of sideways and backwards propping are not accompanied by sufficient scapular adduction. The movement then occurs largely at the gleno-humeral joint which moves into extension and medial rotation, with a semi-flexed elbow and semi-fisted hands. As control over adduction of the scapula in the upright position improves, the humerus is laterally rotated and the weight is caught on the open hand (items 16 and 19). Unilateral backwards protective extension (item 19) is not possible until control of the trunk is sufficient to allow rotation between pelvis and shoulder-girdle in sitting.

Items 10, 12, 13, 17 and 18

This series of items covers stages in the development of prone locomotion. The amphibian reaction (item 10) is the earliest example of lateral weight-shift leading to rotation between the shoulder-girdle and pelvis accompanied by dissociation between the two legs. The components of movement involved are pertinent not only to the development of locomotion but also to the ability to assume the sitting position from prone. Because these components are so important they are analysed in detail here.

Sequence of components of movement during an amphibian reaction towards the right

Pelvis - rotation backwards on the right with weight-shift towards the left

Head - rotation and lateral flexion towards the right

Trunk - lateral flexion towards the right and elongation of the (opposite) weight-bearing side.

Pelvis - further backwards rotation on the right, combined with lateral tilt upwards on the right

Legs - right leg: flexion, abduction, lateral rotation at hip, flexion at knee, dorsiflexion at ankle and toes (may be incomplete at this age)

left leg: extension, adduction and medial rotation at hip, extension at knee, plantarflexion at ankle and toes (may be incomplete at this age).

Arms - right arm: adduction scapula, abduction and lateral rotation humerus, flexed elbow. If the weight is not fully transfered the right hand may remain on the floor, taking part of the weight. In this case there is increased abduction of the scapula, this time combined with abduction and medial rotation of the humerus, pronation of the forearm, and weight taken on the thenar eminence of the hand.

left arm: abduction of the scapula, adduction and lateral rotation of the humerus as the body moves across the supporting left elbow, more supination of the forearm, and the weight taken on the ulnar border of the hand.

These same components of movement are later utilized in creeping, which at first is performed in an ipsilateral pattern, with lateral trunk flexion (item 13). As control over rotation improves, the lateral trunk flexion decreases and a reciprocal creeping pattern emerges. When crawling starts (item 17) and later bear-walking (item 18) there is frequently a return to excessive lateral trunk flexion and an ipsilateral pattern before the child eventually consolidates the reciprocal pattern.

Rolling is another form of locomotion. Rolling from prone to supine frequently occurs early on - very often accidentally - and does not show sufficient consistency of response to be of use in this study*.

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* This statement refers to spontaneous rolling from prone to supine and must not be confused with Touwen's findings on studying the ability of older infants to resume the supine position after they had already been induced actively to roll from supine to prone[103].

Rolling from supine to prone (item 12) is important in that it brings the infant to the position in which prone locomotion can be developed and from which sitting can be achieved. Initial attempts involve either flexion or extension patterns, without break-up, and the infant cannot turn beyond side-lying. Successful rolling to prone demands break-up of patterns and involves rotation. At first the infant initiates with rotation of the head, the whole body following axially through the action of the neck righting reaction, without rotation between shoulder-girdle and pelvis. In its mature form rolling can be initiated from head, shoulder-girdle or pelvis, rotation between shoulder-girdle and pelvis being mediated by the body-righting-reflex-acting-on-the-body.

2.5 THE IMPORTANCE OF A STUDY OF COMPONENTS OF MOVEMENT

Items in the gross motor and fine motor-adaptive sections of the D.D.S.T. reflect the mere achievement of different functional activities without analysing how these activities are performed. Physiotherapists who are involved in the assessment of and therapeutic intervention for infants with cerebral motor disturbance or developmental motor delay need a detailed knowledge of the basic components of movement which are combined in order to achieve motor milestones and perform functional activities. They also need to know how the patterns of these functional activities change at different ages. Subtle changes in the components of movement used in a particular activity may be an early indication of developmental delay. Since the degree of integration or retention of primary motor patterns (primitive reflexes) may also reflect the level of development it was decided to include both selected primary motor patterns and selected components of movement in a supplementary test section.

Chapter 3

METHOD

3.1 THE SAMPLE

3.1.1. Sampling Procedure

The sample consisted of 741 white and 681 urban black infants drawn from the City Council and Divisional Council Child Health Care Clinics in the northern suburbs of the greater Cape Town area. This encompassed the municipal areas of Bellville, Durbanville, Goodwood, Milnerton, Parow and Pinelands in addition to the northern parts of the municipal area of Cape Town. Proportional sampling was used, based upon the 1981 clinic attendance figures. Three clinics were omitted since the clinic attendance figures were too low to allow proportional sampling in each age group. These are given below with their 1981 attendance figures in brackets: Sanddrift (178), Stellenberg (68), Welgemoed (278). Table 7 compares the planned and actual numbers of infants tested at each clinic with the 1981 clinic attendances.

Sampling was cross-sectional at different ages from 16 - 1170 days. Since the greatest developmental change occurs within the first year, more infants were allocated to each group during that period than later. In the black clinics babies were sampled in each 10-day interval from 16 days to 375 days; thereafter in each 20-day interval until 495 days, each 30-day interval until 675 days, each 45-day interval until 810 days and each 60-day interval until 1170 days. In the white clinics, where the numbers were fewer per clinic, babies were sampled in each 30-day interval from 16 days to 375 days; thereafter in each 60-day period to 495 days, each 90-day interval to 675 days and then within each of 3 periods of 134, 179 and 179 days respectively. For the purpose of inclusion in the sample ages were calculated in days. Infants born at less than 37 weeks' gestation were accepted into the sample at their actual age but their performance was analysed at both actual and corrected ages. The planned and actual number of infants tested in each age-group, as well as the equivalent age in months, is given in Tables 8 and 9.

It can be seen that in the white group, where infants were sampled according to age in months, the frequency distribution across the age-intervals in days is not as consistent as that of the black group, where the larger numbers per clinic allowed more accurate sampling. In both groups there was some inadvertent over-representation in the latter part of the three-month level, which is the age at which all babies are brought to the clinic for their first poliomyelitis and triple vaccine immunizations.

A similar over-representation occurred at the 5 month level, which probably represents routine clinic attendances for booster doses, usually given at 4 and 6 months of age.

In both groups there was slight under-representation at 11 - 12 months, which is an age at which clinic attendance is not required. It also proved difficult to find sufficient black children over two years of age as they no longer attended the clinic and seldom seemed to be brought to accompany younger siblings.

The sampling procedure was the same at each clinic. The infants were first seen by the Clinic Sisters, who excluded those with any chronic or acute medical condition. After weighing they were referred for inclusion in the trial. They were accepted if there were no excluding factors (see Exclusions), if their age in days fell into a vacant cell, if the accompanying parent or parents agreed to take part in the study, if they had not already been included in the study and if there was sufficient time left in the clinic session in which to test them. Approximately 10 babies were tested per morning or afternoon clinic session. Sampling was carried out from September 1982 to June 1985.

<u>Exclusions</u>

Infants with congenital abnormalities, neuromuscular disease, known mental retardation, blindness and deafness were excluded, as were those with pronounced malnutrition, acquired chronic disease or acute illness at the time of assessment. As a result of the preliminary screening by the Clinic Sisters only 6 infants had to be excluded on medical grounds by the examiner. These exclusions were made on the following grounds:

Microcephaly	1	Black
Hydrocephaly with shunt	1	Black
Malnutrition/retardation	1	Black
Cerebral palsy	2	White
Neutropaenia/failure to thrive	1	White

Adopted or fostered children were also excluded.

TABLE 7 : CHILDREN TESTED PER CLINIC

	Clinic	Planned infants	Infants assessed	1981 clinic attendance
BLACK CLINICS	Nyanga	198	195	15 686
	Guguletu	366	360	30 934
	Uluntu	114	126	9 923
	Totals	678	681	56 543
WHITE CLINICS	Bellville	66	66	2 864
	Bellvillevallei	47	47	1 521
	Bothasig	19	20	767
	Bothasig Hall	47	49	1 195
	Brooklyn	47	47	2 269
	Durbanville	47	47	2 456
	Groenvallei	66	66	3 336
	Milnerton	19	19	1 222
	Milton Street	66	66	2 749
	Monte Vista	19	18	1 335
	Northern Rugby Club	47	47	1 511
	Parow	47	47	2 121
	Parowvallei	47	47	1 600
	Pinelands	19	20	972
	Table View	47	48	1 591
	Thornton	19	19	606
	Tygerdal	19	19	574
	Vasco	47	49	1 706
	Totals	735	741	30 395

TABLE 8 : PLANNED AND ACTUAL FREQUENCIES OF AGES OF BABIES TESTED - BLACK SAMPLE

Age (months)	Age-interval (days)	Planned frequency	Actual frequency	Cumulative frequency	Percent	Cumulative percent
1	16 - 25	14	15	15	2,203	2,203
	26 - 35	14	14	29	2,056	4,258
	36 - 45	14	16	45	2,349	6,608
2	46 - 55	14	14	59	2,056	8,664
	56 - 65	14	15	74	2,203	10,866
	66 - 75	14	14	88	2,056	12,922
3	76 - 85	14	14	102	2,056	14,978
	86 - 95	14	16	118	2,349	17,327
	96 - 105	14	21	139	3,084	20,411
4	106 - 115	14	17	156	2,496	22,907
	116 - 125	14	15	171	2,203	25,110
	126 - 135	14	14	185	2,056	27,166
5	136 - 145	14	18	203	2,643	29,809
	146 - 155	14	14	217	2,056	31,865
	156 - 165	14	17	234	2,496	34,361
6	166 - 175	14	16	250	2,349	36,711
	176 - 185	14	13	263	1,909	38,620
	186 - 195	14	15	278	2,203	40,822
7	196 - 205	14	14	292	2,056	42,878
	206 - 215	14	14	306	2,056	44,934
	216 - 225	14	14	320	2,056	46,990
8	226 - 235	14	14	334	2,056	49,046
	236 - 245	14	14	348	2,056	51,101
	246 - 255	14	15	363	2,203	53,304
9	256 - 265	14	14	377	2,056	55,360
	266 - 275	14	13	390	1,909	57,269
	276 - 285	14	14	404	2,056	59,325
10	286 - 295	10	10	414	1,468	60,793
	296 - 305	10	8	422	1,175	61,968
	306 - 315	10	12	434	1,762	63,730
11	316 - 325	10	10	444	1,468	65,198
	326 - 335	10	10	454	1,468	66,667
	336 - 345	10	9	463	1,322	67,988
12	346 - 355	10	7	470	1,028	69,016
	356 - 365	10	10	480	1,468	70,485
	366 - 375	10	10	490	1,468	71,955
13,5	376 - 395	10	10	500	1,468	73,421
	396 - 415	10	10	510	1,468	74,890
	416 - 435	10	10	520	1,468	76,358

TABLE 8, cont.:

Age (months)	Age-interval (days)	Planned frequency	Actual frequency	Cumulative frequency	Percent	Cumulative percent
15	436 - 455	10	10	530	1,468	77,827
	456 - 475	10	11	541	1,615	79,442
	476 - 495	10	10	551	1,468	80,910
18	496 - 525	10	10	561	1,468	82,379
	526 - 555	10	10	571	1,468	83,847
	556 - 585	10	10	581	1,468	85,316
21	586 - 615	10	10	591	1,468	86,784
	616 - 645	10	9	600	1,322	88,106
	646 - 675	10	11	611	1,615	89,721
24	676 - 720	10	9	620	1,322	91,043
	721 - 765	10	11	631	1,615	92,658
	766 - 810	10	10	641	1,468	94,126
30	811 - 870	10	4	645	0,587	94,714
	871 - 930	10	6	651	0,881	95,595
	931 - 990	10	6	657	0,881	96,476
36	991 - 1050	10	9	666	1,322	97,797
	1051 - 1110	10	4	670	0,587	98,385
	1111 - 1170	10	11	681	1,615	100,000

TABLE 9 : PLANNED AND ACTUAL FREQUENCIES OF AGES OF BABIES TESTED - WHITE SAMPLE

Age (mnths)	Planned frequency	Actual frequency	Interval (days)	Frequency	Cumulative frequency	Percent	Cumulative percent
			16 - 25	18	18	2,429	2,429
1	45	45	26 - 35	18	36	2,429	4,858
			36 - 45	9	45	1,215	6,078
			46 - 55	18	63	2,429	8,502
2	45	46	56 - 65	17	80	2,294	10,796
			66 - 75	11	91	1,484	12,281
			76 - 85	4	95	0,540	12,821
3	45	50	86 - 95	23	118	3,104	15,924
			96 - 105	23	141	3,104	19,028
			106 - 115	11	152	1,484	20,513
4	45	45	116 - 125	10	162	1,350	21,862
			126 - 135	24	126	3,239	25,101
			136 - 145	19	205	2,564	27,665
5	45	50	146 - 155	20	225	2,699	30,364
			156 - 165	11	236	1,484	31,849
			166 - 175	16	252	2,159	34,008
6	45	47	176 - 185	11	263	1,484	35,493
			186 - 195	20	283	2,699	38,192
			196 - 205	11	294	1,484	39,676
7	45	44	206 - 215	23	317	3,104	42,780
			216 - 225	10	327	1,350	44,130
			226 - 235	16	343	2,159	46,289
8	45	44	236 - 245	11	354	1,484	47,773
			246 - 255	17	371	2,294	50,067
			256 - 265	7	378	0,945	51,012
9	45	42	266 - 275	19	397	2,564	53,576
			276 - 285	16	413	2,159	55,735
			286 - 295	19	432	2,564	58,300
10	33	34	296 - 305	12	444	1,619	59,919
			306 - 315	3	447	0,405	60,324
			316 - 325	7	454	0,945	61,269
11	33	29	326 - 335	15	469	2,024	63,293
			336 - 345	7	476	0,945	64,238
			346 - 355	11	487	1,484	65,722
12	33	31	356 - 365	9	496	1,215	66,937
			366 - 375	11	507	1,484	68,421
			376 - 395	9	516	1,215	69,636
13,5	33	33	396 - 415	15	531	2,024	71,660
			416 - 435	9	540	1,215	72,874

TABLE 9, cont.:

Age (mnths)	Planned frequency	Actual frequency	Interval (days)	Frequency	Cumulative frequency	Percent	Cumulative percent
			436 - 455	13	553	1,754	74,629
15	33	34	456 - 475	8	561	1,080	75,709
			476 - 495	13	574	1,754	77,463
			496 - 525	5	579	0,675	78,138
18	33	34	526 - 555	13	592	1,754	79,892
			556 - 585	16	608	2,159	82,051
			586 - 615	7	615	0,945	82,996
21	33	32	616 - 645	15	630	2,024	85,020
			646 - 675	10	640	1,350	86,370
			676 - 720	16	656	2,159	88,529
24	33	33	721 - 765	8	664	1,080	89,609
			766 - 810	9	673	1,215	90,823
			811 - 870	10	683	1,350	92,173
30	33	33	871 - 930	10	693	1,350	93,522
			931 - 990	13	706	1,754	95,277
			991 - 1050	9	715	1,215	96,491
36	33	35	1051 - 1110	9	724	1,215	97,706
			1111 - 1170	17	741	2,294	100,000

3.1.2. Characteristics of the sample

The final sample consisted of 681 urban black and 741 white infants. The characteristics of the sample were compared with the demographic characteristics of the area as a whole, obtained from the 1980 Census figures for the respective areas.*

3.1.2.1. Number of infants by age and sex

Tables 10 and 11 show details of the total population and the sample in terms of number of children under one year, number of children under 3 years, and sex.

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* Areas 39, 40, 138, 140, 163, 164, 166, 167, 168, 169, 172, 173, 178, 181, 197, 201, 220, 253, 256, 257, 260, 261, 264, 267 and 276.

TABLE 10 : BLACK INFANTS UNDER 3 YEARS AND UNDER 1 YEAR, BY SEX

Under 3 yrs (1095 days)	Total population	Sample	% sampled
Male	3800	330	8,68
Female	4160	338	8,12
Total	7960	668	8,39
Under 1 yr (365 days)			
Male	760	241	31,71
Female	940	238	25,32
Total	1700	479	28,18

TABLE 11 : WHITE INFANTS UNDER 3 YEARS AND UNDER 1 YEAR, BY SEX

Under 3 yrs (1095 days)	Total population	Sample	% sampled
Male	3480	375	10,78
Female	2700	346	12,81
Total	6180	721	11,67
Under 1 yr (365 days)			
Male	980	251	25,61
Female	600	245	40,83
Total	1580	496	31,39

In the black group, a total of 336 boys (49,34%) were tested as against 345 (50,66%) girls. Since the general population shows a slightly greater predominance of girls, particularly in the under one-year age-group (55,29%), girls were slightly under-represented in the black sample.

In the white group, a total of 386 boys (52,09%) and 355 girls (47,91%) were tested. Population figures for the white group show a predominance of boys - rising from 56,31% of children under 3 years to 62,02% of infants under 1 year. Boys were therefore under-represented in the white sample, particularly in the under 1 year age-group.

In both population groups, however, the predominant sex in the sample conformed with that for the group as a whole.

3.1.2.2. Weight percentiles

Each baby was weighed on arrival at the clinic, before referral for testing. The black babies were all weighed naked. The white babies were weighed in their nappies and vests plus one light article of clothing, usually of the stretch towelling variety. 54,77% of black infants and 62,62% of white infants fell between the 25th and 90th percentiles for weight. 20,70% of black infants and 20,92% of white infants were overweight (above the 90th percentile) whilst 24,52% of black infants and 16,46% of white infants were underweight (below the 25th percentile). A breakdown is given in Table 12.

TABLE 12 : WEIGHT PERCENTILES FOR THE TWO SAMPLE GROUPS

Weight percentile	Black		White	
	Frequency	Percentage	Frequency	Percentage
< 3	40	5,735	16	2,159
3- <10	52	7,647	39	5,263
10- <25	75	11,029	67	9,024
25- <50	95	13,971	117	15,789
50- <75	148	21,765	228	30,769
75- <90	130	19,118	119	16,059
90- <97	88	12,941	106	14,305
>97	53	7,794	49	6,613
Totals	681	100,000	741	100,000

3.1.2.3. Prematurity

Fifty-five black infants and 70 white infants in the sample were born 3 or more weeks pre-term, i.e. 8,08% of the black infants and 9,45% of the white infants. A break-down is given in Table 13. The incidence of prematurity for the general population is between 6 and 8% for whites and 13 and 15% for blacks.

For the purposes of this study, these pre-term infants were accepted into the sample at their actual (uncorrected) ages, since their presence was considered representative of pre-term infants within the population as a whole. In order to ascertain whether their presence had any effect on the overall results of the study, the results of the pre-term infants are also analysed separately in Chapter 4, section 4.4.

TABLE 13 : FREQUENCY OF PRE-TERM INFANTS IN THE TWO SAMPLE GROUPS

No. weeks pre-term	Black		White	
	Frequency	Percentage	Frequency	Percentage
12	1	1,82	-	-
10	-	-	1	1,43
8	2	3,64	6	8,57
7	5	9,09	-	-
6	4	7,27	5	7,14
5	5	9,09	-	-
4	29	52,73	25	35,72
3	9	16,36	33	47,14
Totals	55	100,00	70	100,00

3.1.2.4. Birth-ranking

51,55% of the white infants and 42,88% of the black infants were firstborn children. Frequency tables of birth-ranking for each group are given in Tables 14 and 15.

TABLE 14 : FREQUENCY TABLES OF BIRTH RANKING BLACKS

Family	Frequency	Cumulative Frequency	Percent	Cumulative percent
1	292	292	42,878	42,878
2	165	457	24,229	67,107
3	107	564	15,712	82,819
4	67	631	9,838	92,658
5	31	662	4,552	97,210
6	10	672	1,468	98,678
7	4	676	0,587	99,266
8	5	681	0,734	100,000

TABLE 15 : FREQUENCY TABLES OF BIRTH RANKING WHITES

Family	Frequency	Cumulative Frequency	Percent	Cumulative percent
1	382	382	51,552	51,552
2	258	640	34,818	86,370
3	81	721	10,931	97,301
4	17	738	2,294	99,595
5	2	740	0,270	99,865
6	1	741	0,135	100,000

3.1.2.5. Family size

The size of the family was taken as the number of people living within the one dwelling place who had regular contact with the infant concerned. This might include a living-in maid or the members of an extended family group.

There was considerable difference in family size between the black and the white groups. Whereas 73,28% of the white infants belonged to so-called nuclear family groups of 4 or fewer members, 79,74% of the black infants lived in family groups of 5 or more, with 21,44% living in groups of more than 10 people. A break-down of family size is given in Table 16.

TABLE 16 : FAMILY SIZE FOR THE TWO SAMPLE GROUPS

Family size	Blacks		Whites	
	Frequency	Percentage	Frequency	Percentage
4	138	20,264	543	73,279
5- 6	167	24,523	178	24,022
7-10	230	33,774	20	2,699
10	146	21,439	-	-

3.1.2.6. Marital status

All but 5 of the white mothers were married. Of these 5 mothers, 2 were unmarried, one was divorced and 2 were widowed.

43,37% of the black mothers were unmarried, 61,17% of these were young girls with a first baby. The remaining 38,83% lived with a common-law husband and generally had had more than one child by him.

3.1.2.7. Level of education

According to the 1980 Census figures, 73,17% of the black population in the areas included in this study had attained at least primary education, as compared with 80,54 of the black parents in the sample - see Table 17. The parents in this sample appear to be slightly better educated than the population as a whole, the difference being greatest at the level of secondary education.

TABLE 17 : EDUCATIONAL LEVELS OF BLACK PARENTS

Educational level completed	Father		Mother		Total		Population	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
None	147	21,586	118	17,327	265	19,457	25 500	26,154
Primary	326	47,871	270	39,648	596	43,759	40 500	41,538
Secondary	196	28,781	288	42,291	484	35,536	30 420	31,200
Tertiary	12	1,762	5	0,734	17	1,248	420	0,431
Unknown	-	-	-	-	-	-	25 500	26,154
Totals	681	100,000	681	100,000	1362	100,000	97 500	100,000

Of the total white population, 79,50 had attained at least primary education, as compared with 99,86% of the parents in the sample. It must, however, be remembered that the 1980 Census figures for the total population include school children, in particular children who have not yet completed primary school. The educational breakdown for the white parents is shown in Table 18.

TABLE 18 : EDUCATIONAL LEVELS OF WHITE PARENTS

Educational level completed	Father		Mother		Total		Population	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
None	2	0,270	-	-	2	0,270	19 720	19,198
Primary	37	4,993	26	3,509	63	4,251	14 280	13,902
Secondary	463	62,483	497	67,071	960	64,777	56 440	54,945
Tertiary	239	32,254	218	29,420	457	30,837	10 940	10,650
Unknown	-	-	-	-	-	-	1 340	1,305
Totals	741	100,000	741	100,000	1482	100,000	102 720	100,000

3.1.2.8. Parents' occupation

Scoring of the parents' occupation has been adapted from the Socio-economic Status Indices developed by the Technical Management Services of the City Engineer's Department, Cape Town, August 1976[147].

The score for occupation is, in fact, a multiple item score influenced by education, occupation and income, although in the present study education and income are also analysed separately. A simplified version of the occupational index, citing the occupations most commonly encountered during this study, is given in Addendum 1. The occupational groupings for the black and white samples are given in Tables 19 and 20.

TABLE 19 : OCCUPATIONAL SCORES FOR BLACK PARENTS

Occupational score	Father		Mother		Total	
	Frequency	%	Frequency	%	Frequency	%
9	0	-	0	-	0	-
8	0	-	0	-	0	-
7	11	1,62	9	1,32	20	1,47
6	24	3,52	8	1,18	32	2,35
5	112	16,45	7	1,03	119	8,74
4	111	16,30	450	66,08	561	41,19
3	277	40,66	42	6,17	319	23,42
2	138	20,26	70	10,28	208	15,27
1	8	1,18	95	13,95	103	7,56
Totals	681	99,99	681	100,01	1362	100,00

TABLE 20 : OCCUPATIONAL SCORES FOR WHITE PARENTS

Occupational score	Father		Mother		Total	
	Frequency	%	Frequency	%	Frequency	%
9	55	7,42	6	0,81	61	4,12
8	116	15,66	35	4,72	151	10,19
7	158	21,32	126	17,00	284	19,16
6	263	35,49	466	62,89	729	49,19
5	101	13,63	54	7,29	155	10,46
4	35	4,72	49	6,61	84	5,67
3	13	1,75	5	0,66	18	1,21
2 & 1	0	-	0	-	0	-
Totals	741	99,99	741	99,98	1482	100,00

It can be seen that 82,66% of the white parents had an occupational score of 6 or higher, falling largely into the "white collar" and skilled worker categories. In contrast, only 3,82% of the black parents had an occupational score of either 6 or 7 (the highest score in this group) and 46,25% of black parents had an occupational score of 3 or less.

The high percentage of 41,19 for the occupational score of 4 in the black group is due to the fact that the categories of scholar/student and housewife both fall into this group. It can be seen that no less than 450 of the 681 black mothers (66,08%) were allocated this score although the large majority of them did not perform any work for gain.

3.1.2.9. Parents' income

The combined income of both parents is shown in Tables 21 and 22. This is based upon the "take-home" pay since the informant was in almost all instances the mother, who very often did not know her husband's total pay before deductions. This method is not very accurate, particularly in the white group where housing subsidies were frequently also deducted. The mothers were however, asked to make allowance for this in their estimate and, since the income is ranked in groups, the error is unlikely to be significant.

TABLE 21 : FAMILY INCOME - BLACK GROUP

Income p.a.	p.m.	Frequency	%	Cumulative %
R20 000 & over	1 667 & over	0	-	-
15 000-19 999	1 250 - 1 666	0	-	-
10 000-14 999	834 - 1 249	1	0,15	0,15
7 500- 9 999	625 - 833	8	1,18	1,33
5 000- 7 499	417 - 624	15	1,91	3,24
2 500- 4 999	209 - 416	111	16,30	19,54
1 000- 2 499	84 - 208	265	38,91	58,45
500- 999	43 - 83	58	8,52	66,97
Under 500	Under 42	74	10,87	77,84
Parental or family support only	-	151	22,17	100,00
TOTALS		681	100,00	100,00

In most cases, when the family income was less than R500 it represented maintenance paid by the father to the unmarried mother towards the care of the baby. The mother in this case lived with and was supported by her own family, and the income stated does not reflect the economic circumstances of the family. Nevertheless it can be seen that nearly 39% of the black families in the sample had a combined income of between R84 and R208 per month.

TABLE 22 : FAMILY INCOME - WHITE GROUP

Income p.a.	p.m.	Frequency	%	Cumulative %
R20 000 & over	1 667 & over	133	17,95	17,95
15 000-19 999	1 250 - 1 666	147	19,84	37,79
10 000-14 999	834 - 1 249	256	34,55	72,34
7 500- 9 999	625 - 833	154	20,78	93,12
5 000- 7 499	417 - 624	34	4,59	97,71
2 500- 4 999	209 - 416	11	1,48	99,19
1 000- 2 499	84 - 208	2	0,27	99,46
500- 999	42 - 83	0	-	99,46
Under 500	Under 42	0	-	99,46
Parental or family support only	-	4	0,54	100,00
TOTALS		741	100,00	100,00

3.2 ADMINISTRATION OF THE TESTS

The area in which testing was carried out varied considerably between clinics. At all clinics a table was available and a mat was placed either upon the table for younger infants or on the floor for older infants. Only at 2 of the 3 black clinics and 3 of the 18 white clinics was a separate room available for testing, with a heater available in winter. The remaining clinics were conducted mainly in church or civic halls, where as quiet a corner as possible was chosen. At 2 of the white clinics space was very limited and testing had to be carried out in the general waiting and sorting area.

At each clinic the infants were first weighed and screened for general health by the Clinic Sisters. As far as possible all infants were tested before being subjected to any inoculations or injections. No infant was tested in an upset state. If the infant was sleeping, his mother was asked to bring him gently to an alert state by "jiggling" him in an upright position in her arms during the interview. I tried to ensure optimal alertness during testing.

One examiner, myself, performed all interviewing and testing. Occasionally in the black clinics a Clinic Sister had to act as interpreter during the interview. Whilst interviewing the mother the baby was observed for his general state of health, alertness and responsiveness, and an attempt was made to establish rapport before he was undressed and tested. The mother or caretaker was present throughout the testing procedure, and was asked to repeat to the child, in Xhosa, instructions for the more advanced fine motor items. As far as possible babies were undressed completely for testing of gross motor and supplementary items. In cold weather, if no heating was available, vest and nappy were left on. Generally the fine motor items of the DDST were tested first, followed by the DDST gross motor items integrated with the supplementary items in a logical sequence for each infant. Items occurring spontaneously during the course of testing were scored as they occurred.

The mean time taken for testing was 15,52 minutes for the black group and 15,74 minutes for the white group, being shorter for the younger infants and longer for the older ones. The range for the black group was 7 to 23 minutes with a median of 15 minutes. That for the white group was 8 to 25 minutes with a median of 16 minutes.

3.2.1. The DDST Items

The gross and fine motor items of the DDST were carried out in strict accordance with the test manual[148], with the following exceptions:

3.2.1.1. The test manual allow a pass to be scored by parent's report for items 4, 8, 9, 11, 14 and 18 on the fine motor-adaptive scale and items 6, 10-20 and 23 on the gross motor scale. For the purpose of this study I only accepted the parent's report for item 23 (pedals tricycle) on the gross motor scale. All other items were only credited if seen during testing.

3.2.1.2. Item 18 on the fine motor scale - scribbles spontaneously: The test manual does not allow demonstration by the examiner. Since so few of the black children had been given the chance to scribble I demonstrated this item once if the child did not scribble spontaneously. I did this for both black and white children, and was interested to hear many white parents comment that they had never allowed their child to handle a pencil for fear of damage to walls and furniture.

3.2.1.3. Item 20 on the fine motor scale - dumps raisin from bottle spontaneously: The criteria in the test manual do not exclude accidental dumping by shaking. I only scored this present if the child deliberately up-ended the bottle.

3.2.1.4. Item 6 on the gross motor scale - rolls over : The test manual allows scoring for rolling either from prone to supine or supine to prone. Since the former occurs very much earlier than the latter, and may also happen accidentally, I only scored this item as present if the infant rolled from supine to prone.

3.2.2. Supplementary items

The proposed supplementary test items were assessed for reliability between and within observers in a separate trial.

Trial of supplementary items

Fifty-four test items describing specific developmental patterns, either spontaneous or elicited, were included in the initial trial (Table 23). Twenty-four white infants and 20 urban black infants between the ages of 6 and 78 weeks were recorded on colour videotape using two cameras simultaneously. The infants were assessed in an alert but not crying state, in a warm atmosphere and fully undressed. The recording of one (white) infant was used for practice in analysis and was discarded when the three observers had reached consensus. The videotapes of the remaining 43 infants were analysed by the three observers independently, each on three separate occasions over a period of two weeks. Their observations were recorded on a specially designed form which allowed a maximum of five recordings per item for each baby (Addendum 2).

The results were analysed by the Department of Biostatistics of the Medical Research Council.

Variation between observers

A standard one-way analysis of variance was used to test for differences of means between observers over all babies and all viewings. No significant differences were found at the 5% level on the total score over all 54 items, nor on any of the individual items.

Variation within observers

In the total score an increase was observed from the first viewing to the second and from the second to the third, indicating a possible overall learning effect. This was significant at the 0,5% level. However, this was not consistent for individual items. Eight items showed significant differences at the 5% level.

Calculation of reliability

Ten items were excluded because of insufficient data (i.e. observed less than 4 times). In order to ascertain the percentage of total variation in the scores due to differences between the babies only, reliability for the remaining 44 items was estimated using a standard analysis of variance computational procedure which does not require assumptions as to normality of score distrubution or observer/viewing effects. Variations due to differences between infants, observers, viewings, interactions between the foregoing three variables and variables due to random error were also calculated. The estimated reliability ranged from 5,1% to 93% (Table 23). On the basis of this analysis, and since only one observer, myself, was to be used in the main trial, 21 items with a reliability of more than 59% were selected for inclusion in the main trial. Reliability of the selected items ranged from ,60 to ,93, which is comparable with that of the items in Bayley's revised motor scale[31] which ranges from ,57 to ,97.

In order to increase the reliability of all items to at least 80%, multiple observations may be made using the formula

$$\hat{r}_n = \frac{n\hat{r}_1}{1+(n-1)\hat{r}_1}$$

where $\hat{r}_1$ is the estimated reliability of a single observation and $\hat{r}_n$ is the estimated reliability of the mean of n observations. In this case the number of repetitions needed to raise the reliability of the item with the lowest acceptable reliability (item no. 45 - 59,8%) to over 80% would be 3. The increased reliability of multiple observations of the 21 selected items is shown in Table 24.

TABLE 23 : ESTIMATED PERCENTAGE RELIABILITY OF PROPOSED SUPPLEMENTARY ITEMS

Item no.	Item	Estimated reliability
1	Asymmetrical tonic neck reflex posture	56,4
2	Primary walking	38,5
3	Grasp reflex	81,0
4	Galant (trunk incurvation response)	60,3
5	Flexed legs rest on heels/lat. border (supine)	63,4
6	On elbows: adduction scapulae/abd-int. rot. humerus	58,2
7	Ventral suspension: head above line of trunk	21,1
8	Anterior pelvic tilt in prone	29,9
9	Head in line with shoulders on pull to sit	61,8
10	Hands to midline in flexion/int. rotation	33,9
11	Moro still present	49,8
12	On elbows: abd. scapulae/add-neutral rot. humerus	23,4
13	Swimming: adduction scapulae	56,9
14	Supine: hands to knees in internal rot./pronation	70,2
15	Supine: total flexion but no posterior tilt	54,2
16	Startle still present	8,7
17	Downwards parachute reaction of legs	15,1
18	Placing reactions legs (tactile)	67,3
19	Downwards parachute reaction of arms	67,3
20	Weightshift on elbows with lateral trunk flexion	54,2
21	Early weight on hands (int. rot./abd./semiflex./fisted)	67,3
22	Full Landau reaction	*
23	Supine: reach in adduction/neutral rotation	56,2
24	Lifts head in anticipation of pull to sit	17,4
25	Supine: hands-to-feet <u>or</u> total flex. with post. tilt	66,8
26	Bridging	40,0
27	Weightshift on elbows with elongation W-B side	52,5
28	Rolls prone to supine	*
29	Full equilibrium reactions on oblique suspension	52,5
30	Amphibian on weight-shift on elbows	68,2
31	On elbows: reach in internal rotation	44,0
32	Weight on hands in add./neutral rot./open hands	74,7
33	Rolls supine to prone	85,2
34	Pivotting	56,0

TABLE 23, cont.:

Item no.	Item	Estimated reliability
35	Creeping: unilateral with lateral flex. trunk	91,9
36	Creeping: reciprocal with rotation	*
37	Sitting: arms free for play	68,4
38	Sitting to prone	19,5
39	On hands and knees	63,3
40	Sideways protective extension arms	61,9
41	Crawling	92,7
42	Cruising	5,1
43	Bearstanding	80,0
44	Bearwalking	*
45	Backwards protective extension arms	59,5
46	Full equilibrium reactions in sitting	*
47	Sideways protective steps	66,4
48	Backwards protective steps	*
49	Walks on toes	26,9
50	Walks on heels	73,3
51	Walks down steps: 2 feet to each step	-
52	Walks up steps reciprocally	-
53	Walks down steps reciprocally	-
54	Equilibrium reactions in standing (doesn't alter base)	-

* Insufficient observations

\- No observations

TABLE 24 : RELIABILITY FOR INCREASED NUMBER OF OBSERVATIONS OF SUPPLEMENTARY TEST ITEMS

Final item no.	Original item no.	Reliability Single observation	Mean of 2 observations	Mean of 3 observations
17	41	92,7	96,2	97,4
13	35	91,9	95,8	97,1
12	33	85,2	92,0	94,5
1	3	81,0	89,5	92,7
18	43	80,0	89,0	92,3
11	32	74,7	85,5	89,9
21	50	73,3	84,6	89,2
5	14	70,2	82,5	87,6
14	37	68,4	81,2	86,7
10	30	68,2	81,1	86,5
7	19	67,3	80,5	86,1
8	21	67,3	80,5	86,1
9	25	66,8	80,1	85,8
20	47	66,4	79,8	85,6
3	5	63,4	77,6	83,9
15	39	63,3	77,6	83,9
16	40	61,9	76,5	83,0
4	9	61,8	76,4	82,9
6	18	60,6	75,5	82,2
2	4	60,3	75,2	82,0
19	45	59,6	74,7	81,6

ADMINISTRATION OF SUPPLEMENTARY ITEMS

I differentiated between those items of a reflex nature, for which 3 successive observations were required, and those which were spontaneous or requested movement reactions for which only one observation was required.

The supplementary items were administered as follows:

Item 1 - Grasp reflex:
The index finger was placed into the hands from the ulnar side and pressed into the palm. If the grasp reflex was elicited on three successive tests it was scored as being present.

Item 2 - Galant (trunk incurvation):
The trunk incurvation response was tested by ventrally suspending the infant over the palm of my one hand whilst drawing the blunt end of a pin paravertebrally the length of the spine, first on one side and then on the other. Again, three successive reactions on each side were required.

Item 3 - Flexed legs rest on heels and lateral borders of feet in supine:
The infant was observed at rest in supine, as well as whilst conducting other tests in supine. Only one observation was required.

Item 4 - Head in line with shoulders on pull-to-sit:
The infant's hands were grasped using one finger in the palm of the hand and a second finger stabilizing the wrist, and he was pulled slowly from supine to sitting. The item was only scored as being present if the infant could maintain the head position on 3 successive tests.

Item 5 - Supine - hands to knees:
The pattern of the arms is that of internal rotation and forwards flexion at the shoulders, fairly extended elbows, some pronation of the forearm and open hands. The infant was observed at rest in supine as well as whilst conducting other tests in supine. Only one observation was required.

Item 6 - Placing reactions of the feet (tactile):
The dorsum of each foot, one foot at a time, was touched gently against the edge of the table. If the response was present the infant flexed his knee and hip, dorsiflexed his foot and placed the sole of the foot upon the surface of the table.
Three successive reactions on each side were required.

Item 7 - Downwards parachute reaction of the arms:
The infant was held in ventral suspension and was then lowered suddenly, head down, towards the mat. The response was scored present if the infant extended both arms towards the mat and if the reaction was present on 3 successive tests.

Item 8 - Early weight on hands:
The pattern is that of adduction of the scapula, internal rotation and abduction of the humerus, semi-flexion of the elbow, pronation of the forearm and semi-fisting of the hand. The infant was observed whilst moving spontaneously in prone and was also tempted by lifting a toy in front of him. Only 1 observation was required.

Item 9 - Supine - hands to feet or total flexion with posterior pelvic tilt:
Since this item reflects good flexor control, the acceptable alternative to hands-to-feet was flexion of hips and knees combined with posterior tilt of the pelvis, so that the buttocks were raised from the supporting surface. The infant was observed whilst moving spontaneously in supine and was also stimulated by tickling or blowing onto his abdomen. Only one observation was required.

Item 10 - Amphibian reaction when shifting weight on elbows:
The pattern is that of lateral flexion of neck and trunk on the non-weightbearing side and flexion-abduction-lateral rotation of the non-weightbearing leg. The infant was observed whilst moving spontaneously in prone and if necessary was stimulated by moving a toy from side to side in front of him.
Only one observation was required.

Item 11 - Advanced (established) weight on hands:

The pattern is that of abduction of the scapulae, external rotation and adduction of the humerii, extension of the elbows, neutral pronation/supination of the forearms and open hands. The procedure was the same as for item 8. Only one observation was required.

Item 12 - Rolls supine to prone:

The infant was placed in supine and was tempted to roll by his mother's voice or by placing a toy to one side and slightly beyond his head. The pattern of rolling was immaterial. Only one observation was required. This item was included in the supplementary list because of reservations concerning the scoring of the DDST item "rolls over".

Item 13 - Creeping:

The pattern required was the early creeping pattern showing lateral trunk flexion with ipsilateral arm and leg movements, similar to the amphibian reaction but incorporating forwards progression. If the more advanced pattern of trunk rotation and reciprocal limb movements was already established, this was considered to have superceded the original pattern and the item was scored as present. The infant was observed moving spontaneously in prone and was also tempted by moving a toy in front of him beyond his reach. A definite forwards progression was required.

Item 14 - Sitting, arms free for play:

Following item 4 (pull-to-sit) the child was left in unsupported sitting. If he was able to maintain this without arm-support the item was scored as present. In order to encourage him to do this he was offered a toy which required manipulation with both hands.

Item 15 - On hands and knees (all fours):

The pattern required was weightbearing on hands and knees, elbows more or less extended, hips and knees flexed and abdomen not in contact with the surface. No differentiation was made between early and more advanced patterns of weightbearing on hands and knees. The child was placed in prone and, if necessary, was tempted with a toy held in front of him and slightly above the mat. Only one observation was required.

Item 16 - Sideways protective extension of the arms:

The child was placed in sitting and was displaced from side to side by gentle thrusts at waist-level. To be scored present the reaction had to be effective enough to prevent the child's falling sideways and had to be present on each side on 3 successive tests. If it was not effective the examiner caught the child before he fell over.

Item 17 - Crawling:

The pattern required was forwards progression on hands and knees, elbows more or less extended, hips and knees flexed and abdomen not in contact with the floor. A definite forwards progression was required but no differentiation was made between early and more advanced patterns of crawling. The child was placed in prone and was tempted with a toy placed in front of him and beyond his reach, or by his mother's call. Only one observation was required.

Item 18 - Bearstanding:

The pattern required was weightbearing on more or less plantigrade feet and open or semi-flexed hands. It was most often seen as part of the progression from prone to standing when observing the item "pulls to stand" on the gross motor scale of the DDST. Since it is difficult to elicit if not observed during spontaneous movement this was the only supplementary item which, if necessary, was scored according to the parent's report. In this case I demonstrated the position to the parent and asked whether they had seen their child perform it.

Item 19 - Backwards protective extension of the arms:

The child was placed in sitting and was displaced backwards by gentle thrust at chest level, carried out slowly to allow the child time to respond. The response was considered adequate if the child could catch his weight backwards onto one or both hands and avoid falling over. If he failed to do so I caught him. Three successive observations were required. In a child who was not yet walking I carried out this test last in order not to distress him during testing.

Item 20 - Sideways protective steps:

These were only tested if the child was already walking independently. With the child in standing, his weight was shifted sideways by a gentle thrust at waist-level. For the reaction to be regarded as adequate the child had to be able to retain his balance by stepping sideways, either by abducting the leg on the side to which he was pushed or by crossing over with the opposite leg. If he could not do so the examiner caught him. In a child who was already walking this test was usually performed last in order not to distress him. Three successive adequate responses to each side were required.

Item 21 - Walks on heels:

This item applied only to the older children in the sample. They were asked to imitate the examiner, or if necessary the mother, the skill being scored present if they could take 6 successive steps on their heels, i.e. 3 with each foot.

The forms on which the results of the interview and tests were recorded are shown in Addendum 3.

3.3 STATISTICAL TESTS*

3.3.1. Calculation of developmental norms

The percentage of children responding to the different tests at different ages was determined by fitting curves to the response rate as a function of age, using probit analysis[(149)]. In cases where the probit models did not fit, non-parametric logistic regression was used[(150)]. Addendum 4 details the chi-square and p-values indicating goodness-of-fit for these curves.

3.3.2. Analysis of co-variates

Interactions between the age of attainment and the different co-variates were allowed to enter logistic regression equations. The contribution of the interaction term to the predicted age was measured by an "improvement" chi-square statistic. Associated p-values of less than 0,05 were taken to indicate a significant contribution and hence a significant interaction.

3.3.3. Comparison of sample groups

Statistical comparison of the Denver sample and the 2 South African samples was not possible because the data for the original Denver sample is no longer available.

3.3.3.1. In a preliminary comparison of the 2 South African groups interaction terms were derived as described in 4.2 above.

3.3.3.2. In addition, the achievement age distributions of each item for the two South African samples were compared using a chi-square test. A maximum of 18 degrees of freedom ($18 = (19-1) \times (2-1)$) was used to determine significance, being reduced accordingly when 100% achievement was reached in fewer than 19 age-intervals, e.g. if 100% of children achieved fine motor item no. x by the age of 11 months the degree of freedom was taken as $11-1 = 10$.

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* PROGRAMMES USED:
1. Probit analysis : SAS Proc PROBIT
2. Non-parametric logistic regression : GAIM
3. Logistic regression equations co-variates : BMDPLR
4. Graphs for co-variates : SAS Proc GPLOT

Chapter 4

RESULTS

4.1 DDST ITEMS

Tables 25 - 28 give the ages at which 25%, 50%, 75% and 90% of each of the two ethnic samples achieved the fine and gross motor items of the DDST. These are displayed as histograms in Figures 2 - 5. Tables 29 - 32 compare the 50% and 90% attainment ages for each group with those of the Denver sample.

It is not possible to compare the South African and Denver samples statistically since the data for the original Denver sample no longer exists, but Frankenburg and Dodds[56] consider that a difference of one month or more in the achievement of any test item within the first year of life, taking the 50% and 90% attainment ages as norms, should be considered noteworthy.

4.1.1. The black sample

In the fine motor-adaptive items there is a general trend favouring the South African black sample over the original Denver sample. At the 50% attainment level the black sample achieved 20 of the 23 items for which comparative data was available earlier than the Denver sample, although of the items achieved within the first year only 4 items were achieved more than 1 month earlier. The Denver sample achieved 2 out of 10 items in the second and third years considerably earlier (items 20 and 21).

At the 90% attainment level the black sample achieved 16 of the 20 items for which data is available earlier than the Denver sample, 4 of the items achieved within the first year appearing more than one month earlier. In the second and third years the black group achieved 6 of the 7 items considerably earlier, including a reversal or the previous trend on item 21. The Denver sample again achieved item 20 earlier (although less notably so) and reasons for this are advanced in Chapter 5.

In the gross motor items there is again a general trend favouring the South African black sample over the original Denver sample. At the 50% attainment level the black sample achieved 20 of the 25 items earlier, although only 2 of those acquired during the first year were achieved more than one month earlier. The Denver sample achieved item 6 (rolls over) more than 2 months earlier; the validity of the scoring of this item was discussed in Chapter 3. In the second and third years the black sample achieved 9 of the 10 items earlier, 6 of them by more than 4,5 months. The exception was item 23 (pedals tricycle) which the Denver sample achieved 6,71 months earlier.

At the 90% attainment level the black sample achieved 20 of the 24 comparable items earlier, 7 of the first-year items being acquired more than one month earlier. In the second and third years the black group achieved 9 of the 11 items earlier, 6 of them by more than 4 months. The Denver sample again achieved items 6 and 23 earlier by 1,63 and 2,73 months respectively.

4.1.2. The white sample

In the fine motor-adaptive items there is again a general trend favouring the South African white sample over the Denver sample. At the 50% attainment level the white sample achieved 20 of the 23 items earlier than the Denver sample. Only 3 of the items in the first year were acquired more than 1 month earlier, whereas 6 of the 10 items in the second and third years were achieved more than 1,5 months earlier. The Denver sample again achieved item 20 considerably earlier, by 2,48 months.

At the 90% attainment level the white sample achieved 16 of the 18 items for which data is available earlier than the Denver sample. Of those attained within the first year of life only 4 were earlier by more than 1 month, whereas in the second and third years all items were achieved more than 2,5 months earlier, including item 20 (3,43 months earlier).

In the gross motor items there is no general trend at the 50% level, the white South African sample achieving 11 items earlier and the Denver sample 12 items. There is, however, a trend in favour of the Denver sample in the first year (10 out of 14 items, 3 of them by more than 1 month) and in favour of the white South African sample in the second and third years (7 out of 10 items, 5 of them by more than 4,8 months). In the first year the performance of the South African sample was noteworthy for items 7 (no head lag) and 8 (bears some weight on legs).

At the 90% attainment level there is a slight trend in favour of the South African sample, who achieved 14 of the 22 comparable items earlier, 4 of those achieved in the first year being acquired more than 1 month earlier as against 2 items for the Denver sample (being items 5 and 6 - see comments Chapter 3). In the second and third years the only noteworthy differences were achieved by the South African sample who attained 6 of the 10 items earlier, all but one by more than 3,0 months.

4.1.3. Comparative analysis of the two South African samples

Further analysis of the black and white South African samples was undertaken as detailed in Chapter 3, section 3.3.3.

4.1.3.1. Interaction terms

Comparison of the total scores of the black and white samples using the Kruskal-Wallis test showed no significant differences between the ethnic groups at any level of acquisition for fine motor-adaptive or gross motor items. Five fine motor items and 9 gross motor items did, however, show appreciable interaction between ethnic group and age of acquisition. Of these, 3 fine motor items and 2 gross motor items were statistically significant at the $p \leq 0{,}05$ level.

Fine motor items

These 3 items were neat pincer grasp of raisin ($p = 0{,}05$), in which the black group was more advanced, and dumps raisin from bottle spontaneously ($p = 0{,}01$) and tower of 8 cubes ($p = 0{,}03$) in which the white group was more advanced.

Gross motor items

These 2 items were bears some weight on legs ($p = 0{,}009$) and jumps in place ($p = 0{,}01$) in which the black group were more advanced.

In another 7 items the black group were also more advanced at the $p \leq 0,1$ level. These were:

Prone, chest up, arm-support	($p = 0,09$)
Sits without support	($p = 0,08$)
Stands holding on	($p = 0,06$)
Gets to sitting	($p = 0,10$)
Walks holding onto furniture	($p = 0,10$)
Stands momentarily	($p = 0,06$)
Broad jump	($p = 0,10$)

4.1.3.2. Achievement age distributions

Using this method there was no significant difference between the black and white groups with respect to any fine motor items. In 4 gross motor items the black group was significantly advanced. These were:

Sits without support	($p < 0,025$ @ 11 d.o.f.)
Stands holding on	($p < 0,010$ @ 13 d.o.f.)
Gets to sitting	($p < 0,05$ @ 14 d.o.f.)
Heel-to-toe walk	($p < 0,0005$ @ 18 d.o.f.)

In one gross motor item, pedals tricycle, the white group was significantly advanced ($p < 0,0005$ @ 18 d.o.f.).

Although statistically significant differences between the black and white groups were only established for relatively few items, apparent trends are evident in Table 33. Only those items in which the difference in age of acquisition is greater than one month are listed. In the fine motor items in which a notable difference existed the white group performed better in 10 items, all of which involved manipulation of a specific object, whereas the black group performed better in the two basic grasping items. Notable differences in the gross motor items occurred in favour of the black group for 7 items achieved within the first year of life, but in favour of the white group for 6 items acquired during the second and third years. The black group achieved the two jumping items considerably earlier and overtook the white group on balance during the third year, the white group having been more advanced on balance items during the second year.

Overall - in the fine motor-adaptive items the white group achieved 17 out of 25 items for which data is available earlier than the black group at the 50% attainment level, reducing to 13 out of 25 at the 90% level. In the gross motor items the black group achieved 13 of the 17 items occurring in the first year earlier at the 50% level and 15 earlier at the 90% level, whereas in the second and third years the white group achieved 6 of the 9 items for which data is available, earlier at both the 50% and 90% levels.

TABLE 25 : AGE PERCENTILES FOR FINE MOTOR ITEMS (IN MONTHS) - BLACKS

Item no.	Item	25%	50%	75%	90%
1	Follows to midline	100% at less than 16 days			
2	Symmetrical movements	100% at less than 16 days			
3	Follow past midline	0,0000	0,0717	0,8578	1,5654
4	Hands together	0,0000	0,3768	0,9979	1,5569
5	Follows 180^{o}	1,6151	2,3015	2,9878	3,6056
6	Grasps rattle	1,2377	1,6928	2,3152	3,0389
7	Regards raisin	1,9973	2,7519	3,7915	5,0592
8	Reaches for object	2,9613	3,5804	4,1994	4,7566
9	Passes cube hand to hand	4,0947	5,0772	6,0596	6,9439
10	Sitting - looks for yarn	4,0051	5,0375	6,1299	7,0861
11	Sitting - takes 2 cubes	4,8394	5,7388	6,8054	7,9338
12	Rakes raisin - attains	5,5422	6,3583	7,7144	7,9090
13	Thumb-finger grasp	6,8000	7,4000	8,0000	8,6000
14	Bangs 2 cubes held in hands	6,1973	7,6733	9,5008	11,5151
15	Neat pincer grasp raisin	7,6000	8,4000	9,6000	11,0000
16	Tower of 2 cubes	11,8381	13,7952	16,0758	18,4491
17	Dumps raisin from bottle (demonstrated)	10,7377	12,1737	13,8078	15,4525
18	Scribbles spontaneously	11,0353	13,1773	15,7347	18,4582
19	Tower of 4 cubes	15,0861	17,5490	20,0119	22,2285
20	Dumps raisin from bottle (spontaneously)	15,3070	18,4211	22,1776	26,2092
21	Imitates vertical line within 30^{o}	20,7678	25,1381	29,5085	33,4419
22	Copies circle	25,3461	30,0472	34,7484	>36,0000
23	Tower of 8 cubes	19,4160	23,0590	26,7020	29,9808
24	Imitates bridge	26,5453	31,1015	>36,0000	>36,0000
25	Picks longer line	28,4403	32,8093	-	-
26	Copies cross	>36,0000	>36,0000	-	-
27	Draws man (3 parts)	-	-	-	-
28	Imitates square (demonstrated)	-	-	-	-
29	Copies square	-	-	-	-
30	Draws man (6 parts)	-	-	-	-

Fig. 2 AGE PERCENTILES FOR FINE MOTOR ITEMS

BLACK GROUP

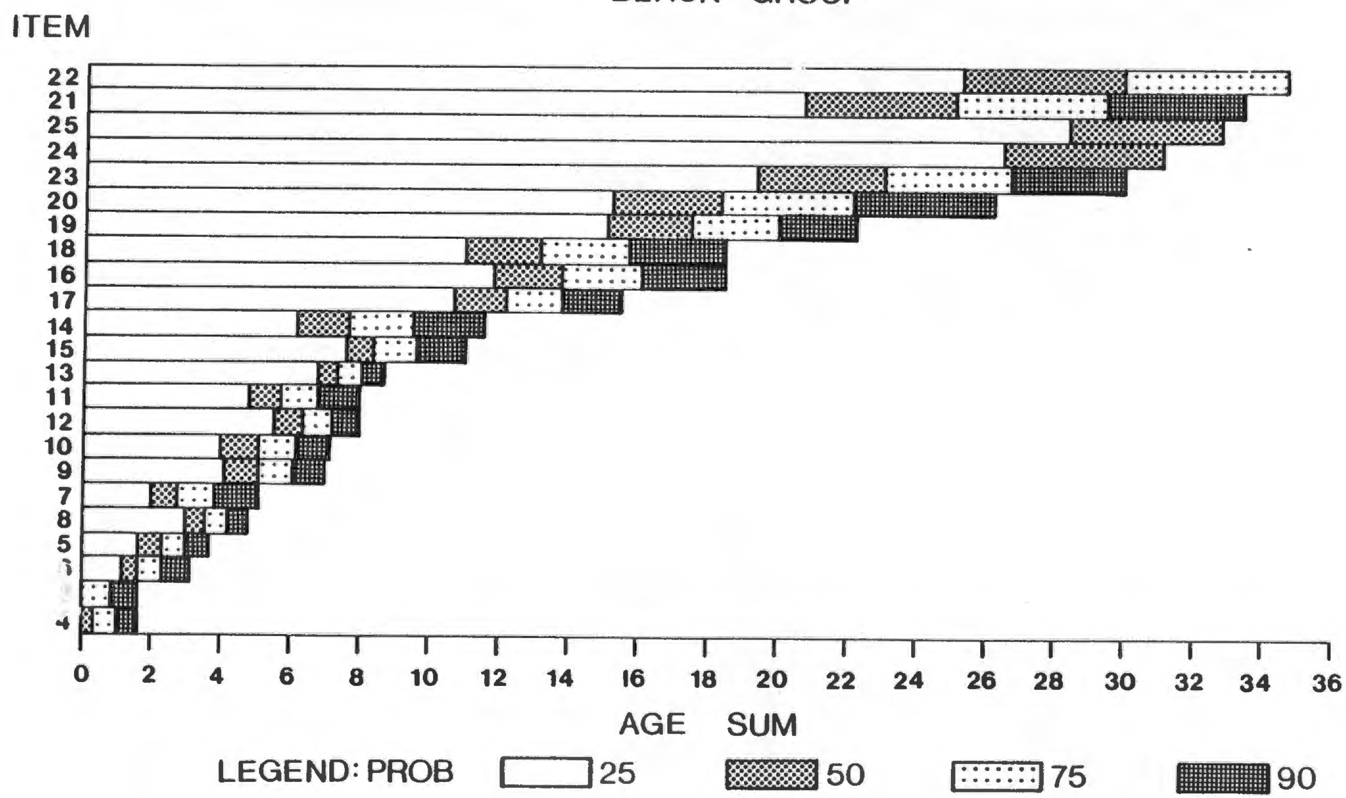


TABLE 26 : AGE PERCENTILES FOR FINE MOTOR ITEMS (IN MONTHS) - WHITES

Item no.	Item	25%	50%	75%	90%
1	Follows to midline	100% at less than 16 days			
2	Symmetrical movements	0,0009	0,0047	0,0253	0,1143
3	Follows past midline	0,1879	0,3501	0,6524	1,1424
4	Hands together	0,3975	0,6048	0,9203	1,3429
5	Follows 180°	1,4127	1,9578	2,7131	3,6392
6	Grasps rattle	1,1290	1,6213	2,3282	3,2247
7	Regards raisin	1,9729	2,6461	3,5489	4,6221
8	Reaches for object	2,8784	3,5261	4,3195	5,1852
9	Passes cube hand to hand	4,2000	5,0000	5,6000	5,8000
10	Sitting - looks for yarn	4,1701	4,8908	5,7360	6,6210
11	Sitting - takes 2 cubes	4,6345	5,5987	6,7636	8,0181
12	Rakes raisin - attains	5,5000	6,0000	6,8000	7,6000
13	Thumb-finger grasp	6,6135	7,6392	8,8242	10,0473
14	Bangs 2 cubes held in hands	6,4105	7,7721	9,4229	11,2064
15	Neat pincer grasp raisin	7,8078	9,1053	10,6184	12,1941
16	Tower of 2 cubes	11,9604	13,2190	14,6100	,15,6505
17	Dumps raisin from bottle (demonstrated)	11,7463	12,9681	14,3169	15,6505
18	Scribbles spontaneously	11,3000	11,8000	14,2000	15,0000
19	Tower of 4 cubes	14,5002	16,3708	18,4827	20,6154
20	Dumps raisin from bottle (spontaneously)	13,8634	15,8827	18,1962	20,5652
21	Imitates vertical line within 30°	18,4754	22,0309	26,2708	30,7802
22	Copies circle	22,8320	26,8316	31,5318	>36,0000
23	Tower of 8 cubes	18,2655	20,4771	22,9564	25,4436
24	Imitates bridge	26,5744	30,0550	33,9914	>36,0000
25	Picks longer line	27,1477	30,8708	35,1044	-
26	Copies cross	32,3577	>36,0000	>36,0000	-
27	Draws man (3 parts)	32,9648	-	-	-
28	Imitates square (demonstrated)	36,0000	-	-	-
29	Copies square	>36,0000	-	-	-
30	Draws man (6 parts)	-	-	-	-

Fig. 3 AGE PERCENTILES FOR FINE MOTOR ITEMS

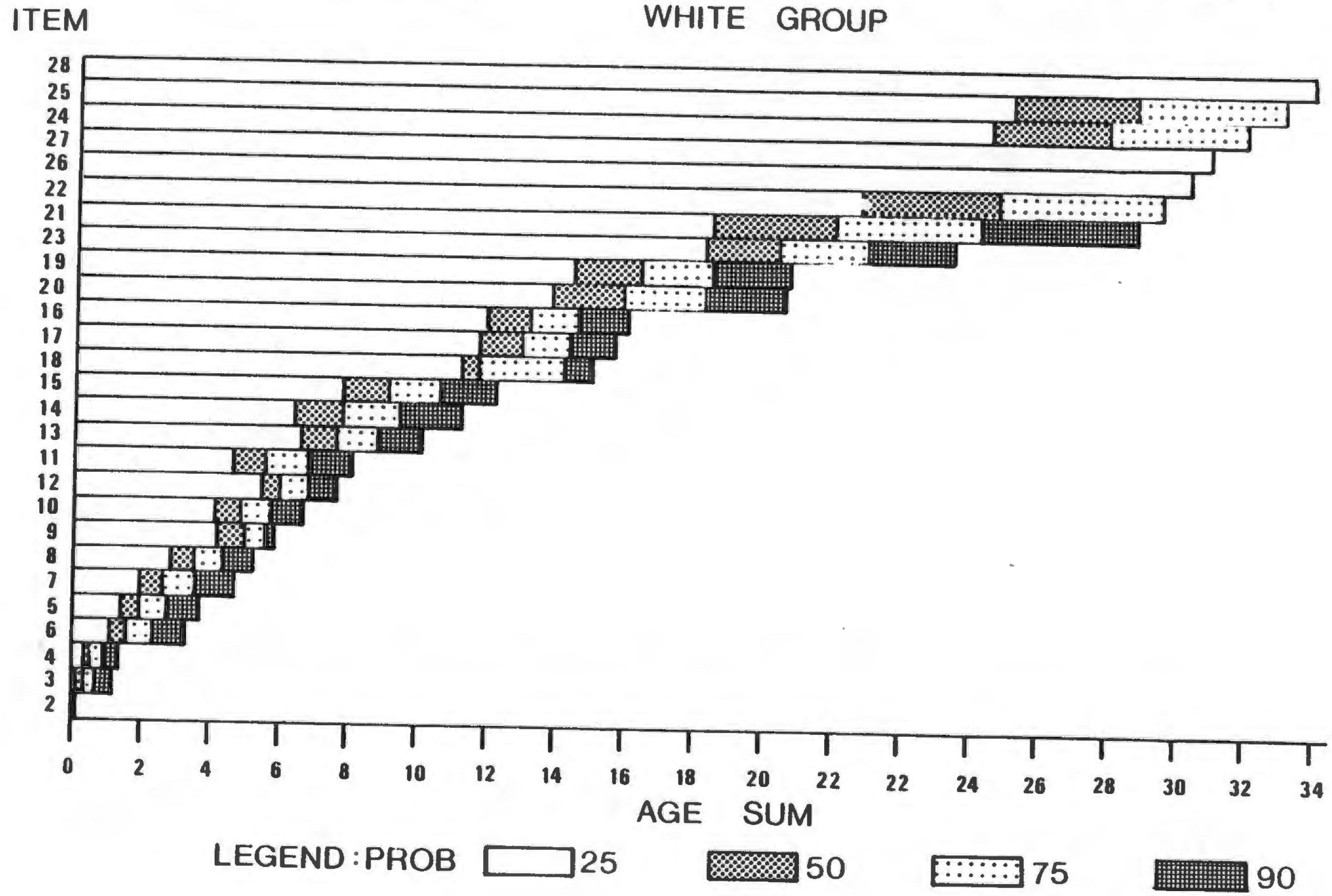
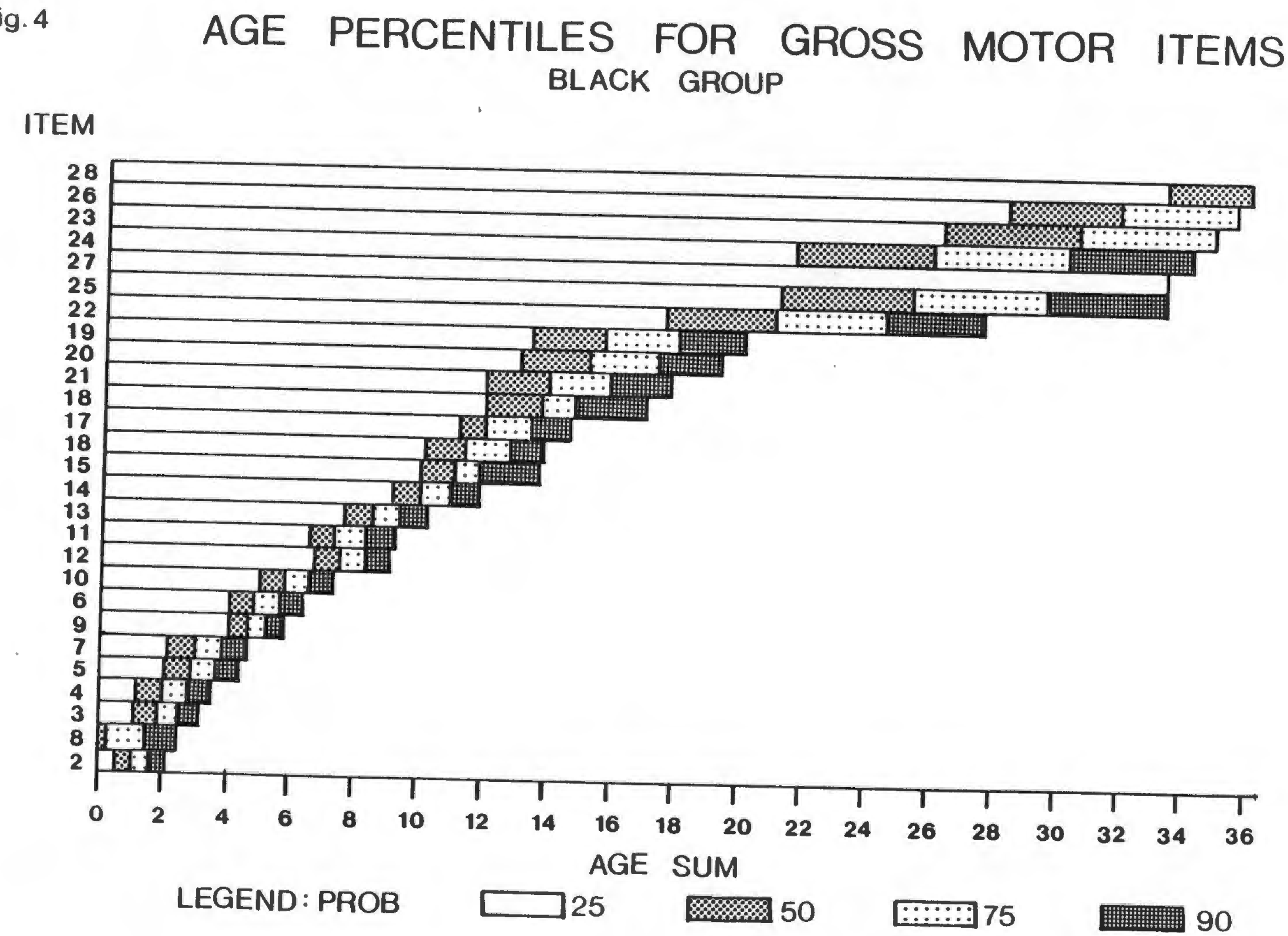


TABLE 27 : AGE PERCENTILES FOR GROSS MOTOR ITEMS (IN MONTHS) - BLACKS

Item no.	Item	25%	50%	75%	90%
1	Prone - lifts head	100% at less than 16 days			
2	Prone - lifts head 45°	0,5729	1,0890	1,6051	2,0696
3	Prone - lifts head 90°	1,1649	1,8263	2,4878	3,0831
4	Sitting - head steady	1,2011	1,9954	2,7897	3,5046
5	Prone - chest up, arm-support	2,0602	2,8538	3,6474	4,3617
6	Rolls over	4,0640	4,8455	5,6270	6,3303
7	Pulls to sit - no headlag	2,1314	2,9818	3,8322	4,5076
8	Bears some weight on legs	0,0000	0,2252	1,3630	2,3870
9	Sits without support	4,0721	4,6411	5,2101	5,7222
10	Stands holding on	5,0230	5,7997	6,5763	7,2753
11	Pulls self to stand	6,5624	7,3561	8,2458	9,1382
12	Gets to sitting	6,7445	7,5229	8,3013	9,0019
13	Walks holding onto furniture	7,6525	8,5267	9,4010	10,1879
14	Stands momentarily	9,1353	10,0470	10,9588	11,7794
15	Stands alone well	10,0000	11,1000	11,8000	13,7000
16	Stoops and recovers	10,1000	11,4000	12,8000	13,8000
17	Walks well	11,2000	12,0000	13,5000	14,6000
18	Walks backwards	12,0000	13,8000	14,8000	17,0000
19	Walks up steps	13,4689	15,7521	18,0352	20,0901
20	Kicks ball forwards	13,1259	15,2721	17,4183	19,3500
21	Throws ball overhand	12,0000	14,0000	15,9000	17,8000
22	Jumps in place	17,6588	21,0916	24,5244	27,6140
23	Pedals tricycle	26,3457	30,6147	34,8838	38,7261
24	Balances on 1 foot (1 sec)	21,6821	25,9873	30,2925	34,1673
25	Broad jump	21,2272	25,4199	29,6127	33,3863
26	Balances on 1 foot (5 sec)	28,3660	31,2054	35,5743	>36,0000
27	Hops on 1 foot	33,4170	>36,0000	>36,0000	-
28	Heel-to-toe walk	33,4217	35,9780	-	-
29	Catches bounced ball	>36,0000	>36,0000	-	-
30	Balances on 1 foot (10 sec)	-	-	-	-
31	Backwards heel-to-toe walk	-	-	-	-

Fig. 4



AGE PERCENTILES FOR GROSS MOTOR ITEMS
BLACK GROUP
ITEM
28
26
23
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32
34
36
AGE SUM
LEGEND: PROB
25
50
75
90

TABLE 28 : AGE PERCENTILES FOR GROSS MOTOR ITEMS (IN MONTHS) - WHITES

Item no.	Item	25%	50%	75%	90%
1	Prone - lifts head	100% at less than 16 days			
2	Prone - lifts head 45°	0,7467	0,9961	1,3290	1,7226
3	Prone - lifts head 90°	1,2346	1,7107	2,3703	3,1790
4	Sitting - head steady	1,5539	2,1996	3,1136	4,2569
5	Prone - chest up, arm-support	2,4309	3,2773	4,4183	5,7813
6	Rolls over	4,5182	5,2836	6,1787	7,1133
7	Pulls to sit - no headlag	1,8915	2,6600	3,7406	5,0840
8	Bears some weight on legs	0,3435	0,7104	1,4691	2,8253
9	Sits without support	4,8498	5,5530	6,3581	7,1820
10	Stands holding on	6,1658	7,0074	7,9638	8,9358
11	Pulls self to stand	7,4904	8,4214	9,4683	10,5212
12	Gets to sitting	7,6930	8,6310	9,6835	10,7399
13	Walks holding onto furniture	8,3155	9,3512	10,5158	11,6876
14	Stands momentarily	9,4493	10,6034	11,8984	13,1987
15	Stands alone well	10,5586	11,7304	13,0322	14,3270
16	Stoops and recovers	10,8776	11,9594	13,1487	14,3200
17	Walks well	11,1162	12,1522	13,2848	14,3941
18	Walks backwards	12,7221	13,5894	14,5158	15,4034
19	Walks up steps	13,6164	15,1824	16,9286	18,6713
20	Kicks ball forwards	13,1000	14,2000	15,0000	17,0000
21	Throws ball overhand	12,5528	13,4241	14,3560	15,2498
22	Jumps in place	18,7702	23,0492	28,3037	34,0497
23	Pedals tricycle	21,3910	25,8540	31,2483	>36,0000
24	Balances on 1 foot (1 sec)	18,7630	22,6723	27,3961	32,4838
25	Broad jump	22,0844	26,7206	32,3300	>36,0000
26	Balances on 1 foot (5 sec)	27,7042	32,6830	>36,0000	-
27	Hops on 1 foot	38,8440	>36,0000	-	-
28	Heel-to-toe walk	34,4183	-	-	-
29	Catches bounced ball	>36,0000	-	-	-
30	Balances on 1 foot (10 sec)	-	-	-	-
31	Backwards heel-to-toe walk	-	-	-	-

Fig. 5

AGE PERCENTILES FOR GROSS MOTOR ITEMS

WHITE GROUP

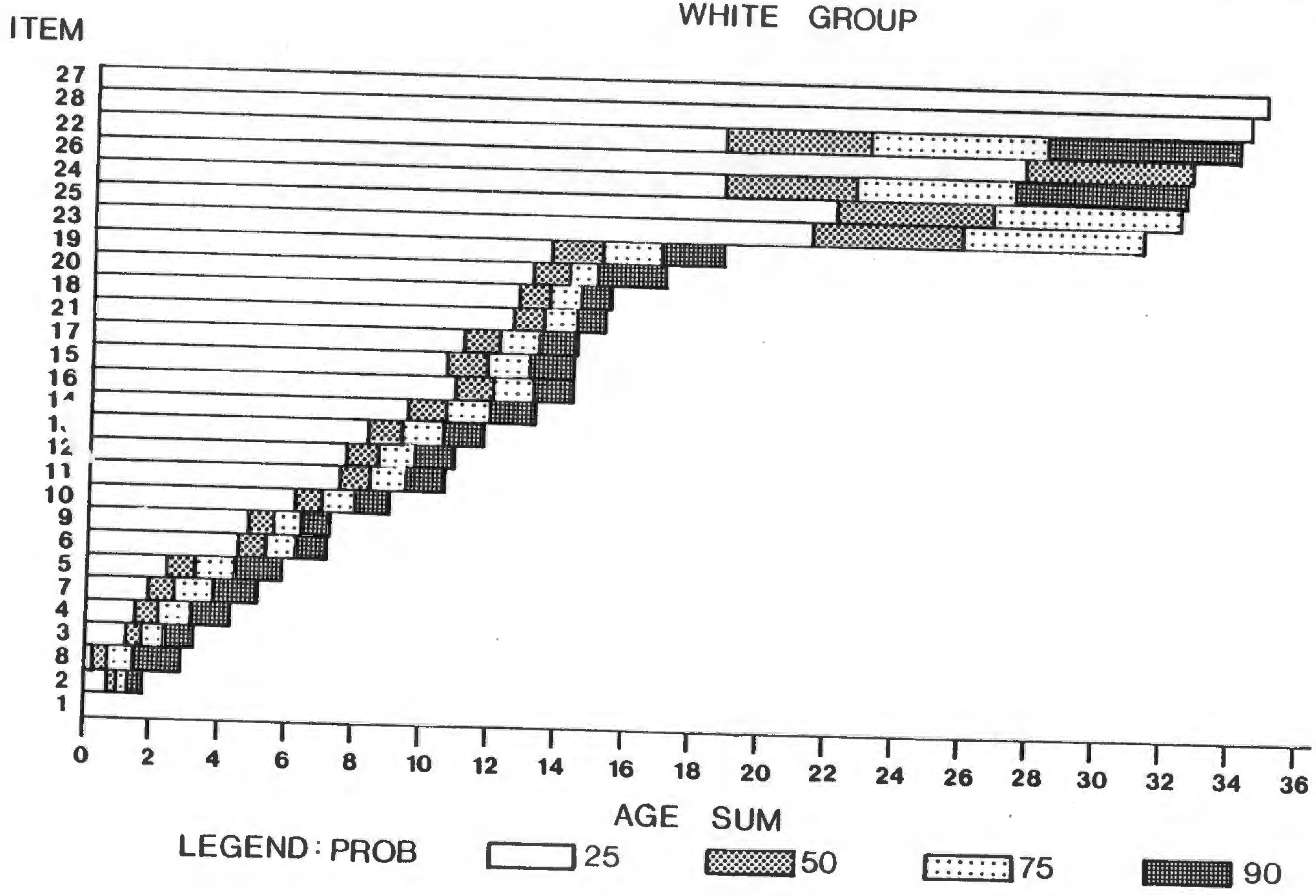


TABLE 29 : COMPARISON OF S.A. BLACK AND DENVER SAMPLES FOR 50% AND 90% ACHIEVEMENT AGES - FINE MOTOR ITEMS

Item no.	Item	Age when 50% pass Black	DDST	Diff.	Age when 90% pass Black	DDST	Diff.
3	Follows past midline	0,07	1,3	-1,23	1,57	2,5	-0,93
4	Hands together	0,38	2,2	-1,82	1,56	3,7	-2,14
5	Follows 180°	2,30	2,4	-0,10	3,61	4,0	-0,39
6	Grasps rattle	1,69	3,3	-1,61	3,07	4,2	-1,13
7	Regards raisin	2,75	3,3	-0,55	5,06	5,0	+0,06
8	Reaches for object	3,58	3,6	-0,02	4,76	5,0	-0,24
9	Passes cube hand to hand	5,08	5,6	-0,52	6,94	7,5	-0,56
10	Sitting - looks for yarn	5,07	5,6	-0,53	7,09	7,5	-0,41
11	Sitting - takes 2 cubes	5,74	6,1	-0,36	7,93	7,5	+0,43
12	Rakes raisin - attains	6,36	5,6	+0,76	7,91	7,8	+0,11
13	Thumb-finger grasp	7,40	8,3	-0,90	8,60	10,6	-2,00
14	Bangs 2 cubes held in hands	7,67	8,4	-0,73	11,52	12,3	-0,78
15	Neat pincer grasp of raisin	8,40	10,7	-2,30	11,00	14,7	-3,70
16	Tower of 2 cubes	13,80	14,1	-0,30	18,45	20,0	-1,55
17	Dumps raisin from bottle (dem.)	12,17	14,8	-2,63	15,45	36,0	-20,55
18	Scribbles spon.	13,18	13,3	-0,12	18,46	25,2	-6,74
19	Tower of 4 cubes	17,55	17,9	-0,35	22,23	26,4	-4,17
20	Dumps raisin from bottle (spon.)	18,42	13,4	+5,02	26,21	24,0	+2,21
21	Imitates vertical line within 30°	25,14	21,7	+3,44	33,44	36,0	-2,56
22	Copies circle	30,05	31,2	-1,15	-	39,6	-
23	Tower of 8 cubes	23,06	23,8	-0,74	29,98	40,8	-10,82
24	Imitates bridge	31,10	32,4	-1,30	-	-	-
25	Picks longer line	32,81	34,8	-1,99	-	-	-
26	Copies cross	-	-	-	-	-	-

TABLE 30 : COMPARISON OF S.A. WHITE AND DENVER SAMPLES FOR 50% AND 90% ACHIEVEMENT AGES - FINE MOTOR ITEMS

Item no.	Item	Age when 50% pass White	DDST	Diff.	Age when 90% pass White	DDST	Diff.
3	Follows past midline	0,35	1,3	-0,95	1,14	2,5	-1,36
4	Hands together	0,60	2,2	-1,60	1,34	3,7	-2,36
5	Follows 180°	1,96	2,4	-0,44	3,64	4,0	-0,36
6	Grasps rattle	1,62	3,3	-1,68	3,22	4,2	-0,98
7	Regards raisin	2,65	3,3	-0,65	4,62	5,0	-0,38
8	Reaches for object	3,53	3,6	-0,07	5,19	5,0	+0,19
9	Passes cube hand to hand	5,00	5,6	-0,60	5,80	7,5	-1,70
10	Sitting - looks for yarn	4,89	5,6	-0,71	6,62	7,5	-0,88
11	Sitting - takes 2 cubes	5,60	6,1	-0,50	8,02	7,5	+0,52
12	Rakes raisin - attains	6,00	5,6	+0,40	7,60	7,8	-0,20
13	Thumb-finger grasp	7,64	8,3	-0,66	10,05	10,6	-0,55
14	Bangs 2 cubes held in hands	7,77	8,4	-0,63	11,21	12,3	-1,09
15	Neat pincer grasp of raisin	9,11	10,7	-1,59	12,19	14,7	-2,51
16	Tower of 2 cubes	13,22	14,1	-0,88	15,99	20,0	-4,01
17	Dumps raisin from bottle (dem.)	12,97	14,8	-1,13	15,65	36,0	-20,35
18	Scribbles spon.	11,80	13,3	-1,50	15,00	25,2	-10,20
19	Tower of 4 cubes	16,37	17,9	-1,53	20,62	26,4	-5,78
20	Dumps raisin from bottle (spon.)	15,88	13,4	+2,48	20,57	24,0	-3,43
21	Imitates vertical line within 30°	22,03	21,7	+0,33	30,78	36,00	-5,22
22	Copies circle	26,83	31,2	-4,37	-	-	-
23	Tower of 8 cubes	20,48	23,8	-3,32	25,44	40,8	-15,36
24	Imitates bridge	30,06	32,4	-2,34	-	-	-
25	Picks longer line	30,87	34,8	-3,93	-	-	-
26	Copies cross	-	-	-	-	-	-

TABLE 31 : COMPARISON OF S.A. BLACK AND DENVER SAMPLES FOR 50% AND 90% ACHIEVEMENT AGES - GROSS MOTOR ITEMS

Item no.	Item	Age when 50% pass Black	DDST	Diff.	Age when 90% pass Black	DDST	Diff.
2	Prone - lifts head 45°	1,09	-	-	2,07	2,6	-0,53
3	Prone - lifts head 90°	1,83	2,2	-0,37	3,08	3,2	-0,12
4	Sitting - head steady	2,00	2,9	-0,9	3,50	4,2	-0,7
5	Prone - chest up arm-support	2,85	3,0	-0,15	4,36	4,3	+0,06
6	Rolls over	4,85	2,8	+2,05	6,33	4,7	+1,63
7	Pull-to-sit no lag	2,98	4,2	-1,22	4,60	7,7	-3,1
8	Bears some weight on legs	0,23	4,2	-3,97	2,39	6,3	-3,91
9	Sits without supp.	4,64	5,5	-0,86	5,72	7,8	-2,08
10	Stands holding on	5,80	5,8	0,00	7,28	10,0	-2,72
11	Pulls self to stand	7,36	7,6	-0,24	9,14	10,0	-0,86
12	Gets to sitting	7,52	7,6	-0,08	9,00	11,0	-2,00
13	Walks holding onto furniture	8,53	9,2	-0,67	10,19	12,7	-2,51
14	Stands momentarily	10,05	9,8	+0,25	11,78	13,0	-1,22
15	Stands alone well	11,10	11,5	-0,40	13,70	13,9	-0,20
16	Stoops and re-covers	11,40	11,6	-0,20	13,80	14,3	-0,50
17	Walks well	12,00	12,1	-0,10	14,60	14,3	+0,30
18	Walks backwards	13,80	14,3	-0,50	17,00	21,5	-4,50
19	Walks up steps	15,75	17,0	-1,25	20,09	22,0	-1,91
20	Kicks ball forward	15,27	20,0	-4,73	19,35	24,0	-4,65
21	Throws ball over-hand	14,00	19,8	-5,80	17,80	31,2	-13,40
22	Jumps in place	21,09	22,3	-1,21	27,61	36,0	-8,39
23	Pedals tricycle	30,61	23,9	+6,71	38,73	36,0	+2,73
24	Balances 1 foot (1 sec)	25,99	30,0	-4,58	34,17	38,4	-4,23
25	Broad jump	25,42	33,6	-8,18	33,39	38,4	-5,01
26	Balances 1 foot (5 sec.)	31,21	38,4	-7,1	-	-	-
27	Hops on 1 foot	-	-	-	-	-	-
28	Heel-to-toe walk	35,98	43,2	-7,22	-	-	-

TABLE 32 : COMPARISON OF S.A. WHITE AND DENVER SAMPLES FOR 50% AND 90% ACHIEVEMENT AGES - GROSS MOTOR ITEMS

Item no.	Item	Age when 50% pass			Age when 90% pass		
		White	DDST	Diff.	White	DDST	Diff.
2	Prone - lifts head 45°	1,00	-	-	1,72	2,6	-0,88
3	Prone - lifts head 90°	1,71	2,2	-0,49	3,18	3,2	-0,02
4	Sitting - head steady	2,20	2,9	-0,7	4,26	4,2	+0,06
5	Prone - chest up arm-support	3,28	3,0	+0,28	5,78	4,3	+1,48
6	Rolls over	5,28	2,8	+2,48	7,11	4,7	+2,41
7	Pull-to-sit no lag	2,66	4,2	-1,54	5,08	7,7	-2,62
8	Bears some weight on legs	0,71	4,2	-3,49	2,83	6,3	-3,47
9	Sits without support	5,55	5,5	+0,05	7,18	7,8	-0,62
10	Stands holding on	7,01	5,8	+1,21	8,94	10,0	-1,06
11	Pulls self to stand	8,42	7,6	+0,82	10,52	10,0	+0,52
12	Gets to sitting	8,63	7,6	+1,03	10,74	11,0	-0,26
13	Walks holding onto furniture	9,35	9,2	+0,15	11,69	12,7	-1,01
14	Stands momentarily	10,60	9,8	+0,80	13,20	13,0	+0,20
15	Stands alone well	11,73	11,5	+0,23	14,33	13,9	+0,43
16	Stoops and recovers	11,96	11,6	+0,36	14,32	14,3	+0,02
17	Walks well	12,15	12,1	+0,05	14,39	14,3	+0,09
18	Walks backwards	13,59	14,3	-0,71	15,40	21,5	-6,10
19	Walks up steps	15,18	17,0	-1,82	18,67	22,0	-3,33
20	Kicks ball forward	14,20	20,0	-4,82	17,00	24,0	-7,00
21	Throws ball overhand	13,42	19,8	-6,38	15,25	31,2	-15,95
22	Jumps in place	23,05	22,3	+0,75	34,05	36,0	-1,95
23	Pedals tricycle	25,85	23,9	+1,95	-	36,0	-
24	Balances 1 foot (1 sec.)	22,67	30,0	-7,33	32,48	38,4	-5,92
25	Broad jump	26,72	33,6	-6,88	-	-	-
26	Balances 1 foot (5 sec.)	32,68	38,4	-5,72	-	-	-
27	Hops on 1 foot	-	-	-	-	-	-
28	Heel-to-toe walk	-	-	-	-	-	-

TABLE 33 : COMPARISON OF S.A. BLACK AND WHITE GROUPS FOR 50% AND 90% ACHIEVEMENT AGES - FINE AND GROSS MOTOR ITEMS

Item no.	Item	50% Black	50% White	50% Diff.	90% Black	90% White	90% Diff.
FINE MOTOR ITEMS							
9	Passes cube hand to hand	5,08	5,00	-	6,94	5,80	1,14W
13	Thumb-finger grasp	7,40	7,64	-	8,60	10,05	1,45B
15	Neat Pincer grasp raisin	8,40	9,11	-	11,00	12,19	1,19B
16	Tower of 2 cubes	13,80	13,22	-	18,45	15,99	2,46B
18	Scribbles spontaneously	13,18	11,80	1,38W	18,46	15,00	3,46W
19	Tower of 4 cubes	17,55	16,37	1,18W	22,23	20,62	1,61W
20	Dumps raisin from bottle (spontaneously)	18,42	15,88	2,54W	26,21	20,57	5,64W
21	Imitates vertical line	25,14	22,03	3,11W	33,44	30,78	2,66W
22	Copies circle	30,05	26,83	3,22W	-	-	-
23	Tower of 8 cubes	23,06	20,48	2,58W	29,98	25,44	4,54W
24	Imitates bridge	31,10	30,05	1,05W	-	-	-
25	Picks longer line	32,81	30,87	1,94W	-	-	-
GROSS MOTOR ITEMS							
5	Prone - Chest up, arm-support	2,85	3,28	-	4,36	5,78	1,42B
9	Sits without support	4,64	5,55	-	5,72	7,18	1,46B
10	Stands holding on	5,80	7,01	1,21B	7,28	8,94	1,66B
11	Pulls self to stand	7,36	8,42	1,06B	9,14	10,52	1,38B
12	Gets to sitting	7,52	8,63	1,11B	9,00	10,74	1,74B
13	Walks holding onto furniture	8,53	9,35	-	10,19	11,69	1,50B
14	Stands momentarily	10,05	10,60	-	11,78	13,20	1,42B
18	Walks backwards	13,80	13,59	-	17,00	15,40	1,60W
19	Walks up steps	15,75	15,18	-	20,09	18,67	1,42W
20	Kicks ball forwards	15,27	14,20	1,07W	19,35	17,00	2,35W
21	Throws ball overhand	14,00	13,42	-	17,80	15,25	2,55W
22	Jumps in place	21,09	23,05	1,96B	27,61	34,05	6,44B
23	Pedals tricycle	30,61	25,85	4,76W	-	-	-
24	Balances 1 foot (1 sec.)	25,99	22,67	3,32W	34,17	32,48	1,69W
25	Broad jump	25,43	26,72	1,30B	33,39	>36,00	>2,61
26	Balances 1 foot (5 sec.)	31,21	32,68	1,47B	-	-	-
28	Heel-to-toe walk	35,99	>36,00	-	-	-	-

4.2 SUPPLEMENTARY ITEMS

Tables 34 and 35 give the ages at which 25%, 50%, 75% and 90% of each of the two ethnic groups achieved the supplementary items. These are displayed as histograms in Figures 6 and 7. Table 36 compares the 50% and 90% attainment ages for the 2 groups.

The white infants appeared to lose the grasp reflex sooner, but both groups retained the Galant response to approximately the same age. Graphs depicting the developmental course of each of these items are shown in Figures 8 - 11.

The trend at both 50% and 90% attainment levels was towards earlier achievement by the black group, who reached all but 2 items earlier than the white group at the 50% level and all but 4 items at the 90% level. The difference was greater for the later items than for the earlier ones, being more than one month earlier for items 14, 17, 18 and 19 at the 50% level and for items 12, 14, 15, 17 and 18 at the 90% level. The trend reversed for the three most advanced items, the final item (walks on heels) being achieved earlier by the white group at both 50% and 90% levels whilst backwards protective extension of the arms and sideways protective steps were achieved earlier by the white group at the 90% level. Only for one item could a statistically significant difference be shown. This was item 14 - sitting, arms free for play, which the black group achieved earlier ($p = 0,05$ @ 18 d.o.f./$p = 0,0025$ @ 11 d.o.f.).

Items 8 and 13 were analysed separately and their developmental courses are shown separately for each group in Figures 12 - 15. These patterns both disappear as more mature patterns develop. Items 8 (early weight on hands) gives way to the more advanced form of weight on hands (item 11), and the relationship of these two items is shown separately for each group in Figures 16 and 17. Item 13 (creeping) gives way to crawling (item 17) and the relationship of these two items in each group is shown in Figures 18 and 19.

Three related items (3, 5 and 9) represent the development of flexion against gravity. Figure 20 illustrates the course of their development for the black group and Figure 21 that for the white group.

TABLE 34 : AGE PERCENTILES FOR SUPPLEMENTARY ITEMS (IN MONTHS) - BLACK GROUP

Item no.	Item	25%	50%	75%	90%
1	Grasp reflex	1,7015	0,6745	0,0000	0,0000
2	Galant	4,7845	3,6994	2,6142	1,6375
3	Supine - flexed legs rest on heels and lat. border	0,3479	0,9296	1,5113	2,0349
4	Head in line with shoulders on pull-to-sit	2,1059	2,9784	3,8508	4,6360
5	Supine - hands to knees (in int. rotation)	2,5677	3,2866	4,0056	4,6527
6	Placing reactions feet (tactile)	100% present at less than 16 days			
7	Downwards parachute arms	4,1498	5,0187	5,8877	6,6698
8	Early weight on hands*				
9	Hands to feet in supine/ total flex. + post. tilt	3,7740	4,3554	4,9368	5,4601
10	Amphibian	3,2893	4,0391	4,7888	5,4636
11	Advanced weight on hands	4,5134	5,2710	6,0286	6,7105
12	Rolls supine to prone	3,8000	5,0000	5,6000	6,0000
13	Creeping - unilateral with lat. flex. trunk*				
14	Sitting - arms free for play	4,6896	5,3081	5,9267	6,4835
15	All fours	5,6000	6,5000	7,3000	8,0000
16	Sideways protective extension arms	5,1121	5,9291	6,7461	7,4814
17	Crawling	6,6000	7,8000	8,8000	9,7000
18	Bear-standing	6,6000	8,2000	9,4000	11,2000
19	Backwards protective extension arms	9,5500	10,4000	11,8000	14,0000
20	Sideways protective steps	11,4000	12,6000	14,4000	15,9000
21	Walks on heels	22,8576	27,2451	31,6327	35,5816

* These items are analysed separately in Figures 12 and 14

Fig. 6 AGE PERCENTILES FOR SUPPLEMENTARY ITEMS

BLACK GROUP

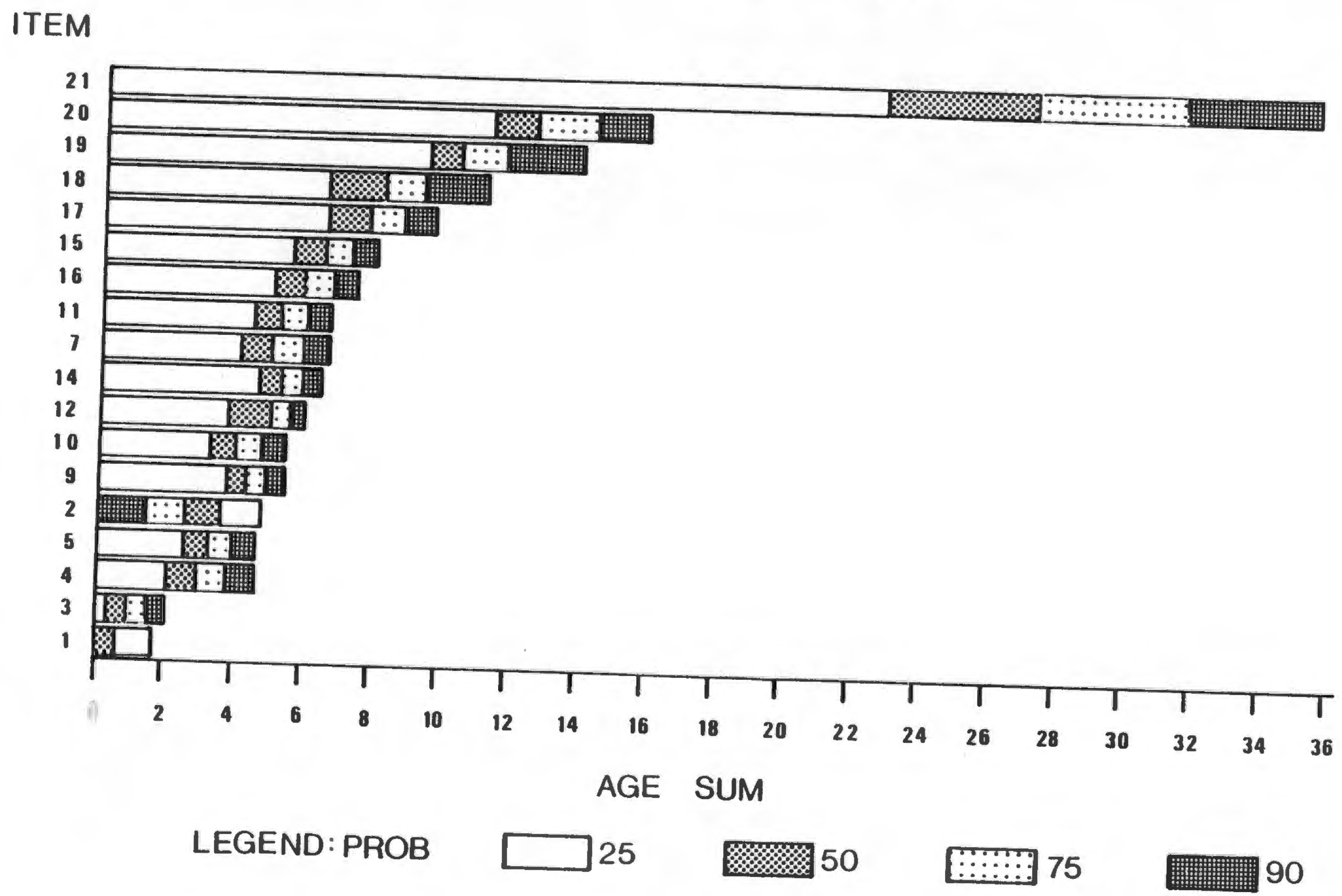


TABLE 35 : AGE PERCENTILES FOR SUPPLEMENTARY ITEMS (IN MONTHS) - WHITE GROUP

Item no.	Item	25%	50%	75%	90%
1	Grasp reflex	1,2105	0,0000	0,0000	0,0000
2	Galant	4,9834	3,7989	2,6144	1,5484
3	Supine - flexed legs rest on heels and lat. border	0,9798	1,3742	1,7685	2,1236
4	Head in line with shoulders on pull-to-sit	1,9507	2,9846	4,0186	4,9492
5	Supine - hands to knees (in int. rotation)	3,0646	3,8490	4,6335	5,3395
6	Placing reactions feet (tactile)	100% present at less than 16 days			
7	Downwards parachute arms	4,3365	5,1658	5,9951	6,741
8	Early weight on hands*				
9	Hands to feet in supine/ total flex. + post. tilt	3,9264	4,6794	5,6124	6,3712
10	Amphibian	3,4153	4,0845	4,7536	5,3559
11	Advanced weight on hands	5,0495	5,8033	6,5570	7,2354
12	Rolls supine to prone	4,6313	5,4607	6,2902	7,0367
13	Creeping - unilateral with lat. flex. trunk*				
14	Sitting - arms free for play	5,8166	6,5102	7,2038	7,8280
15	All fours	6,1502	7,4440	9,0101	10,6994
16	Sideways protective extension arms	5,9770	6,5199	7,6628	8,4214
17	Crawling	7,5000	9,1000	9,9000	12,1000
18	Bear-standing	7,7257	9,3030	10,8804	12,3001
19	Backwards protective extension arms	10,3295	11,4394	12,5492	13,5481
20	Sideways protective steps	11,6508	12,7239	13,7970	14,7628
21	Walks on heels	21,2526	25,4193	29,5859	33,3361

* These items are analysed separately in Figures 13 and 15.

Fig. 7 AGE PERCENTILES FOR SUPPLEMENTARY ITEMS

WHITE GROUP

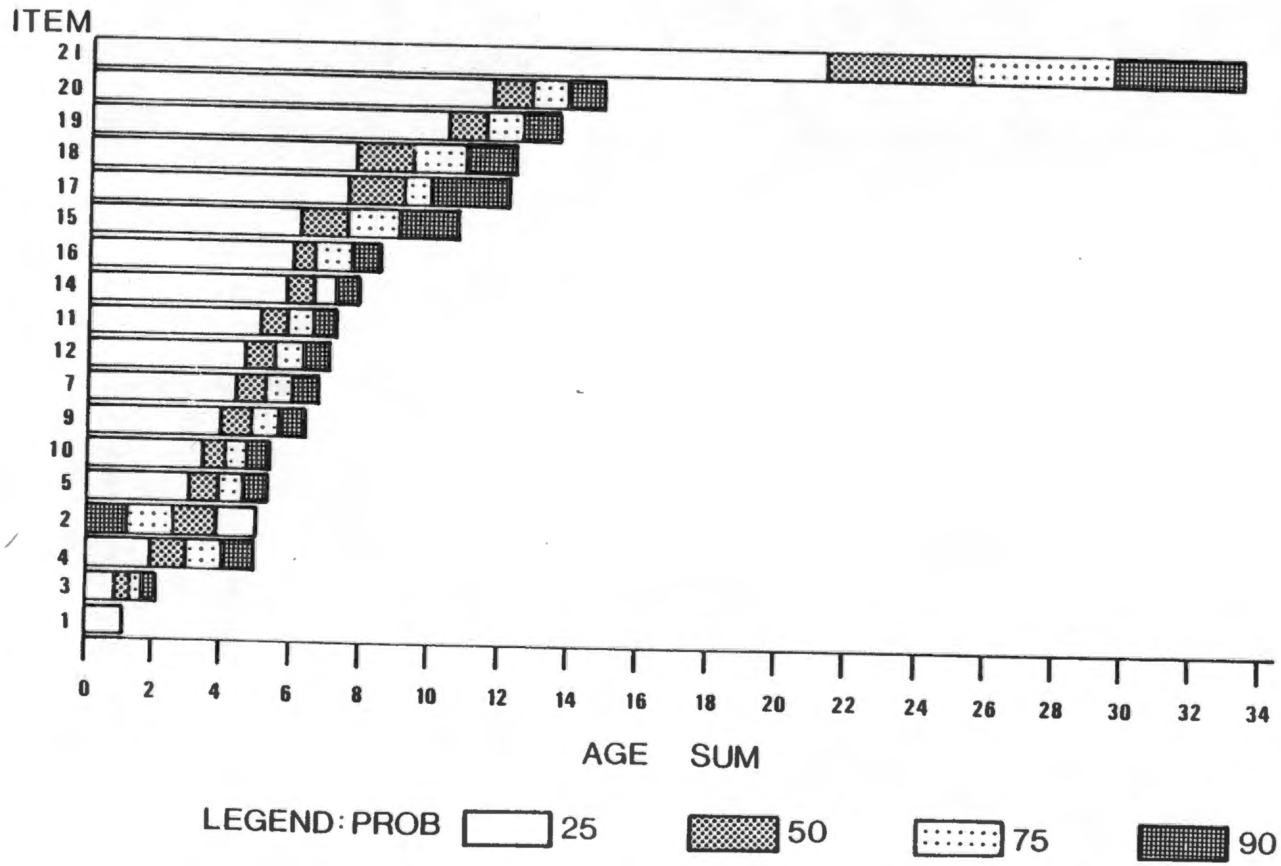


TABLE 36 : COMPARISON OF S.A. BLACK AND WHITE GROUPS FOR 50% AND 90% ACHIEVEMENT AGES - SUPPLEMENTARY ITEMS

Item no.	Item	50% Black	50% White	50% Diff.*	90% Black	90% White	90% Diff.*
1	Grasp reflex (disappears)	0,67	0,00	-	0,00	0,00	-
2	Galant (disappears)	3,70	3,80	-	1,64	1,55	-
3	Supine - flexed legs rest on heels and lat. border	0,93	1,37	-	2,03	2,12	-
4	Head in line with shoulders on pull-to-sit	2,98	2,98	-	4,64	4,95	-
5	Supine - hands to knees (in int. rotation)	3,29	3,85	-	4,65	5,34	-
6	Placing reactions feet (tactile)	100% present at less than 16 days					
7	Downwards parachute arms	5,02	5,17	-	6,67	6,74	-
9	Hands to feet/total flex.	4,36	4,77	-	5,46	6,37	-
10	Amphibian	4,04	4,08	-	5,46	5,36	-
11	Advanced weight on hands	5,27	5,80	-	6,71	7,24	-
12	Rolls supine to prone	5,00	5,46	-	6,00	7,04	1,04B
14	Sitting - arms free for play	5,31	6,51	1,20B	6,48	7,83	1,35B
15	All fours	6,50	7,44	-	8,00	10,70	2,70B
16	Sideways protective extension arms	5,93	6,52	-	7,48	8,42	-
17	Crawling	7,80	9,10	1,30B	9,70	12,10	2,40B
18	Bear-standing	8,20	9,30	1,10B	11,20	12,30	1,10B
19	Backwards protective extension arms	10,40	11,44	1,04B	14,00	13,55	-
20	Sideways protective steps	12,60	12,72	-	15,90	14,76	1,14W
21	Walks on heels	27,25	25,42	1,83W	35,58	33,34	2,24W

* Differences are only noted when greater than one month. The capitals B or W denote in which group's favour the difference occurred.

Fig. 8

ESTIMATED MEAN FUNCTION

SUPPLEMENTARY ITEM 1 (BLACK GROUP)

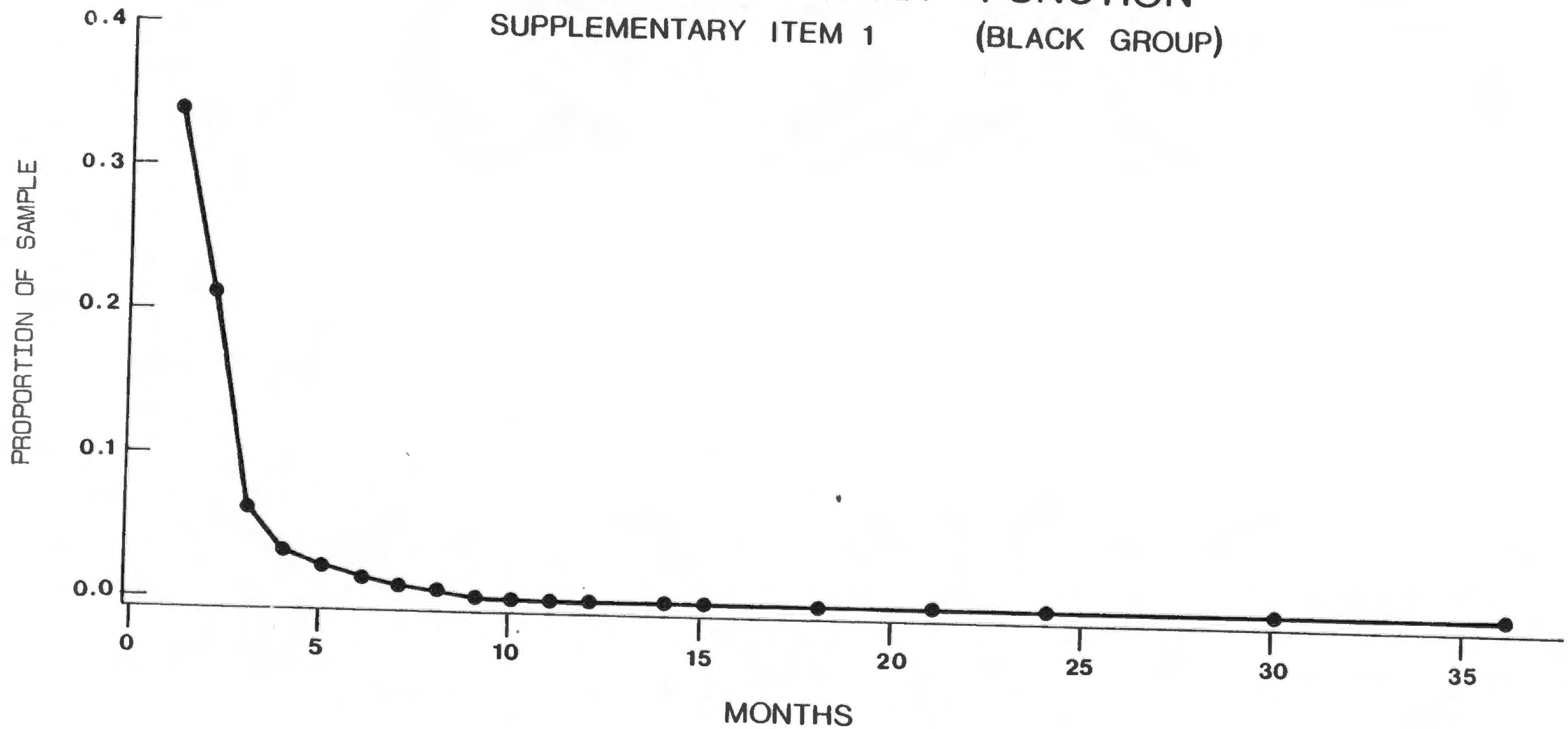


Fig. 9

ESTIMATED MEAN FUNCTION
SUPPLEMENTARY ITEM 1 (WHITE GROUP)

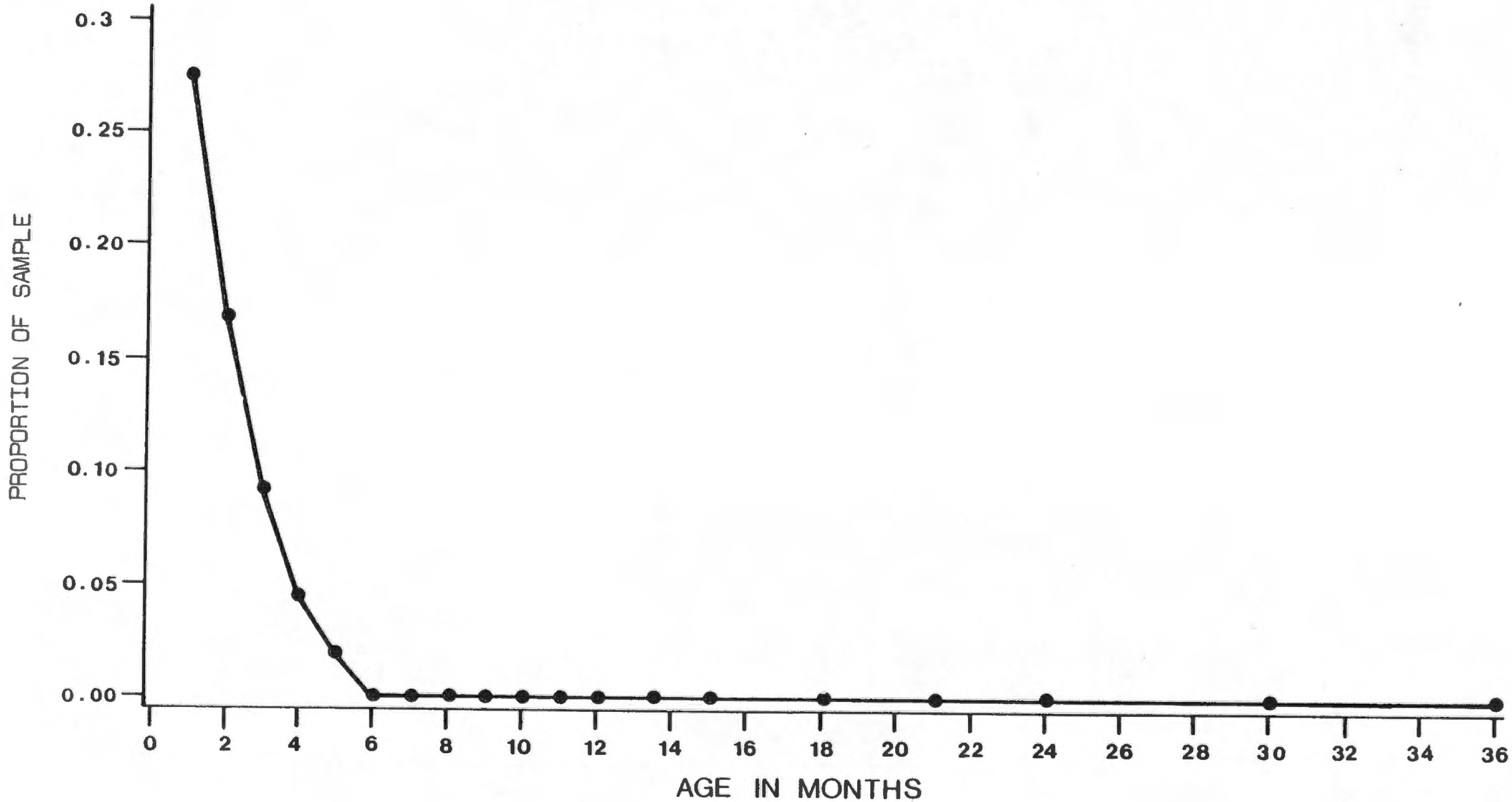


Fig. 10

ESTIMATED MEAN FUNCTION

SUPPLEMENTARY ITEM 2 (BLACK GROUP)

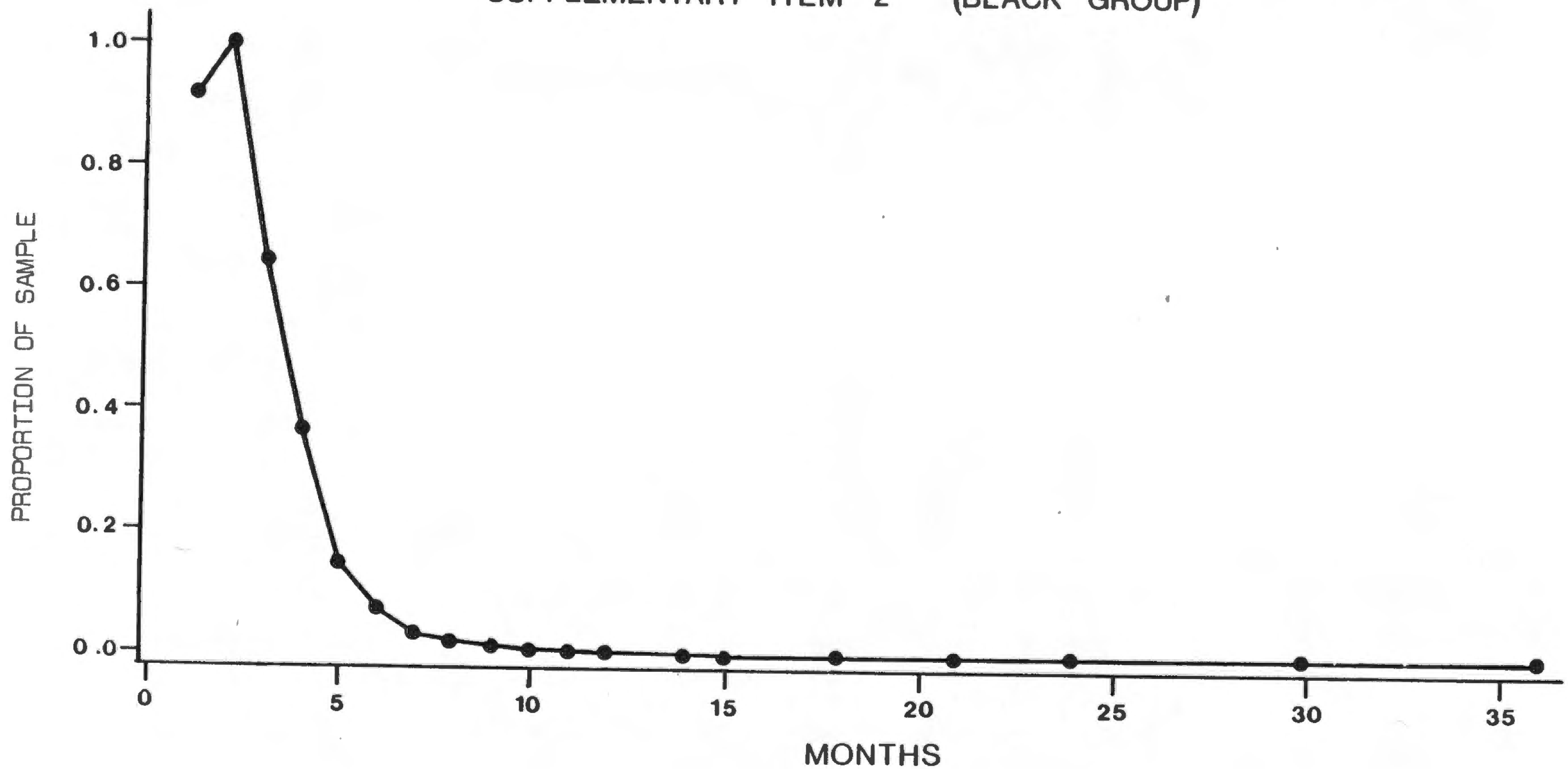


Fig. 11

ESTIMATED MEAN FUNCTION

SUPPLEMENTARY ITEM 2 (WHITE GROUP)

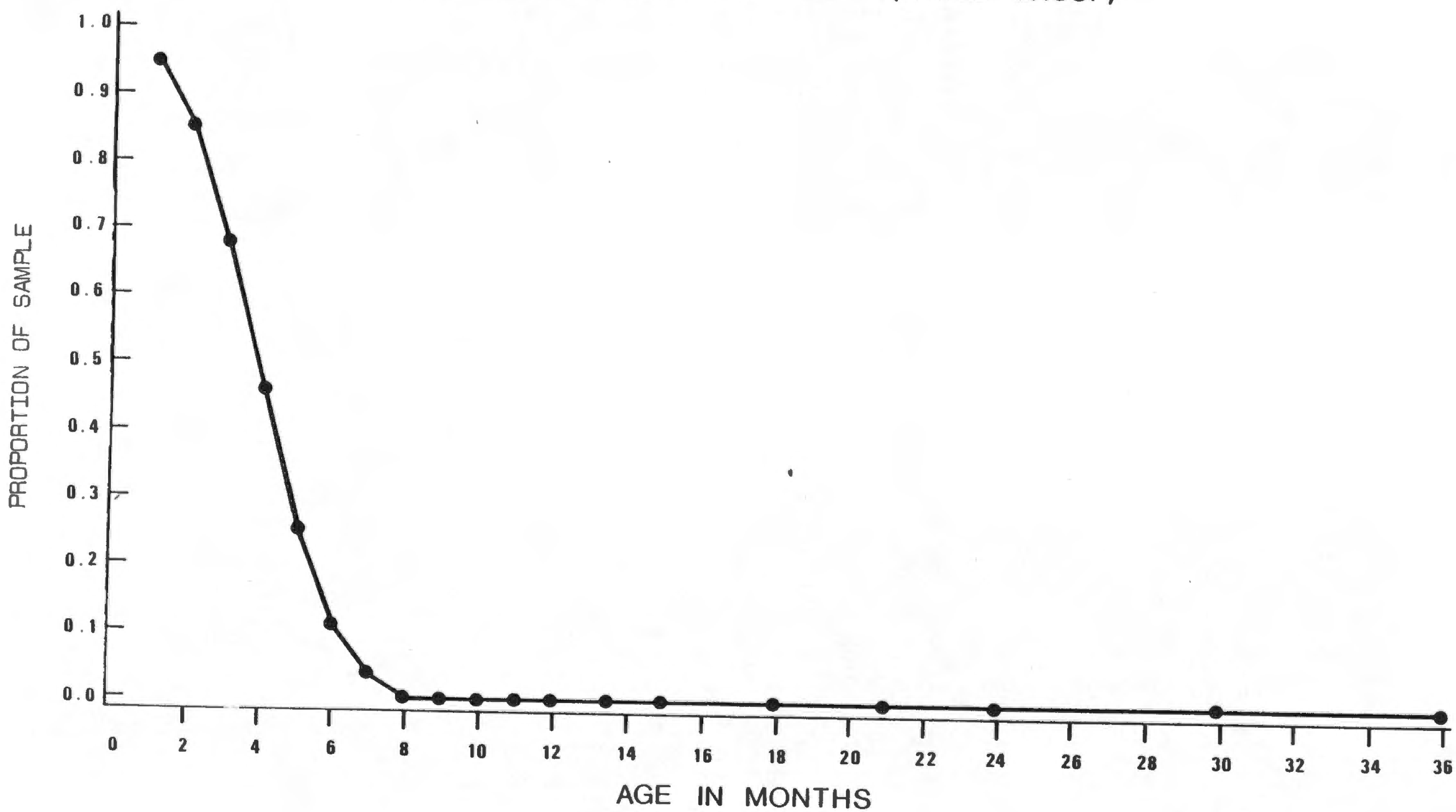


Fig. 12

ESTIMATED MEAN FUNCTION
SUPPLEMENTARY ITEM 8 (BLACK GROUP)

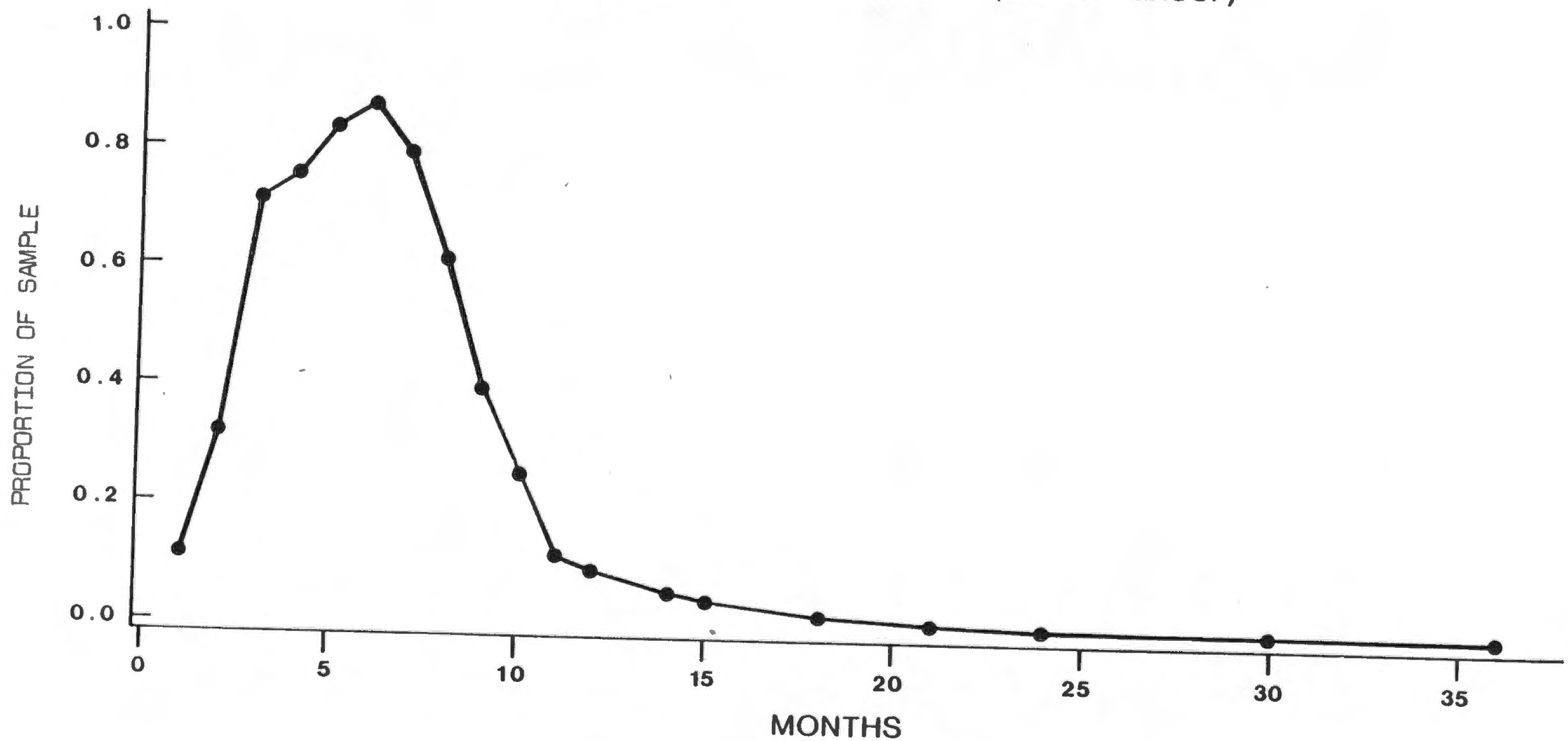


Fig. 13

ESTIMATED MEAN FUNCTION

SUPPLEMENTARY ITEM 8 (WHITE GROUP)

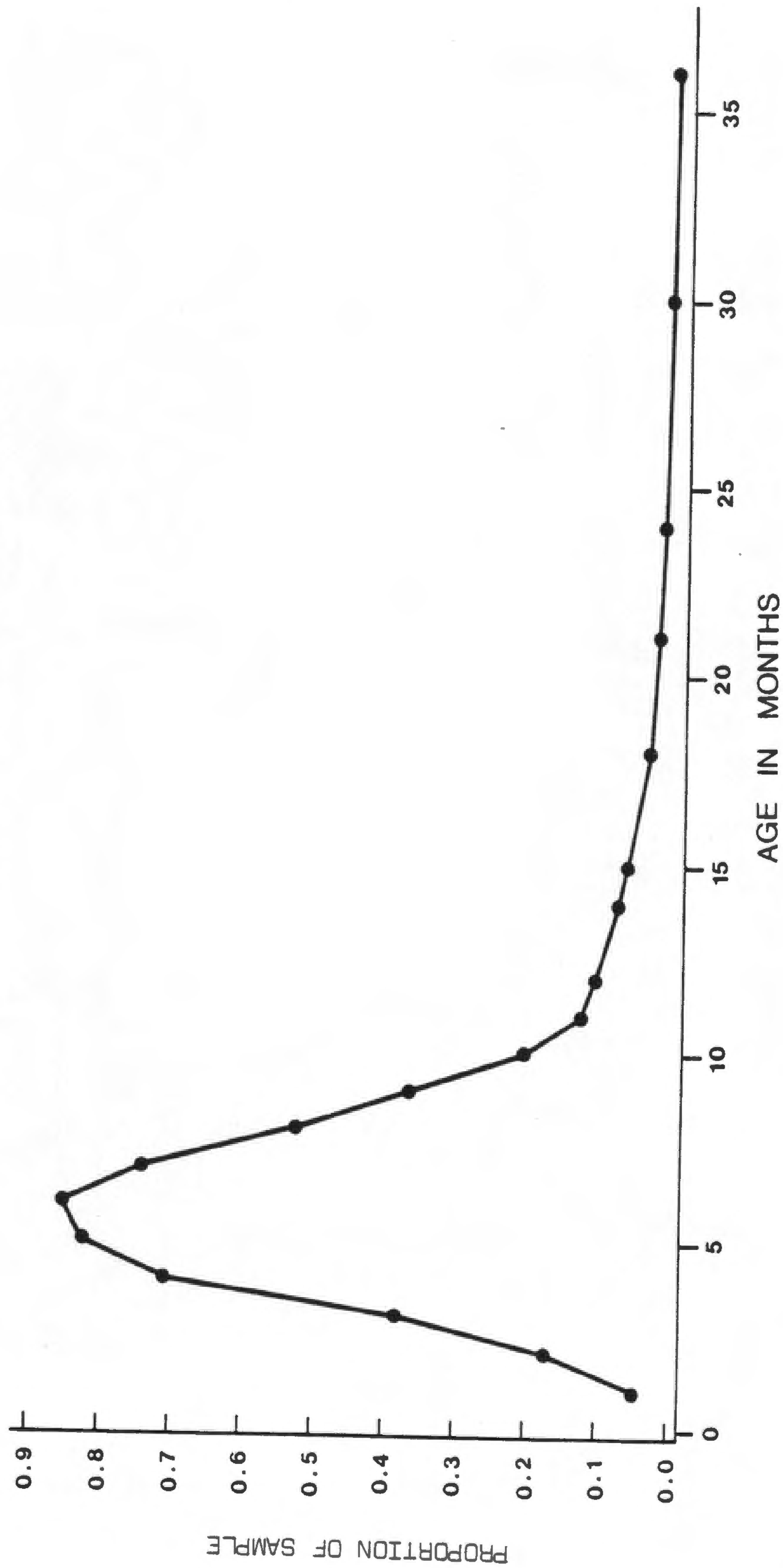


Fig. 14

ESTIMATED MEAN FUNCTION

SUPPLEMENTARY ITEM 13 (BLACK GROUP)

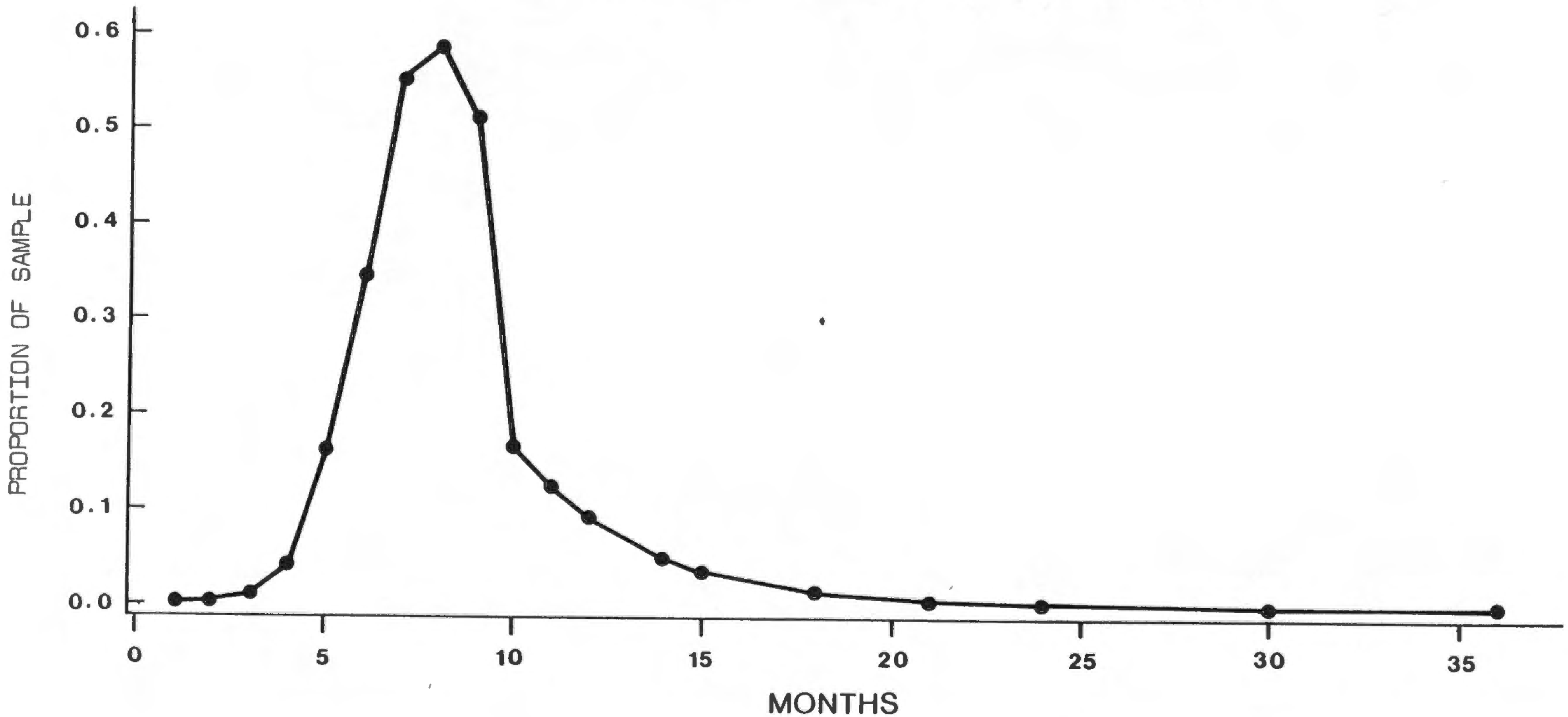
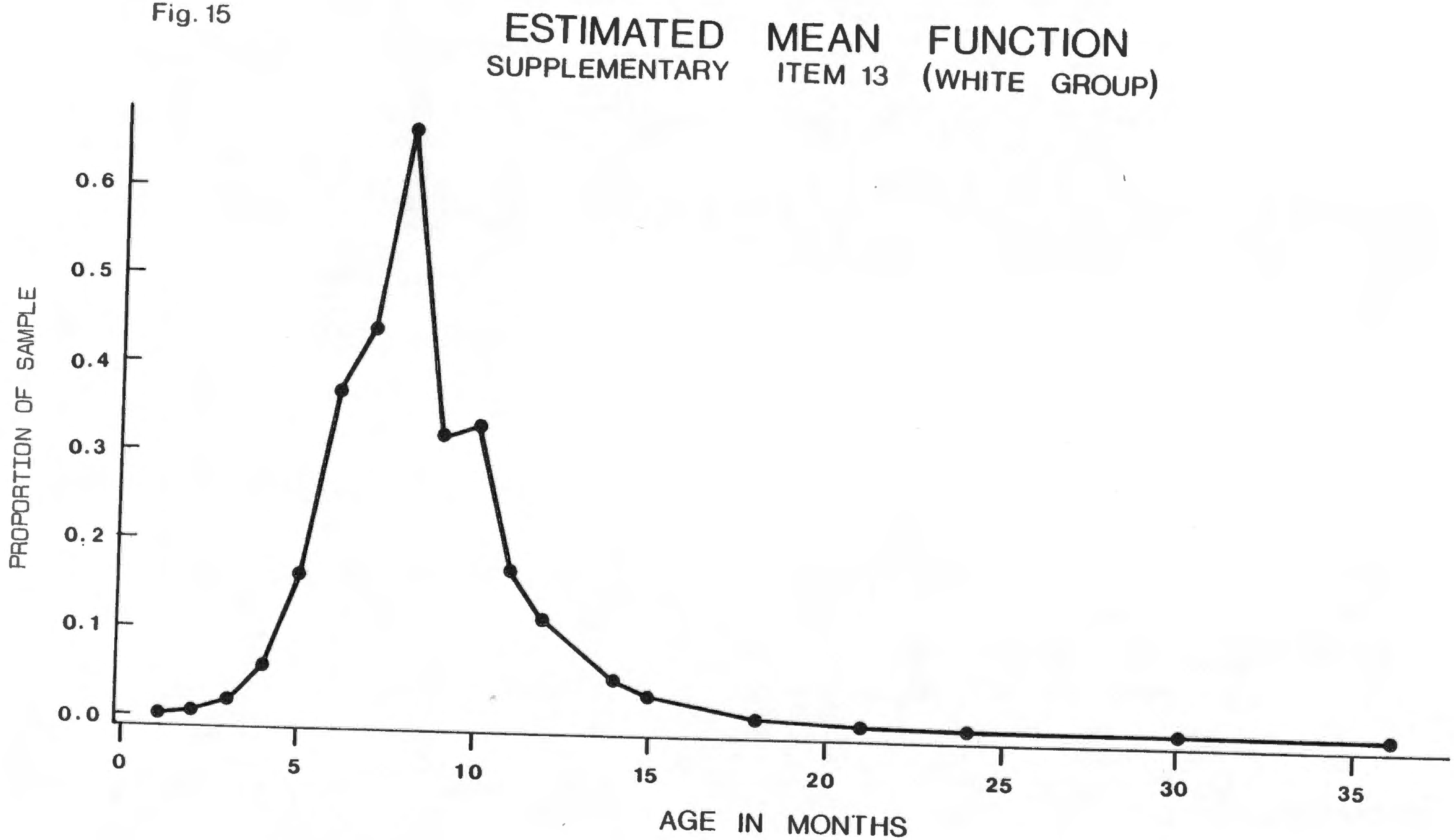


Fig. 15


ESTIMATED MEAN FUNCTION
SUPPLEMENTARY ITEM 13 (WHITE GROUP)
PROPORTION OF SAMPLE
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0.1
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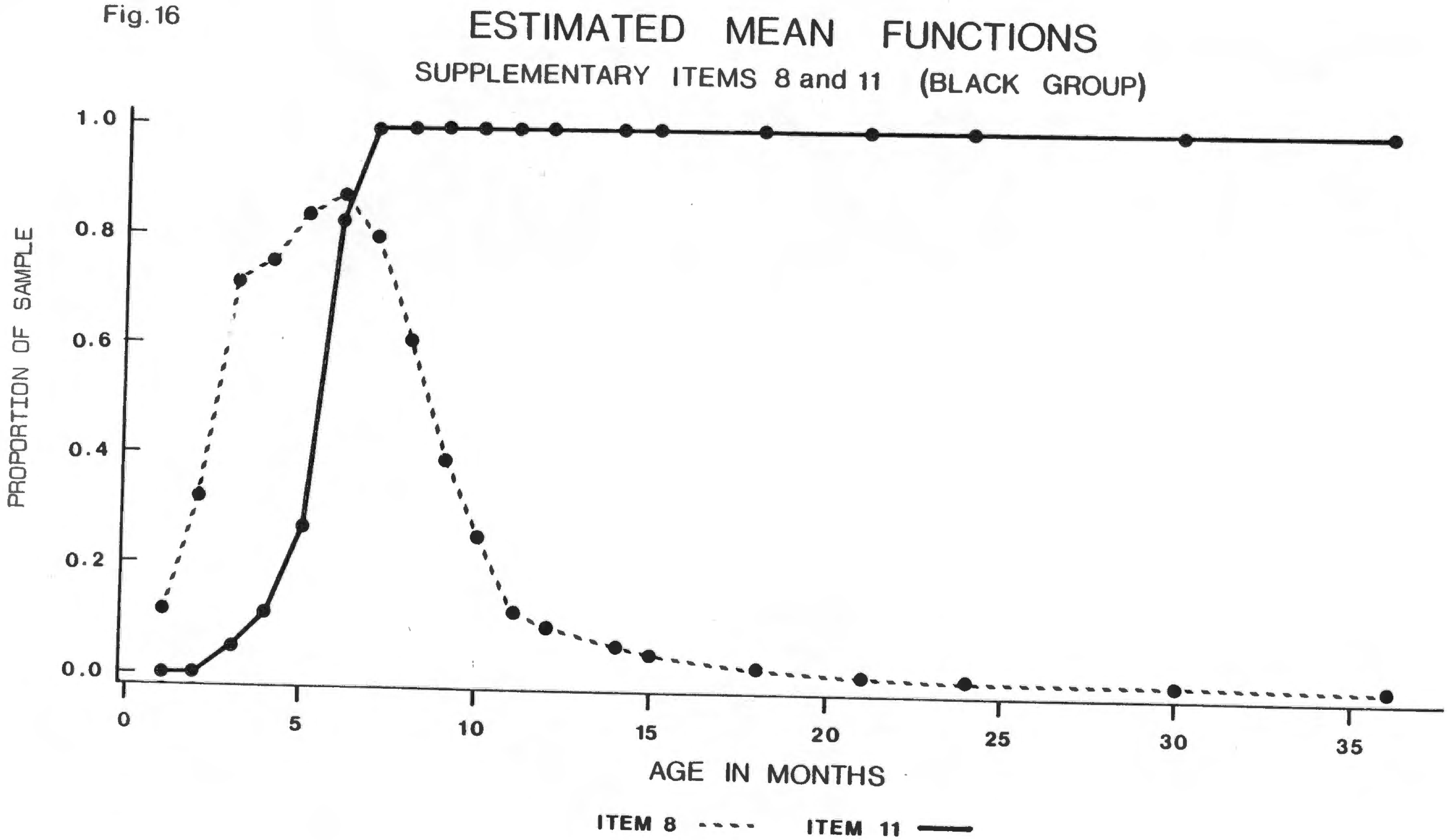
0.5
0.6
0
5
10
15
20
25
30
35
AGE IN MONTHS

Fig. 16


ESTIMATED MEAN FUNCTIONS
SUPPLEMENTARY ITEMS 8 and 11 (BLACK GROUP)
PROPORTION OF SAMPLE
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0.6
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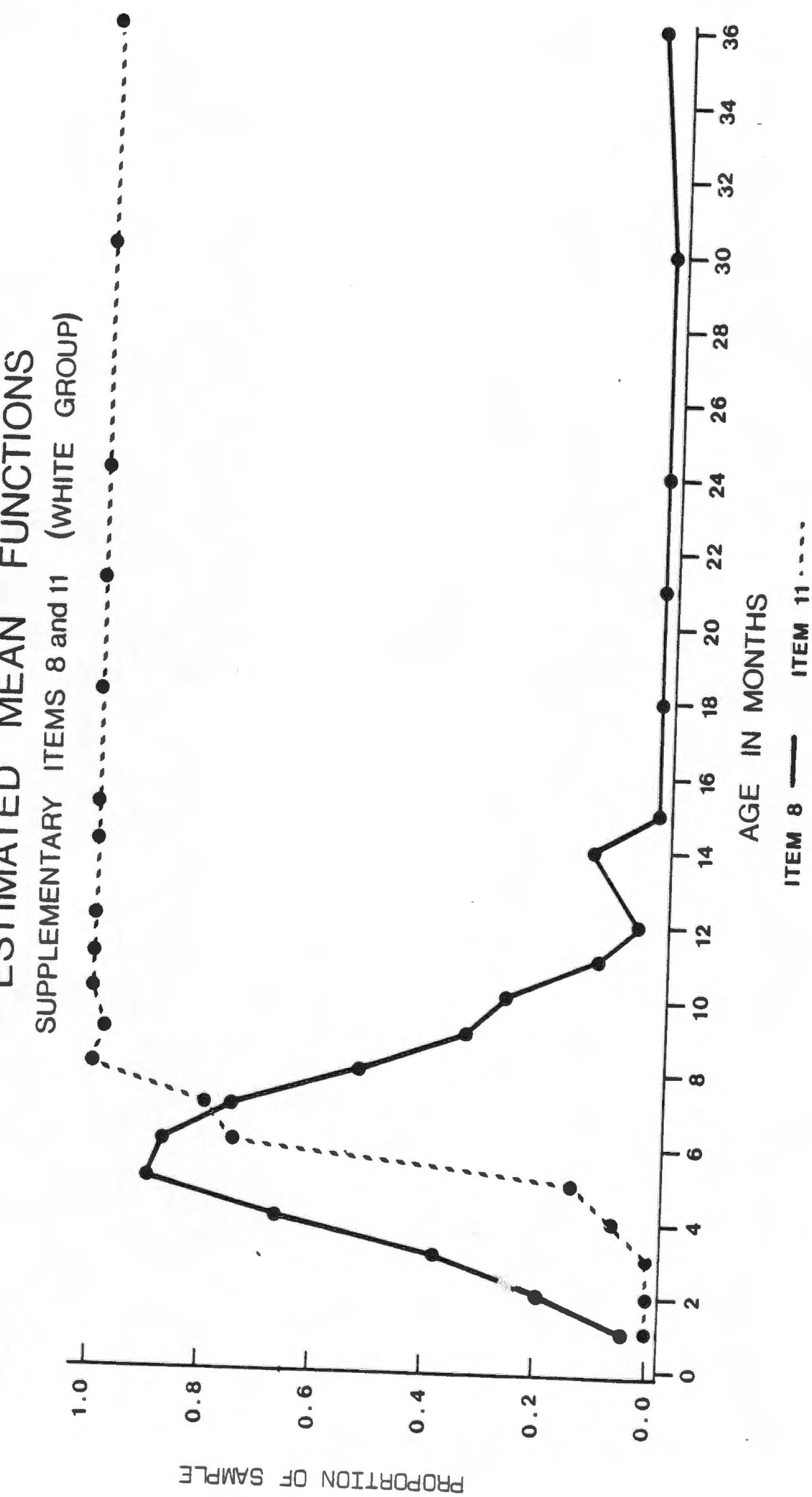
0
5
10
15
20
25
30
35
AGE IN MONTHS
ITEM 8 ----
ITEM 11 ——

Fig. 17


ESTIMATED MEAN FUNCTIONS
SUPPLEMENTARY ITEMS 8 and 11 (WHITE GROUP)
PROPORTION OF SAMPLE
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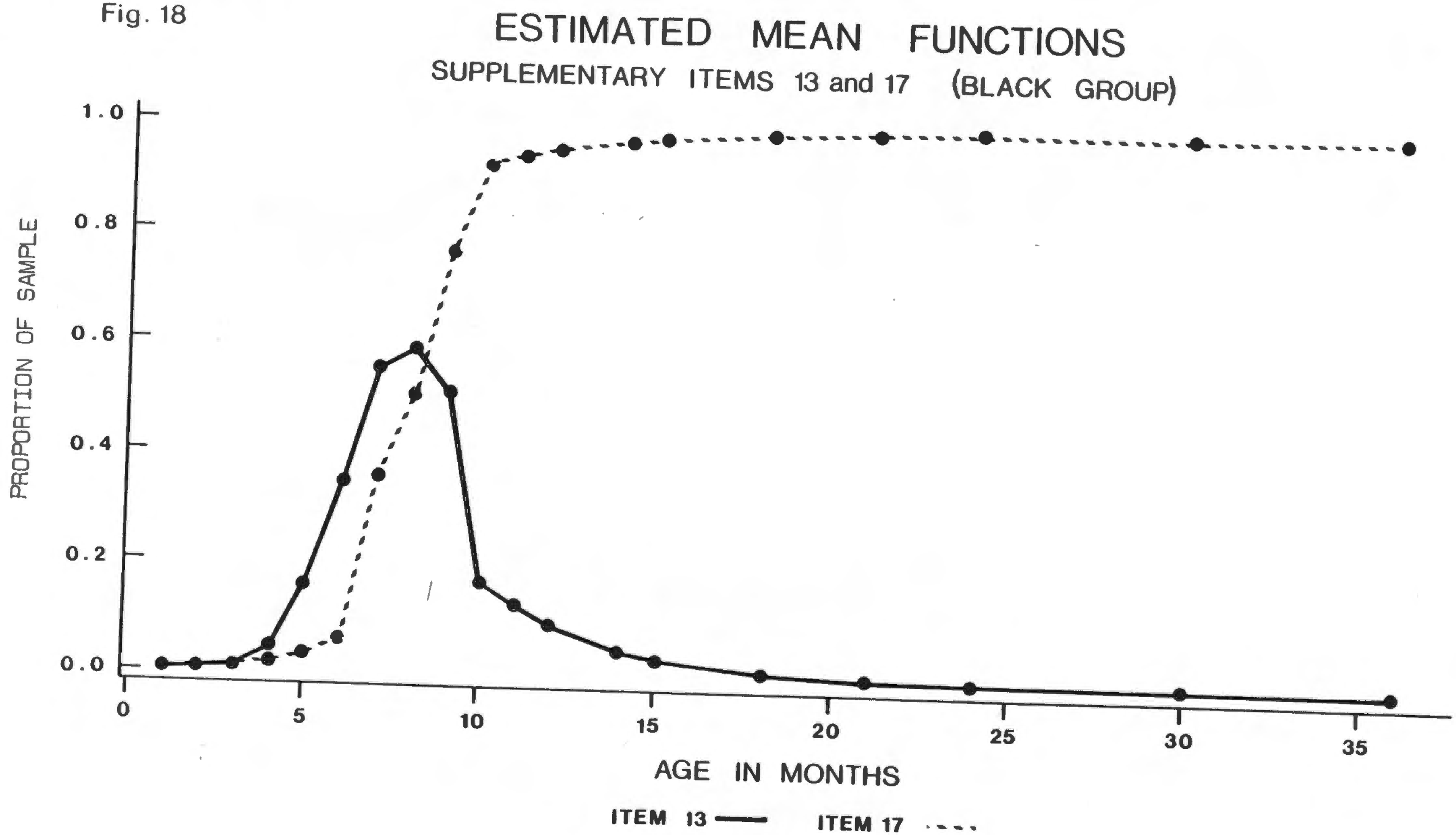
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
AGE IN MONTHS
ITEM 8
ITEM 11

Fig. 18


ESTIMATED MEAN FUNCTIONS
SUPPLEMENTARY ITEMS 13 and 17 (BLACK GROUP)
PROPORTION OF SAMPLE
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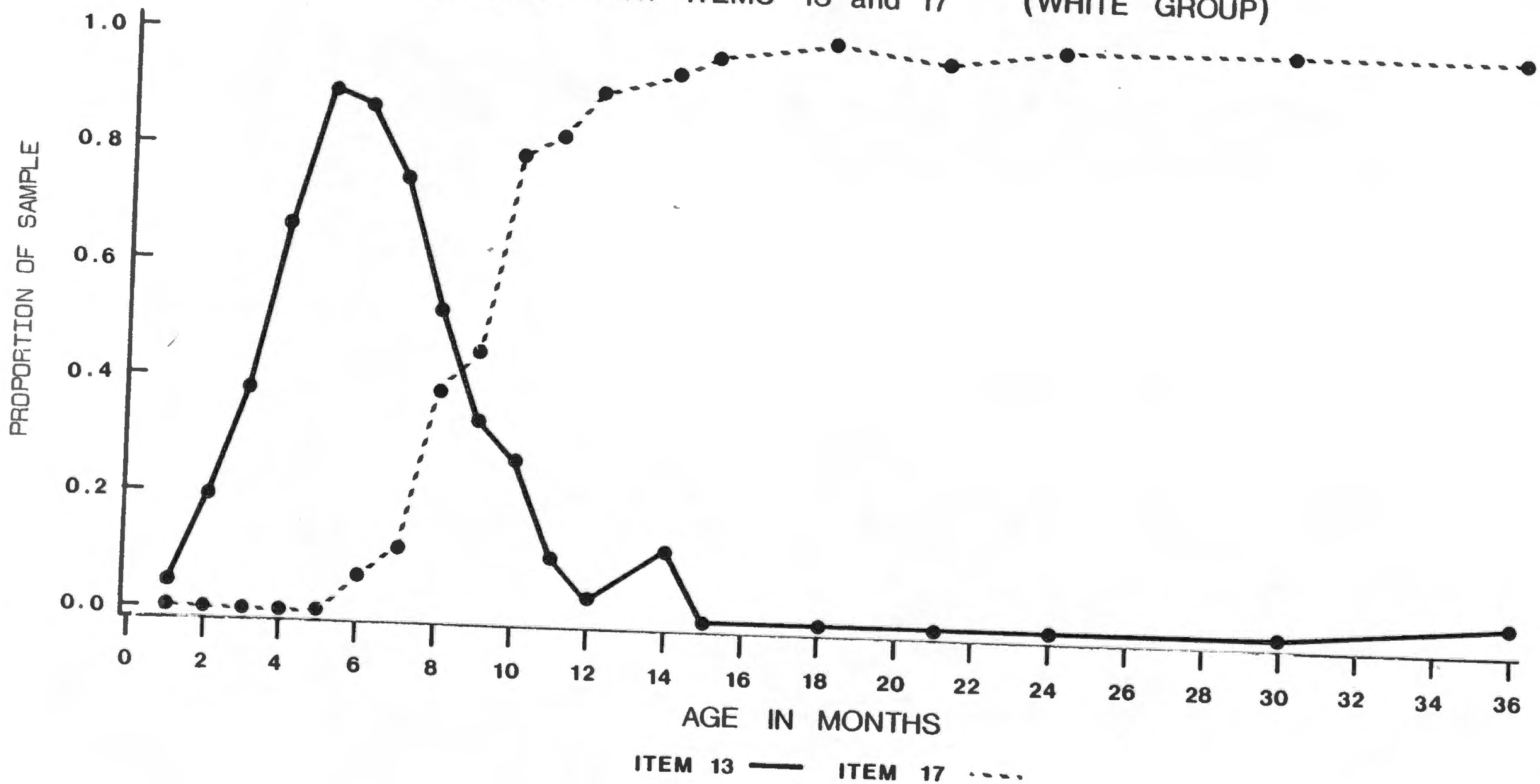
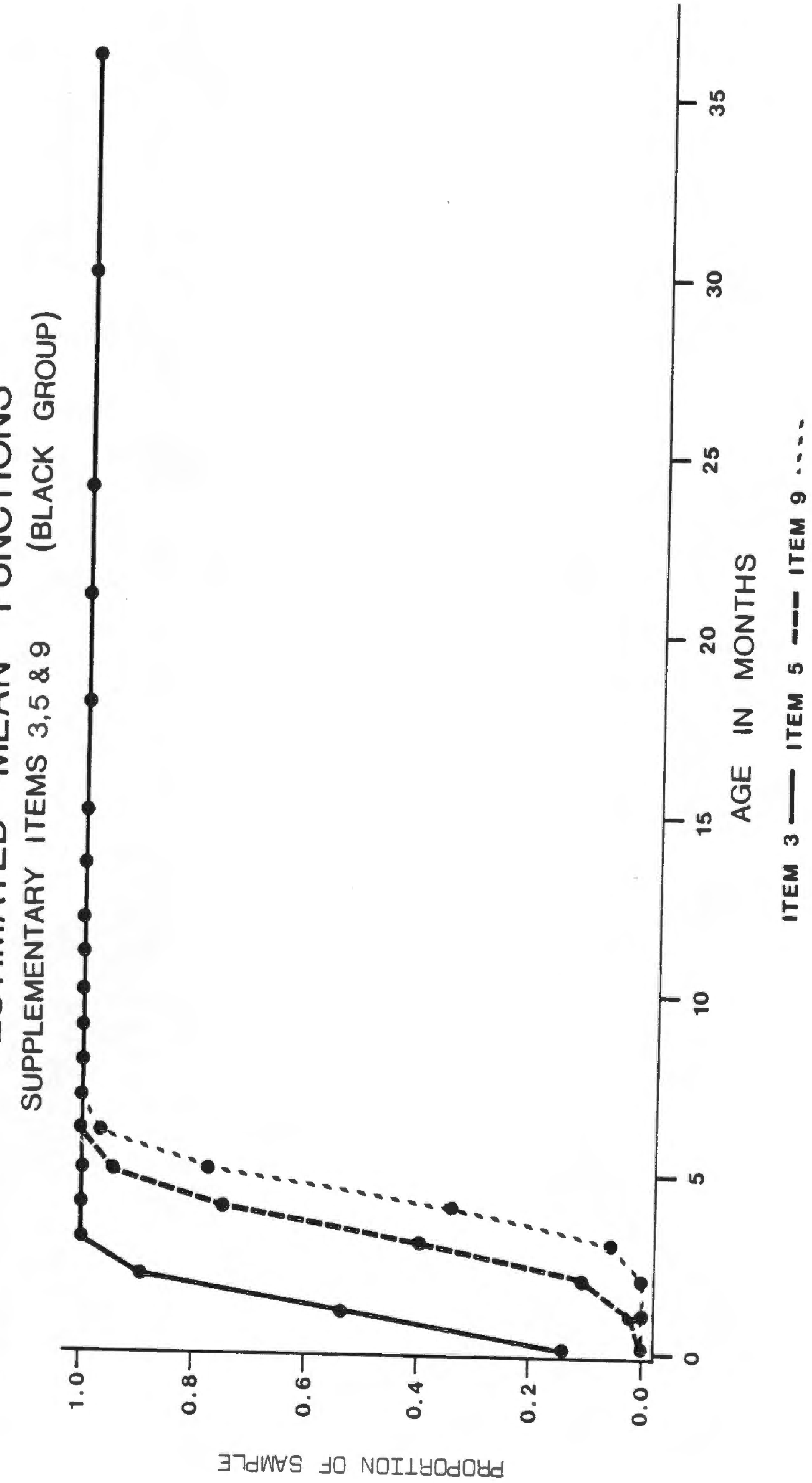
0.6
0.4
0.2
0.0
0
5
10
15
20
25
30
35
AGE IN MONTHS
ITEM 13
ITEM 17

Fig. 19

ESTIMATED MEAN FUNCTIONS

SUPPLEMENTARY ITEMS 13 and 17 (WHITE GROUP)




ESTIMATED MEAN FUNCTIONS
SUPPLEMENTARY ITEMS 3,5 & 9 (BLACK GROUP)
PROPORTION OF SAMPLE
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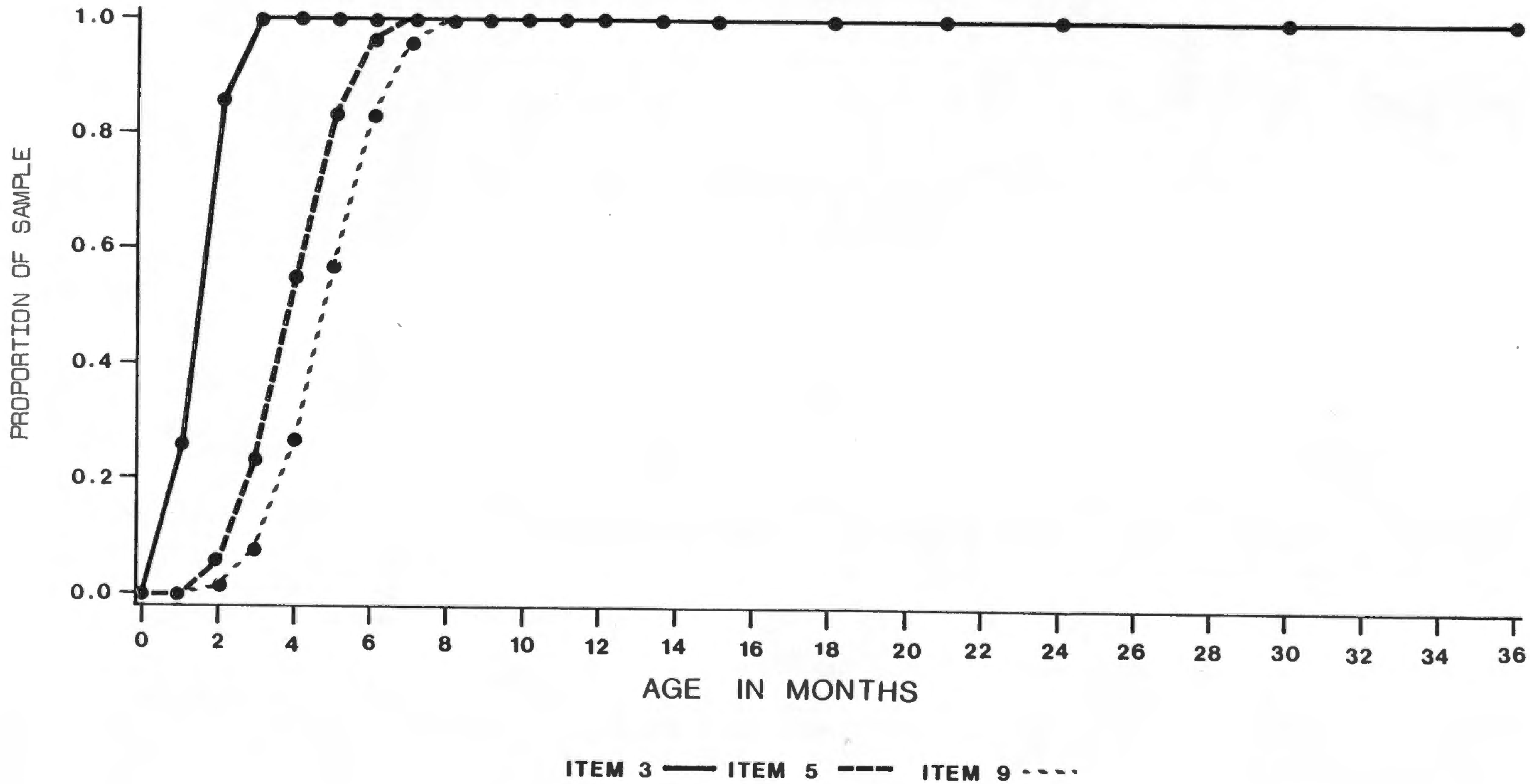
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
35
AGE IN MONTHS
ITEM 3 —— ITEM 5 - - - ITEM 9 ....

Fig. 20

Fig. 21

ESTIMATED MEAN FUNCTIONS

SUPPLEMENTARY ITEMS 3,5 & 9 (WHITE GROUP)



4.3 ANALYSIS OF VARIABLES

Interaction between the age of acquisition and the following variables was analysed by means of logistic regression:

Sex
Weight percentile at time of examination
Birthrank (firstborn c/f later born)
Family size
Father's education
Mother's education
Father's occupation
Mother's occupation
Family income

Graphs of achievement distributions versus age were plotted when interactions became evident but in most cases significance could not be proven due to the small sample size in each of the age-intervals.

4.3.1. Sex

There was no significant interaction relating to any gross motor items for either ethnic group, nor to any fine motor items for the black group. One fine motor item - neat pincer grasp of raisin - was achieved significantly earlier by white girls ($p = 0{,}04$).

4.3.2. Weight percentiles

There was no significant interaction relating to any fine motor item in the black group, but in the white group one fine motor item - dumps raisin from bottle when demonstrated - was achieved earlier by the heavier babies ($p = 0{,}02$). This was not considered relevant.

One gross motor item - broad jump - was achieved significantly earlier by the heaviest (90th percentile or above) babies in the black group ($p = 0{,}02$).

In the white group 2 gross motor items - stands momentarily ($p = 0{,}02$) and walks well ($p = 0{,}02$) were related to weight. The most striking feature was the late acquisition of standing and walking by babies weighing in at the 10th percentile or less.

Several other gross motor items appeared marginally related to weight. These items were:

For the black infants

Pull-to-sit - no head lag
Sits without support
Gets to sitting
Jumps in place
Balances on 1 foot (1 sec.)

For the white infants

Gets to sitting
Stands alone well
Walks backwards
Balances on one foot (5 sec.)
Hops on one foot

Once again the most noticeable feature was the late acquisition of gross motor skills by infants weighing in at the 10th percentile or less. The heaviest infants (90th percentile or above) performed best in all but two of the items mentioned above.

4.3.3. Birth rank

There was no significant interaction relating to any fine motor items in either group. In the black group 1 item - walks holding onto furniture - was acquired earlier by firstborns ($p = 0,05$) whilst in the white group the item rolls over was also acquired earlier by firstborns ($p = 0,02$).

4.3.4. Family size

There was no significant interaction relating to any fine motor item in either ethnic group, nor to any gross motor item in the black group. In the white group, pulls to standing was acquired earlier by children from smaller families ($p = 0,03$) whilst walks well was achieved earlier by moderately sized families ($p = 0,02$).

4.3.5. Parents' education

No significant relationships were observed in respect of any fine motor items excepting one item in the black group - imitates a bridge - in which a highly significant relationship between the better educated mothers and the achievement of the item was observed ($p = 0,002$).
The only gross motor item for which a significant interaction was observed was the item pulls to standing in the black group, which was again related to the mother's education ($p = 0,03$).

4.3.6. Parents' occupation

There was no relationship between either parent's occupation and the acquisition of any fine motor item in either ethnic group.

Father's occupation influenced one gross motor item - pulls to sit without a head-lag - which was acquired first by infants with fathers in the lowest occupational group ($p = 0{,}04$). There was, however, no consistent trend with increasing occupational levels.

The father's occupation also was related to one item in the white group - stands momentarily - which was again acquired first by infants with fathers in the lowest occupational group for the white sample (in this case group 3 - see Addendum 1) ($p = 0{,}03$). Once again there was no consistent relationship to increasing occupational levels.

4.3.7. Family income

There was no interaction between family income and the age of acquisition of any fine motor items by either ethnic group, nor of any gross motor items by the white group. In the black group 2 items (bears some weight on legs and balances on 1 leg for 5 seconds) both displayed some interaction with income ($p = 0{,}04$ in both cases) but there was no consistent trend with increasing or decreasing levels of income.

4.4 THE PRE-TERM INFANTS

The sample contained 125 infants born at less than 37 weeks' gestation, 55 black and 70 white. This represents 8,79% of the total sample. Of the white infants,9,45% were born pre-term as compared with 8,08% of the black infants.

Addenda 5.1 and 5.2 list the black and white infants respectively in terms of the number of days pre-term and the weight percentile groups into which they fall.

In the black group, by the actual age of testing, there did not appear to be any direct relationship between the number of days pre-term and the percentile weight. 50,00% of those born at 34 weeks' gestation or less still weighed in at below the 25th percentile, but so did 55,17% of babies born at 36 weeks' gestation.

In the white group, however, 66,66% of those infants born at 34 weeks' gestation or less still weighed less than the 25th percentile at the time of testing, as against only 28,00% of those born at 36 weeks and 9,09% of those born at 37 weeks.

Addendum 5.3 shows the distribution of pre-term infants according to weight. It can be seen that the black and white groups differ considerably. Although the peak incidence for both groups is between the 25th and 75th percentiles, the graph for the black group deviates from the normal distribution, showing over-representation of infants below the 25th percentile. The graph for the white group is closer to a normal distribution, although with an unexplained dip in the number of infants between the 10th and 25th percentiles.

The performance of the pre-term infants on the fine and gross motor items of the DDST is shown in Addenda 5.4 - 5.7. Although the number of infants in each age group is too small to allow any statistically significant conclusions, there appears to be very little overall difference in the achievements of the pre-term and full-term infants.

On the fine motor-adaptive scales both groups were slower to grasp a rattle than their full-term counterparts. The black group was also slower in reaching and in raking/attaining a raisin, whilst the white group was slower in manipulating cubes and looking for the yarn. However, both groups overtook the full-term infants in the same three later items : neat pincer grasp of raisin, tower of 2 cubes and scribbles spontaneously.

On the gross motor scales, both black and white pre-term groups were slower than the full-term infants in acquiring the items related to head-control and sitting, in particular in achieving unsupported sitting. Again, both pre-term groups overtook the full-term infants later. The black infants appeared to do so earlier - achieving pull-to-stand, gets-to-sitting and walking holding onto furniture earlier than their full-term counterparts - whereas both pre-term groups overtook the full-term infants on standing alone well, stooping and recovering and walking well.

No other consistent differences were noted between the pre-term and full-term groups, although the white pre-term group appeared to go through an astasic stage not noted in any other group.

Chapter 5

DISCUSSION

5.1 COMPARISON OF DENVER AND SOUTH AFRICAN SAMPLES

Because the original Denver data cannot be recalled in order to allow statistical comparison, Frankenburg et al's criteria[56] for a "notable" difference in ages of attainment, i.e. a difference of one month or more in the attainment-age of items acquired during the first year of life, has been accepted as the basis for discussion.

5.1.1. Fine motor development

Both black and white South African infants performed notably better than the Denver sample on two items involving early midline orientation and another two items reflecting basic grasping patterns. The black infants also excelled at the third basic grasping item and the white infants at two items involving manipulation of cubes in the midline. The Denver sample did not achieve any fine motor item significantly earlier in the first year.

Song Jie[151] found Shanghai Chinese infants to be in advance of the Denver infants on the same three basic grasping items. Solomons[86] reported Yucatecan infants to be advanced in two of these three items as well as on one of the items requiring manipulation of cubes in the midline. Yalaz and Epir[97] noted that urban Turkish infants were advanced on hands-together and on two of the three grasping items (they omitted grasping a rattle from their study); their infants were, however, considerably delayed on reaching and on looking for yarn. Pedneault et al[94] found French-Canadian babies to be advanced over the Denver sample in passing a cube hand-to-hand as well as looking for yarn. Findings with a Cardiff sample[90] approximated the performance of the Denver infants with the exception of passing a cube hand-to-hand, in which the Cardiff babies were delayed. None of the authors offered reasons for their findings.

The three basic grasping items represent stages in the development of control of the radial side of the hand. The young baby grasps the rattle using the ulnar side of the palm of his hand. Over a period of weeks the pattern of grasp changes to total palmar and then to radial palmar. As weight-bearing on the hands brings the thumb out of the palm, the infant gradually develops the use of the radial tripod (thumb, index and middle fingers) and eventually achieves a precise "pincer" grip. In none of the above studies could any correlation be found between the development of arm-support and the use of the thumb in grasp. The Yucatecan and black South African samples both came from communities in which toys were relatively scarce, whereas the Denver, Cardiff, Canadian, Shanghai and Ankara children came from environments in which toys were freely available. It would appear, therefore, that the evolution of grasp occurs relatively independently of the opportunity to manipulate objects.

In view of the marked differences in socio-economic circumstances between the two South African groups, no obvious reasons can be found for the superiority of both these groups over the Denver sample on basic grasping items, nor that of the white infants on early manipulative items.

Frankenburg et al[56] do not give any guidelines for interpretation of differences in performance during the second and third years. The performance of the South African children was particularly noteworthy at the 90% attainment level, where the black sample achieved five out of seven items between 2,56 and 20,55 months earlier than the Denver sample (mean difference 8,97 months) and the white sample achieved all 8 items for which data is available by between 2,51 and 20,35 months earlier (mean difference 8,36 months).

The items in which the South African children excelled most during the second and third year were dumping a raisin from a bottle after demonstration, building towers of 4 and 8 blocks and scribbling spontaneously. The early achievement of scribbling spontaneously may have been influenced by the change in procedure employed in this study, as explained in Chapter 3, and for this reason the results will not be considered valid, although Yalaz and Epir[97] found that their Ankara sample acquired scribbling at the same age as the black South African group. They also found early acquisition of dumping a raisin from a bottle after demonstration as well as building towers of 2 to 4 blocks.

The Denver children performed better than both South African groups in dumping a raisin from a bottle spontaneously, although at the 90% level there was a reversal in favour of the white South African sample. The validity of the Denver test method for this item was queried in Chapter 3 since the criteria in the Denver manual did not exclude accidental dumping of the raisin. The stricter criteria employed in this study will have influenced the recorded performance of the South African children. The Turkish sample of Yalaz and Epir[97] also performed similarly to the black South African infants on this item, but they do not mention their criteria.

Studies carried out in other countries have not shown any obvious differences between the performance of the indigenous and Denver samples after the first year, with the exception of Japan where Ueda noted that Tokyo children[95] were delayed in copying a circle whilst Okinawa children[96] were delayed in all items after the first year.

It is difficult to explain the markedly better performance of the South African children during the second and third year, particularly in view of the widely discrepant environmental and socio-economic backgrounds of the two South African groups. It is more than 20 years since the items on the DDST were standardized[56] and although the form of the test has been revised as recently as 1981[89] the norms for Denver children remain unaltered. It is therefore tempting to postulate that general advances in nutrition and child-care, as well as recent enthusiasm for early stimulation, may have accounted for improved performance in this later study. However, of the five studies using the DDST which have been published in the last five years[86,90,94,97,151] only the Turkish study[97] has shown similarly advanced performance.

5.1.2. Gross motor development

In the first year, three identical items occurred notably earlier in both South African samples than in the Denver sample. One of these items reflected head-control in flexion and the other two reflected weight-bearing on the legs. The black infants also excelled in another two items involving weight-bearing on the legs and in a further two items involving independent sitting. Advanced head-control in flexion on pull-to-sitting was also found in the Yucatecan, Shanghai and Ankara studies(86, 151, 97) whilst early weight-bearing on the legs was seen in the Canadian, Yucatecan and Ankara studies(94, 86, 97). This early weight-bearing did not, however, persist for as many items as in the two South African samples. In particular the Yucatecan study reported markedly late acquisition of standing holding-on, standing alone momentarily and walking holding-onto-furniture, whilst the Ankara infants were slow in standing alone momentarily. Although the Cardiff studies(90, 91) claim early weight-bearing, re-analysis of the 1974 data(92) showed that the difference between the Cardiff and Denver infants was less than one month. The Cardiff infants were also late in acquiring standing holding-on and pull to standing.

It is interesting that despite the markedly early weight-bearing on the lower limbs observed in the South African infants, they do not show a notable advance in the development of extension in the prone position. Since the South African infants were well advanced on head-control in flexion it may be that this imbalance between flexor and extensor tone prevented the early acquisition of head steady in sitting seen in the Canadian and Yucatecan infants, although only the Canadian infants showed development in prone in advance of the Denver sample(94, 86). The black South African infants appeared to overcome this imbalance and achieved independent sitting as well as getting to sitting in advance of the Denver infants, but at the 50% level the white South African infants still lagged behind in getting to sitting.

The only item in the first year acquired obviously earlier by the Denver infants was rolls over. The reliability of the Denver scoring for this item has been queried in Chapter 3 and much stricter scoring criteria were used in this South African study. Delay in rolling was also reported in the Cardiff, Canadian, Tokyo Shanghai and Turkish studies and the ages of acquisition of rolling in these five studies approximate the attainment ages of the South African samples. Pedneault(94) in the Canadian study does specify rolling from supine to prone, and found this to be delayed in relation to the Denver sample at three months.

In the second and third years there was again a similarity in the performances of the two South African samples, both of whom attained the same five items between 4,58 and 8,18 months earlier than the Denver children at the 50% level (mean difference = 6,08 months for the black infants and 6,23 months for the white infants). At the 90% level there was more variety in the items achieved earlier, but the black group acquired six items and the white group five items more than three months in advance of the Denver children (mean differences 6,70 months for the black children and 7,66 months for the white children). Analysis of these items shows that they represent a broad range of skills including co-ordination, balance, physical strength and learned skills. No other studies have shown this degree of advance over the Denver sample, although both Ankara and Cardiff children were advanced in kicking and throwing[97,90]. Shanghai children were advanced on throwing a ball only. The Ankara children were advanced in relation to the Denver children in balancing on one leg for one second, but were delayed in five other items acquired during the second and third years.

The only item achieved notably earlier by the Denver sample after the first year was pedalling a tricycle, particularly in comparison with the black group. This was undoubtedly related to lack of opportunity, since very few black children had access to a tricycle and this was the one item in this study accepted by parent's report as it was not possible to take a tricycle to each clinic. Only three other studies appeared to have used this item. Of these, the Cardiff and Tokyo children acquired the ability to pedal a tricycle much later than the Denver sample, whilst the Shanghai study found this item so inappropriate that it was eventually excluded from general use.

Overall, five of the previous eight studies using the DDST found fairly good correlation with the majority of the gross motor items. The exceptions were Cardiff and Japan. In Cardiff a slight delay in the acquisition of gross motor items[90] was confirmed by a later study[92]. In Japan, Tokyo infants were found to show delayed gross motor development in the first seven months[95] and Okinawa infants were delayed in comparison with the Denver sample throughout, although the gross motor development of the Okinawa infants was in advance of that of the Tokyo infants initially[96].

Very few reasons were advanced for these differences. Ueda[95] suggested that delayed early motor development might be due to the preferred use of supine by Japanese mothers, a view also expressed by Song Jie[151] who noted that the Chinese infants were particularly delayed in prone development. Ueda[96] also suggested that the initially faster development of Okinawa as compared to Tokyo infants might be related to the lighter clothing needed in the warmer climate, to a tendency on the part of Okinawa mothers to encourage walking and to different socio-economic circumstances. However, whilst the Okinawa children had a poorer socio-economic background than their Tokyo counterparts, Bryant et al[91] and Epir and Yalaz[98] found little difference in gross motor achievement due to social class - differences only becoming apparent from the second year and favouring the higher socio-economic groups.

In view of the disparate ethnic and socio-economic backgrounds of the two South African groups, and the fact that both groups were advanced in the same or similar gross motor items, it seems likely that the reasons for their advanced motor behaviour in comparison with the Denver sample may be a combination of climate and child-handling practices. Child-handling practices will be discussed in detail in the section comparing the performance of black and white South African infants (5.2) but certain similarities in practice are discussed below.

In general, South African parents do not use the prams and carry-cots which were popular twenty years ago. Although baby "cocoons" have recently become popular for very young infants, at the time of this study both black and white infants spent a lot of time in an upright or semi-reclining position. Black infants are carried on their caretaker's back for many hours of the day, whilst white infants were observed propped in plastic baby-seats, in baby-buggies and, increasingly, in slings worn either on the mother's back or against her chest. In these positions forwards control of the head is encouraged, as well as the early vertical control of head and trunk required for sitting. In contrast, when black infants are removed from their caretaker's back - except during periods of active play - they are swaddled and placed on their sides, as when sleeping with their parents. Although white parents place their babies in prone, on questioning it becomes apparent that this is done primarily for sleeping. These factors may contribute to the comparatively delayed prone development and the relatively advanced head-control in flexion, midline orientation and (on the part of the black group) sitting.

Both black and white parents were observed to stand their babies on their laps from as early as 16 days, being relatively casual about the support to the head which would have been thought necessary a decade or so ago. In the case of the black babies further use of the standing position was noted, which will be discussed in more detail in section 5.2.

5.2 COMPARATIVE PERFORMANCE OF THE TWO SOUTH AFRICAN SAMPLES

5.2.1. Fine motor items

The white infants achieved eight items at the 50% level and six items at the 90% level notably earlier than the black infants. Statistical significance was shown for only two items. All items but one involved manipulation of objects, the remaining item requiring recognition of the longer line of two. The black infants acquired two basic grasping items considerably earlier (one significantly so) as well as building a tower of two blocks.

Previously published African studies make very little reference to specific items of fine motor-adaptive performance. The item for which the most information is available is precision grasp. Although the age at which 50% of the sample attain an item and the median age of attainment cannot be equated, it appears that both the black Cape Town infants and the black Johannesburg infants tested by Liddicoat[23] achieved precision grasp at approximately the same age. This was in advance of other African samples, being about one month earlier than Faladé's Senegalese sample[6] and the white Cape Town infants, who both achieved precision grip at about the same age as Bayley's norm (9,30 months). Poole[28] found that Nigerian infants acquired precision grip at 10,00 months, but Geber's[8] findings were no different from the Griffiths and Cattell norms (both 11 months) which approximate Gesell's norm of 48 weeks.

Frankenburg[44] found that both black and "Anglo" samples in Denver corresponded to the original Denver norm of 10,70 months. In the only other negro study in which this item is reported, Scott et al[41] reported a median of 32,21 weeks, which closely approximates the South African urban black performance.

Touwen[57] in a detailed study of grasping behaviour, demonstrated the wide variability in the normal evolution of grasping, finding a mean of 12 months but a range of from 10 to 17 months for the acquisition of pincer grasp in Dutch children, who have been found relatively slow in motor development[57,51]. Even allowing this variability, however, it would seem advisable to use Bayley's norm[31] when evaluating pincer grip in South African infants.

Of the three African studies reporting on other aspects of fine motor behaviour, two found that African infants are in advance of the Gesell schedules, particularly within the first year(6,8), whereas one noted white infants to be advanced in items representing "perceptual and sensori-motor responses to stimuli"(2). Both studies finding advanced behaviour initially found that performance deteriorated between the second and third year, ascribing this to poor nutrition and greatly reduced stimulation from the mother after weaning.

Studies on American negros proposed that both nutrition and socio-economic circumstances influence fine motor performance. The three studies carried out prior to 1950 all showed delayed fine motor behaviour in negro infants as compared with white infants(37,48,39) and, although McGraw(37) rejected nutritional influences, the other two studies stressed the poor nutritional status of the negro samples. Knobloch and Pasamanick(40) in a follow-up study of Pasamanick's 1946 sample(39) re-affirmed the role of nutrition in development generally, but found that fine motor development was the one area in which the heavier infants did not, in fact, perform better. In support of the role played by socio-economic circumstances, Pasamanick found that the fine motor performance of negro infants, although delayed in comparison to white infants with superior backgrounds, was advanced in comparison to that of institutionalized or fostered white infants.

Later studies in groups which were better matched for socio-economic background have shown little difference in fine motor performance between negro and white infants. Bayley(19) found that black infants were advanced on two items of midline arm and hand use. Grantham-McGregor and Hawke(52) found black Jamaican infants to be slightly advanced in comparison with the Gesell schedules and found a significant correlation with socio-economic status, infants from higher socio-economic groups performing better ($p < 0,05$). In comparing three groups of infants of unskilled parents, Frankenburg(44) reported equal performance of black and "Anglo" infants but found that the black infants performed better than Spanish-surname infants (traditionally from one of the lowest socio-economic groups) on four fine motor items. As in the present study Anglo (and Spanish-surname) children identified the longer of two lines earlier than the black children.

In a study in the United Kingdom, Pollak <u>et al</u>[45] found no difference in the fine motor performance of English and West Indian babies at three and six months of age, but reported the English babies to be advanced over the West Indian infants at nine months of age.

That the black South African infants possessed the motor co-ordination required for manipulative tasks is proven by their significantly earlier acquisition of basic grasping items. Despite this the white children performed better on items requiring manipulation of objects. Factors which must be considered are nutrition, socio-economic conditions and experience. Nutrition may have played a minor role in the infants' performance. Although a higher percentage of black infants than white infants weighed over the 75th percentile, there were also more black infants weighing less than the 25th percentile. Just over 38% of black infants weighed in at less than the 50th percentile, compared with just over 32% of white infants. However, no infants tested was obviously malnourished and breast-feeding in the black infants was generally continued until nearly two years of age. There was no correlation between weight and any fine motor items for either group, with the exception of dumping a raisin from a bottle after demonstration, which was achieved earlier by the heavier babies in the white group. The weight was not thought to influence the performance (although the reverse might be true!). Despite the fact that the socio-economic circumstances of the black infants were, in general, vastly below those of their white counterparts, no correlation was found between family size, parents' occupation or family income and fine motor performance. In the black group only a significant correlation was found between the mother's education and the ability to build a bridge ($p=0,002$).

It seems most likely that the explanation for the more advanced fine motor performance of the white infants is secondary to the differences in socio-economic status, reflecting the greater availability of toys in white households, in particular of "educational" toys such as blocks and crayons. The white children thus had more manipulative experience.

It is possible that the item "picks longer line of two" is conceptually unsuited to black infants; although their performance was still in advance of the Denver norms, it was delayed in relation to that of the white infants, as also noted by Frankenburg[44].

5.2.2. Gross motor items

Using the criteria of Frankenburg et al once more[56], the black infants achieved seven items notably earlier in the first year. Statistical significance could be shown for six of these, as well as for one further item. Analysis of these items shows that one is related to arm-support, two to independent sitting and five to standing. Although these items included walking holding onto furniture, there was no difference between the black and white groups in the age of independent walking. In the second year the two jumping items and balance on one foot for 5 seconds occurred considerably earlier, and the two jumping items as well as heel-toe walking occurred significantly earlier.

The white infants performed earlier on 6 items acquired during the second and third years, most of which involved learned skills. Only in the case of one item, riding a tricycle, was this statistically significant.

Gross motor development is better documented than fine motor development in the earlier African studies, and this study supports the findings of Falad頁6], Geber[8], Griffiths[21], Kilbride[17], Leiderman[30] and Super[33] regarding the advanced motor performance of black African infants in the first year of life. In particular it corroborates Griffiths' findings for urban black South African infants. It also support Falad鈥檚 finding of a temporary plateau in the second year, followed by a re-emergence of advanced performance on items requiring equilibrium. Although the performance of the black children did not equal that of the white children in the other second and third-year items, they cannot be said to show the noticeable decline in performance described in earlier African studies as they still achieved these items in advance of the Denver norms.

As far as most of the specific items are concerned, this study confirms the findings of other African studies, particularly as regards the early acquisition of sitting and standing by black infants. It also confirms Super's finding that primary standing is retained until it is integrated with mature standing, as well as his observations of rather slower development in prone, although the South African black infants did achieve arm-support significantly in advance of their white counterparts. Despite the earlier acquisition of standing items, however, this study does not confirm the earlier achievement of walking seen in previous studies of black African infants.

The superiority of the black infants on the two jumping items was unexpected, although Super relates the practice of jumping to early standing ability(33). It is interesting that these are the only two items in the inventory requiring physical strength, broad-jump being used specifically as a test of strength in the Bruininks-Oseretsky test of motor performance in older children(157).

Most of the earlier African studies proposed that child-handling practices were largely responsible for the advanced motor performance of black infants(7,10,17,30,33). These practices included not only the method of carrying and the constant proximity of child and mother, but also specific handling practices related to sitting, standing and walking(17,30,33). Ethnic differences predisposing to enhanced early development were also proposed by Geber and Dean(8,9) on the basis of studies of newborn Ugandan infants, and this view has been supported by Cobb(11), Leiderman(30), Keefer et al(34) and Hennessy et al(35). Geber and Dean(8) also postulated a degree of influence of socio-economic circumstances, since they found that infants from lower socio-economic groups showed advanced development in early infancy; infants from higher socio-economic groups were less advanced in early infancy but also did not show such a marked decline in the second year. Both Faladé(6) and Geber(7,8) explained this decline in terms of decreased nutrition and maternal contact after weaning, the malnutrition sometimes being severe, as with kwashiorkor.

The same pattern of advanced early gross motor development in black infants was noted in comparative studies of American negro and white infants by Pasamanick(39), Scott et al(41), Bayley(19) and Walters(32), although the duration of advanced gross motor performance ranged from 24 weeks(32) to two years(39). Only McGraw(37) found white infants to be advanced. Frankenburg et al(44) found the black infants to be advanced on a few early items only.

In the four studies which compared the development of American negro infants to the Gesell norms, three studies reported the negro infants to be advanced in gross motor behaviour(49,50,52). Curti(48) found the negro infant to be delayed in most aspects of gross motor performance, but not in standing and walking.

In both the comparative and the normative negro studies a divergence of opinion was expressed regarding the effects of socio-economic circumstances. Three studies(41,49,50) found advanced performance in the lower socio-economic groups, whilst two studies(39,32) reported advanced performance in the higher socio-economic groups. Curti(48) attributed the poor performance of her 1935 Jamaican infants at least in part to poor nutrition, poverty and overcrowding. Williams and Scott(49) postulate that child-handling practices are a function of social class and that the lower social classes display less restrictive practices, enhancing gross motor development. They also rejected ethnic factors.

In the present study there is a wide discrepancy in the socio-economic backgrounds of the black and white samples, yet relatively few interactions could be shown between gross motor performance and the different variables related to socio-economic circumstances. There were, however, more interactions affecting the black group than the white group. Although there was no correlation with family size, black first-born infants walked holding-on earlier than later-ranked children ($p= 0,05$). Black infants of better-educated mothers also pulled to standing earlier ($p=0,03$) and there was a positive correlation between the higher black income levels and the earliest and most advanced weight-bearing activities observed (bears some weight on legs and balances on 1 leg for 5 seconds - in both of which $p=0,04$). Conversely, black children with parents in the lowest occupational groups gained head-control earlier on pull-to-sit ($p=0,04$). With none of these variables, however, could consistent trends be shown with increasing or decreasing ranking of variables.

Although the overall socio-economic level of the black group fell far below that of the white group, the advanced gross motor performance of the black infants in the first year cannot be attributed to their lower socio-economic circumstances per se, as some earlier studies have implied[8,41,49,50]. Not only is there some evidence for improved gross motor performance with improved socio-economic levels within the black group, as shown above, but the socio-economic circumstances of the present black sample are not strictly comparable with those of the early African studies. Although gross overcrowding and poverty were present in many circumstances, the present sample came from an urban background, the parents were better educated and most of the parents were employed in situations which brought them and their families into contact with so-called Western culture.

In both black and white samples there was some interaction between weight and the acquisition of gross motor activities. This was demonstrated for six gross motor items with the black babies and seven gross motor items with the white babies. In all instances the heavier babies performed best, whereas babies weighing below the 10th percentile were considerably delayed in gross motor skills, particularly in standing and walking. It is, however, difficult to explain the advanced first year performance of the black infants in terms of weight, since although the black sample had a slightly greater proportion of infants weighing more than the 90th percentile, it also had a considerably greater proportion of infants weighing less than the 25th percentile. However, no seriously malnourished babies were included in the sample.

The similarities in handling practices between black and white parents have been described in section 5.1.2. Despite these similarities, several differences in handling practice were evident. All but three of the 681 black infants were carried on the caretaker's back. Two young mothers favoured the shop-bought front sling and one mother sported an enormous antique pram! No pushchairs or baby-buggies were seen in the black clinics. Although the baby's head was often covered, no attempt was made to support it as such, and it frequently hung backwards. The method of putting the baby onto the mother's back varied according to the age of the infant. Young babies are lifted by both arms at about elbow level, the mother crossing her own arms to do so, with the baby facing her. As she bends forwards she swings the baby over her shoulder, uncrossing her arms so that the baby lands face down on her back. The infant is then left completely unsupported while the mother sorts out her blankets. When the top edge of the first blanket is tied, the mother then widely abducts the infant's legs around her own waist before fastening the lower edge of the blanket. Older babies are swung around by one arm only - a right-handed mother grasping the right arm of the baby as it faces her, and swinging the baby over her own left shoulder.

The babies are carried thus for much of the mother's walking and working day, but when she is at leisure, as when waiting in the clinic, she handles the baby rather casually, mostly in the standing position. The patterns most often observed were encouraging the baby to pull himself up to standing from sitting or squatting on the mother's lap and, from as early as four months of age, sliding the baby over the edge of her lap (from the prone position) until the infant takes his weight on his feet on the floor, supported only by his mother's hands on top of his own hands, which are on her lap. Bouncing or jumping activities, as noted by Super(33) were not seen in the mothers in this study.* From a very early age babies are also placed precariously in sitting on the edge of their mother's lap, facing the mother and supported only by the mother's hands on their thighs.

Although these three patterns of handling were seen over and over again, they did not seem to constitute conscious practice by the mother. They appeared rather to be a culturally-determined habitual form of handling used automatically, with relatively little attention focused on the child. With very few exceptions, black infants sleep in their parents' beds, swaddled and lying on their sides.

Handling practices among white parents appear to be less stereotyped but most white babies spend a considerable portion of the day propped up in sitting or semi-reclining in plastic baby seats, baby-buggies or infant car-seats. Very young infants are transported in prams or

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* Lee(152), who found superior jumping skill in older black children, attributed this to "non-authoritarian" maternal attitudes.

cocoons; these are most used for transport and sleeping only. White infants are afforded relatively more support than black infants, especially in sitting. Most white mothers placed their babies in prone for sleeping. Although Holt[54] ascribes superior development in prone to the use of the prone position for sleeping, no such relationship was noted in the present study. On the contrary, the black infants, who did not sleep in prone, acquired arm-support in prone significantly in advance of the white infants.

After the first year the black children appeared to have less restraints placed upon their motor behaviour than the white children, but they also had less opportunity for experience in activities such as climbing stairs, ball-play and riding a tricycle.

Although Dennis[77, 141, 153] considered that motor development could be retarded but not advanced by handling practices, there is ample neurological evidence that the use of a synapse facilitates the passage of further impulses across that synapse[158]. Wyke[107] also states that handling leads to maturation of mechanoreceptors, enhancing their response to stimuli. It is likely, therefore, that child-handling practices play a significant role in the differential gross motor development of black and white South African infants, in particular with regard to the early acquisition of head-control in flexion, sitting and standing by the black infants and with regard to the advanced skill of the white children in learned activities during the second and third years. Nevertheless, as Illingworth[100] points out, such practice can only be effective when nervous system maturation is sufficient.

It is probable, therefore, that handling practices alone do not account for all the differences in performance, in particular for the advanced performance of the black infants relatively early in the first year. Several writers proposed that genetic factors may play a part in early gross motor development[39, 100, 154] and some have related these specifically to the state of muscle tone observed in newborn infants of different ethnic origins[19,34,35].

Because the present study only included infants from 16 days of age onwards no assumptions can be made regarding the neuro-motor status at birth of the two populations studied. Since the differences in gross motor development between the black and white infants cannot be explained purely in terms of other variables, there are grounds for accepting an ethnic component.

5.3 COMPARISON OF BLACK AND WHITE INFANTS ON THE SUPPLEMENTARY ITEMS

In comparing the black and white infants a similar pattern was observed to that noted with the DDST gross motor items. The black infants were advanced in six first-year items whereas the white infants were advanced in two items observed in the second and third years. The items in which the black infants were advanced were rolling, two items related to independent sitting and three items related to prone locomotion. The white infants were advanced in two protective reactions in standing.

For the purpose of discussion the supplementary reactions will be divided into the vanishing reactions (primary motor patterns), developmental components of movement and protective reactions.

5.3.1. Vanishing reactions

Items in this category are the grasp reflex, the Galant (or trunk incurvation) reflex and the tactile placing reactions of the feet.

5.3.1.1. The neonatal palmar grasp reflex

In this study the grasp reflex was lost earlier by white infants, which is in opposition to Pollak's findings that West Indian babies (in the United Kingdom) were highly significantly advanced at one month of age in their ability to open their hands[45]. Since 50% of black infants in this study had already lost the palmar grasp reflex by 0,67 months, the difference between the black and white infants can probably be discounted, particularly in view of the black infant's earlier acquisition of basic grasping items.
For both groups the age at which the reflex was lost is considerably younger than that reported by Peiper[116] and by Touwen[57].
Touwen records that the time elapse between initial changes in the response and eventual disappearance can be as much as 16 weeks. He also found a very inconsistent developmental course.
Paine et al[123] considered the devolutional course to be too inconsistent to be evaluated by cross-sectional studies. In view of the extremely short developmental course observed in the present cross-sectional study a longitudinal study would be of value.

5.3.1.2. Galant reflex

This reflex, which represents lack of postural control, was lost by both black and white infants by about 4 months of age. Both South African samples showed comparatively delayed prone development in relation to their overall performance, which might predispose to retention of the Galant reflex, but the absence of comparative date from other studies makes it impossible to draw any conclusions and again indicates the need for a longitudinal study.

5.3.1.3. Tactile placing reactions of the feet

This response was obtained consistently in both groups at all ages. It was obtained in response to a purely tactile stimulus and it was never found necessary to apply traction, as suggested by Paine et al(123). It seems probable that this consistent response is related to the equally consistent ability to weightbear at all ages noted in both groups, but particularly in the black infants.

5.3.2. Developmental components of movement

Three developmental sequences were studied, the earliest related to flexor control against gravity, the second to arm-support and the third to prone locomotion. The developmental courses of these sequences show overlap between successive patterns.

In the three spontaneous patterns representing the development of flexion against gravity (Figs. 20 and 21) the white infants lagged slightly behind the black infants in the acquisition of successive patterns, but there is no significant difference in performance. Once the most advanced form of spontaneous flexion against gravity became part of the infant's repertoire, he continued to use all three forms at will, dependent upon his degree of spontaneous activity at the time.

In contrast to this series of patterns, the other two series studied showed loss of the original pattern as the more advanced form was developed. Although 100% of black infants acquired the most advanced form of arm-support considerably in advance of the white infants (Figs. 16 and 17), there was fluctuation between the two groups as to the preferred form at different stages during development. Nearly 90% of black infants were still sometimes using the earlier form of arm-support at six months of age, at which stage well over 80% of them had already achieved the advanced form. The early form was abandoned by all but 10% of black infants by twelve months of age. In contrast, at 7,5 months only 75% of white infants were still using the early pattern, although at that age scarcely 80% had already achieved the advanced pattern. All but 10% of the white infants abandoned the early form by 15 months of age.

The relationships between creeping and crawling were shown in Figs. 18 and 19 . The most interesting feature here is the very early rejection by the black infants of creeping as a mode of progression. At eight months only 60% had acquired creeping, but since crawling had already been achieved by 50% of black infants by that stage the creeping pattern was rapidly abandoned, being seen occasionally in less than 20% of black children at 10 months, by which age over 90% were crawling. The white infants showed a different picture, creeping being attained by 90% of white infants at five months and still being used by 50% at eight months of age, at which age only 38% of white infants were crawling. Crawling was only achieved by 90% of white infants at just over 12 months of age.

Touwen[57] studied the development of locomotion in the prone position, describing four phases before crawling on all fours is used consistently. Not all of his infants utilized all five phases. Both his findings and those of McGraw[37] agree with the findings of the present study regarding variability in onset and overlap of the different phases. The term "overlap" is chosen in preference to Touwen's use of "relapse" since the infant at no stage loses a newly-acquired ability but merely resorts to an earlier pattern when it affords more stability for a particular task.

Although I agree with Touwen on the importance of longitudinal studies, it has been shown by the present study that cross-sectional data can provide information regarding the developmental course of related behavioural activities. It is not possible from the present study, however, to relate performance in one sequence of developmentally-related behaviours to performance in a different sequence. For this, longitudinal studies are required. Even using longitudinal studies, Touwen[57] could not find uniform relationships between the developmental courses of different items.

5.3.3. Protective reactions

Whereas the black infants were advanced with respect to protective reactions in sitting, achieving sitting with arms free for play (implying the presence of equilibrium reactions) and protective backwards extension of the arms earlier, the white infants were advanced with respect to protective reactions in standing - acquiring protective sideways steps earlier, as well as walking-on-heels (implying the presence of equilibrium reactions in standing). These findings correlate well with the performance of the two groups of infants on the DDST gross motor scale, in which black infants were advanced in independent sitting whereas white infants were advanced in balance on one foot (for one second) for a brief period during the second year.

No difference was found between the black and white groups in the downwards parachute reaction and in sideways protective extension of the arms. The former was, however, developed by both groups considerably in advance of the age cited by Paine et al[123].

The developmental course of related protective reactions could not be established as poor inter- and intra-observer reliability had resulted in the exclusion of certain items from the series originally planned.

5.4 DEVELOPMENTAL NORMS FOR PRE-TERM INFANTS

Traditionally the age of pre-term infants has been corrected for gestational age at time of birth when assessing motor behaviour. Palisano et al[155], in a comparative study of full-term and low-risk pre-term infants found that scores for gross and fine motor performance were comparable when based upon adjusted age, but lower in the pre-term infants when based upon chronological age. They concluded that adjusted age should be used up to one year but that further studies were needed on older age-groups. Miller et al[165], on the other hand, found that use of the corrected age failed to identify abnormal infants, particularly after nine months of age. They also found that use of the adjusted age resulted in over-correction for the most premature infants, especially in the first few months of life.

The present study shows little difference between pre-term and full-term infants after eight to nine months of age, the black infants catching up earlier. This supports Miller's suggestion that the uncorrected age should be used when evaluating pre-term infants for suspected motor development problems. However, this study was not designed specifically to evaluate pre-term infants and further research in this area is needed.

5.5 LIMITATIONS OF THE STUDY

Although the trends evidenced in this study were only supported statistically in relatively few instances, it seems likely that this is due to the relatively small numbers of infants in each age-cell. In the gross motor items, in particular, statistical significance would possibly have been proven in even more items had the numbers of children tested been larger. It may be, also, that the statistical design of the study - that of probit analysis - was in itself limiting as it prevented more direct comparison of means, especially since the Denver data could no longer be recalled.

Although little correlation was found between motor performance and socio-economic factors, the extremely wide gap between the black and white groups in all factors relating to socio-economic circumstances made analysis of the underlying reasons for differences in performance difficult. This wide discrepancy, coupled with the small numbers of infants in each age-cell, made it impossible to stratify part of the sample in order to obtain two groups with comparable socio-economic backgrounds.

Although on the basis of this study the most likely reasons for differences in performance appear to include handling practices, ethnic traits and nutrition, longitudinal studies of two groups more equally matched for socio-economic background, and including evaluation of new-born behaviour, may be more successful in identifying reasons for differences in motor performance as well as in establishing relationships between different motor behaviours which might be of use in predicting later motor performance.

Chapter 6

CONCLUSIONS

1. Both white and urban black infants in this study achieved the majority of the items on the gross motor and fine motor-adaptive sections of the Denver Developmental Screening Test at notably earlier ages than those standardized for the Denver sample.

2. Significant differences did exist in the ages of acquisition of gross motor and fine motor-adaptive items between the groups of white and urban black infants. These differences favoured the white infant in most of the fine motor items and the black infants in most of the gross motor items - particularly gross motor items acquired during the first year of life.

3. Environmental factors, in particular child-handling practices but also nutrition, appeared to play a major role in determining these differences in motor performance, but the effects of genetic traits cannot be discounted. Very little correlation was shown between motor performance and socio-economic circumstances.

4. Performance in the supplementary items showed a pattern of superior performance by the black infants commensurate with their performance on the gross motor items of the DDST. For both groups, performance on the reflex and protective reactions was consistent with the findings for related items on the DDST. The developmental sequences of movement in which specific components of movement evolve over a period of time showed considerable variation between the groups and further study is necessary in order to establish whether this is due to cultural differences or whether such variations exist within cultural groups. At present the acquisition of a particular component of movement at a particular age cannot be considered predictive for future evolution of the developmental sequence concerned.

Recommendations

1. The findings of this study should be taken into account when using the DDST to assess black and white children in the Western Cape area within the first three years of life. Use of the DDST without adaptation could result in under-referral of children requiring

intervention, particularly when assessing the gross motor performance of black infants within the first year of life. When assessing the fine motor performance of black infants deductions should probably be based upon the achievement of basic grasping items rather than the handling of material which may be unfamiliar. Culturally unsuited items should be excluded. Certain of the DDST items for which the criteria are equivocal should be restandardized for South African use, using stricter criteria.

The degree by which both white and urban black infants achieved both gross and fine motor-adaptive items in advance of Denver children during the second and third years is striking, and renders use of the unadapted DDST norms ineffective in identifying questionable or even abnormal performance by Western Cape infants.

2. Longitudinal studies are necessary in order to confirm the reasons postulated for differences in motor performance between the two groups. The two groups should be more evenly matched for socio-economic factors than in the present study, and the study should include detailed evaluation in the newborn period in order to investigate possible ethnic characteristics related to postural tone, spontaneous movement, alertness and other factors.

3. Longitudinal studies will also be of value in following the evolution of related components of movement within a developmental sequence and determining their value as predictors of future motor behaviour.

4. Since there appears to be some evidence that use of the corrected age when assessing pre-term babies may lead to under-referral of infants requiring intervention, a longitudinal study of the motor development of low-risk pre-term infants is also indicated.

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ADDENDUM 1

SIMPLIFIED OCCUPATIONAL INDEX BASED UPON WORKING PAPER 6 - 76 OF THE CITY ENGINEER'S DEPARTMENT, CAPE TOWN[147]

S.E.S. score	Occupations
9	Medical doctors, dentists, veterinarians, pharmacists; University professors and lecturers in tertiary education; Legislative officials, judges, lawyers; Economists, public accountants and auditors; Architects, town planners, civil and chemical engineers; Chemists, physical scientists not elsewhere classified.
8	Physicists, biologists, botanists, zoologists; Bacteriologists, pathologists, pharmacologists; Physiotherapists, occupational therapists, optometrists; Surveyors, statisticians/mathematicians, actuaries, accountants; System analysts and computer programmers; Engineers not classified elsewhere, metallurgists; School principals and inspectors; Aircraft pilots, navigators, flight engineers; Authors, editors, journalists, reporters, P.R.O's; Government administrators and executive officials; Managerial posts exc. trade, transport, farm, catering/hotel; Clerical supervisors; technical and engineering /electronics salesmen; Insurance and real estate salesmen.
7	Draughtsmen, engineering and science/medical technicians; Dieticians, radiographers, speech therapists, social workers; Chiropractors, osteopaths etc; Teachers - secondary, primary, pre-primary; Ships deck officers, pilots and engineers; Ministers and missionaries (ordained); Librarians, archivists, curators, anthropologists, translators; Commercial artists and designers; actors;

7 (cont.)	Transport, trade, catering and hotel managers; Post and railway-station masters; traffic officers; Buyers, commercial travellers (not elsewhere classified); Book-keepers, credit controllers; Farmers, nurserymen (own property); Tool and metal pattern-makers, photo-engravers, electro-typers;
6	Professional nurses; photographers and cameramen; Fine artists, composers, musicians, dancers, singers; Professional sportsmen, coaches, sports officials; All office work not elsewhere classified, receptionists; Brokers and agents not elsewhere classified; Own business (wholesale and retail), sales supervisors; Policemen, detectives, firemen, armed forces; Railway engine drivers and firemen; Skilled workers : jewellery and precious metal; electrical, electronics, radio and television, telephone; watch and precision instrument; machinery fitters; aircraft, diesel and office machine mechanics; Mining (certified), metal and chemical processing and manufacture; Quarrymen (certified), production supervisors and foremen; Boilermakers and metal moulders; Farm managers and supervisors;
5	Pharmacy and nursing assistants; Non-ordained religious workers; Stock-clerks, shop salesmen/assistants; Housekeepers, hairdressers, beauticians, etc; Undertakers; Hunters, game wardens, conservation workers; Cabinet makers, stonecutters, blacksmiths, carpenters; Electrical workers not classified elsewhere; Plumbers, welders, metal workers, machine tool operators; Busdrivers; railway brakemen, signalmen and shunters; Motor vehicle mechanics; Glass engravers; Compositors, typesetters, printers, bookbinders.

4	Sorting clerks, messengers ; postmen ; Caretakers, lift-attendants, air hostesses, ambulance-men; Panel-beaters, spray-painters, other painters; Plasterers, brick-layers, glaziers; Taxi, lorry, truck, ambulance and other drivers; Heavy vehicle/machinery operators; Merchant seamen not classified elsewhere; Semiskilled workers not classified elsewhere; Scholar or student; housewife/husband.
3	Cooks, waiters, barmen, baggage-handlers; Semiskilled farm-workers and forestry workers; Fishermen, food-workers; Textile and clothing workers, shoe-makers; General construction workers; Unemployed; retired ; institutional inmate.
2	Chars, chambermaids, launderers; Gardeners; Unskilled labourers not classified elsewhere.
1	Domestic servants; Unskilled farm-workers; Child (not scholar).

ADDENDUM 2 : PILOT TRIAL OF SUPPLEMENTARY ITEMS

OBSERVER			
VIEWING (1,2,3)			
AGE IN WEEKS			
CODE NUMBER			

GROSS MOTOR SECTION - NEW TEST ITEMS

Please tick one block each time an item is noted. Do not exceed 5, even if noted more than 5 times.

	Item						total
1.	A.T.N.R. posture						
2.	Primary walking						
3.	Grasp reflex (tonic)						
4.	Galant						
5.	Supine, flexed legs resting on heels and lat. border						
6.	On elbows, add. scapulae, abd/int. rot shoulders						
7.	Head above line of trunk in ventral suspension						
8.	Ant. pelvic tilt in prone						
9.	Head in line with shoulders on P.T.S.						
10.	Hands to midline in flexion and int.rot.						
11.	Moro still present						
12.	On elbows, abd. scapulae, add/neutral rot. shoulders						
13.	Swimming - add. scapulae						
14.	Supine - hands to knees in int.rot./pronation						
15.	Supine - total flexor pattern but no post. tilt						
16.	Startle still present (spontaneous or induced)						
17.	Downwards parachute legs						
18.	Placing reactions legs (tactile)						
19.	Downwards parachute arms						
20.	Weightshift on elbows with lat. trunk flex.						
21.	Early weight on hands (int.rot./abd/semi-flex/fisted)						
22.	Full Landau						
23.	Supine - reach in add. + neutral rot.						
24.	Lifts head in anticipation of P.T.S.						
25.	Hands to feet in supine <u>or</u> total flex. c̄ post. tilt						
26.	Bridging						
27.	Weightshift on elbows with elongation W-B side						
28.	Rolls prone to supine						
29.	Full E.R. on obliques						
30.	Amphibian on weightshift in puppy (rot.)						

							total
31. Puppy - reach in int.rot.							
32. Weight on hands in add./neutral rot./open hands							
33. Rolls supine to prone							
34. Pivotting							
35. Creeping - unilateral with lat. flex.							
36. Creeping - reciprocal with rot.							
37. Sitting - arms free for play							
38. Sitting to prone							
39. All fours (with or without rocking)							
40. Sideways protective ext. arms							
41. Crawling							
42. Cruising							
43. Bear-standing							
44. Bear-walking							
45. Backwards protective ext. arms							
46. Full E.R. in sitting							
47. Sideways protective steps							
48. Backwards protective steps							
49. Walks on toes							
50. Walks on heels							
51. Walks down steps - 2 feet to each step							
52. Walks up steps reciprocally							
53. Walks down steps reciprocally							
54. E.R. in standing (doesn't alter base)							

ADDENDUM 3 : RECORD FORMS

ASSESSMENT FORM - CROSS-SECTIONAL SAMPLE

Name

Date of test Ethnic group

Date of birth ______________

Age ______________ Age (days-unadjusted)

Gestation

Adjusted age Age (days-adjusted)

Sex

Position in family

Number in house

Father's occupation ....

education ....

Mother's occupation ....
(actual/previous?)

education ....

Income R.................. p.m.

Marital status

Weight .... kg. Percentile

Time spent testing (minutes)

No. 1

DENVER - FINE MOTOR

1. Follows to midline
2. Equal movements
3. Follows past midline
4. Hands together
5. Follows 180°
6. Grasps rattle
7. Regards raisin
8. Reaches for object
9. Passes cube hand to hand
10. Sitting - looks for yarn
11. Sitting - takes 2 cubes
12. Rakes raisin : attains
13. Thumb-finger grasp
14. Bangs 2 cubes held in hands
15. Neat pincer grasp of raisin
16. Tower of 2 cubes
17. Dumps raisin from bottle - demonstrated
18. Scribbles spontaneously
19. Tower of 4 cubes
20. Dumps raisin from bottle - spontaneously
21. Imitates vertical line within 30°
22. Copies O
23. Tower of 8 blocks
24. Imitates bridge
25. Picks longer line (3 of 3 <u>or</u> 5 of 6)
26. Copies +
27. Draws man 3 parts
28. Imitates □ - demonstrated
29. Copies □
30. Draws man 6 parts

No. 2

DENVER GROSS MOTOR

1.	Prone - lifts head	
2.	Prone - head up 45°	
3.	Prone - head up 90°	
4.	Sitting - head steady	
5.	Prone - chest up, arm-support	
6.	Rolls over	
7.	Pull to sit - no head lag	
8.	Bears some weight on legs	
9.	Sits without support	
10.	Stands holding on	
11.	Pulls self to stand	
12.	Gets to sitting	
13.	Walks holding on furniture	
14.	Stands momentarily	
15.	Stands alone well	
16.	Stoops and recovers	
17.	Walks well	
18.	Walks backwards	
19.	Walks up steps	
20.	Kicks ball forwards	
21.	Throws ball overhand	
22.	Jumps in place	
23.	Pedals tricycle	
24.	Balance on 1 foot (1 sec./2 of 3)	
25.	Broad jump	
26.	Balance on 1 foot (5 sec./2 of 3)	
27.	Hops on 1 foot	
28.	Heel to toe walk/2 of 3	
29.	Catches bounced ball/2 of 3	
30.	Balance on 1 foot (10 sec./2 of 3)	
31.	Backwards heel-toe/2 of 3	

No. | | | | | 3 |

SUPPLEMENTARY ITEMS

1. Grasp reflex (tonic)
2. Galant
3. Supine, flexed legs resting on heels and lat. border
4. Head in line with shoulders on P.T.S.
5. Supine - hands to knees in int. rot.
6. Placing reactions feet (tactile)
7. Downwards parachute arms
8. Early weight on hands (int. rot/abd/semiflex/fisted)
9. Hands to feet in supine <u>or</u> total flexion $\bar{c}$ post. tilt
10. Amphibian on weight-shift in puppy (rotation)
11. Weight on hands in add/neutral rot/open hands
12. Rolls supine to prone
13. Creeping - unilateral with lat. flexion
14. Sitting - arms free for play
15. All fours (with or without rocking)
16. Sideways protective extension arms
17. Crawling
18. Bear standing
19. Backwards protective extension arms
20. Sideways protective steps
21. Walks on heels

No. | | | | | 4 |

ADDENDUM 4 - GOODNESS-OF-FIT FOR PROBIT ANALYSIS AND NON-PARAMETRIC LOGISTIC REGRESSION MODELS

4.1 FINE ITEMS IN BLACK GROUP

Item	Probit Function	Chi-Square	P-value
3	-4,9385 + 0,8579	0,7671	1,0000
4	4,5908 + 1,0859	0,1850	1,0000
5	2,7383 + 0,9827	1,0518	1,0000
6	3,8660 + 2,1542	1,9033	1,0000
7	2,8695 + 2,1046	5,4236	0,9963
8	1,0989 + 1,0896	9,2740	0,9313
9	1,5144 + 0,6865	18,0632	0,3849
10	1,7827 + 0,6349	8,8090	0,9461
11	-1,9136 + 3,9568	10,1689	0,8964
12	-0,2550 + 0,8265	15,3923	0,5672
13	Non-parametric	R^2 = 98,86%	
14	-1,4335 + 3,1572	29,1903	0,0328
15	Non-parametric	R^2 = 99,09%	
16	-6,5695 + 4,4086	12,1093	0,7935
17	-8,4301 + 5,3736	23,0252	0,1131
18	-4,8051 + 3,8027	18,0000	0,3888
19	0,1940 + 0,2739	3,0848	0,9999
20	-5,5890 + 3,6344	8,5961	0,9521
21	1,1204 + 0,1543	10,7247	0,8705
22	0,6890 + 0,1435	24,4121	0,1087
23	0,7307 + 0,1851	16,3856	0,4967
24	-9,6360 + 4,2580	6,6025	0,9881
25	-11,4756 + 4,7198	4,2110	0,9993
27	1,0531 + 0,0828	37,9832	0,0025

4.2 FINE ITEMS IN WHITE GROUP

Item	Probit Function	Chi-Square	P-value
2	7,1545 + 0,4024	7,6153	0,9741
3	6,1373 + 1,0837	4,3785	0,9991
4	5,8078 + 1,6066	0,8090	1,0000
5	3,6113 + 2,0671	3,3256	0,9999
6	4,0994 + 1,8637	8,1448	0,9634
7	2,7643 + 2,2976	15,3437	0,5707
8	0,8121 + 3,3233	2,2513	1,0000
9	Non-parametric	98,97%	
10	-1,7160 + 4,2309	7,1178	0,9820
11	-1,1466 + 3,5683	17,8638	0,3975
12	Non-parametric	99,08%	
13	-4,5097 + 4,6770	16,6575	0,4778
14	-2,1810 + 3,5020	7,0736	0,9826
15	-4,6991 + 4,3874	6,5162	0,9890
16	-12,4039 + 6,7414	10,4797	0,8823
17	-12,4665 + 6,8162	5,7814	0,9945
18	Non-parametric	99,38%	
19	-10,5400 + 5,5589	9,3032	0,9303
20	-8,7159 + 4,9601	9,9428	0,9030
21	-6,8506 + 3,8321	3,1381	0,9999
22	-8,7457 + 4,1786	1,7429	1,0000
23	-12,8183 + 5,9014	3,7155	0,9997
24	-13,6489 + 5,4801	0,5109	1,0000
25	-13,0007 + 5,2483	2,4243	1,0000
26	-14,1180 + 5,3047	1,7987	1,0000
27	-21,3503 + 7,3455	0,0572	1,0000

4.3 GROSS ITEMS IN BLACK GROUP

Item	Probit Function	Chi-Square	P-value
2	3,5768 + 1,3068	0,5680	1,0000
3	3,1376 + 1,0197	0,4589	1,0000
4	3,3056 + 0,8492	2,0323	1,0000
5	2,5746 + 0,8499	6,6300	0,9879
6	0,8180 + 0,8631	10,2626	0,8922
7	2,6351 + 0,7931	2,0058	1,0000
8	4,8665 + 0,5928	5,3540	0,9966
9	-0,5016 + 1,1854	0,4921	1,0000
10	-0,0369 + 0,8654	17,2595	0,4369
11	-6,7886 + 5,907	21,3214	0,1665
12	-1,5185 + 0,8665	14,4064	0,6382
13	-1,5783 + 0,7715	9,3493	0,9287
14	-2,4325 + 0,7398	6,8723	0,9851
15	Non-parametric	98,13%	
16	Non-parametric	98,57%	
17	Non-parametric	98,98%	
18	Non-parametric	98,61%	0,0339
19	0,3465 + 0,2954	22,0759	0,1841
20	0,2005 + 0,3143	17,7873	0,4024
21	Non-parametric	98,31%	
22	0,8558 + 0,1965	9,6435	0,9179
23	0,1630 + 0,1580	8,3172	0,9593
24	0,9286 + 0,1567	23,0082	0,1490
25	0,9107 + 0,1609	18,0951	0,3829
26	-0,9830 + 0,1871	3,6398	0,9997
27	-0,3816 + 0,1409	5,3598	0,9966
28	-4,4931 + 0,2638	0,0332	1,0000
29	1,3161 + 0,0673	29,5422	0,0298
30	Non-parametric	91,06%	
31	1,5670 + 0,0490	20,2699	0,2607

4.4 GROSS ITEMS IN WHITE GROUP

Item	Probit Function	Chi-Square	P-value
2	5,009 + 2,2298	0,4676	1,0000
3	3,8897 + 2,0681	4,0307	0,9994
4	2,4700 + 1,9409	11,4708	0,8311
5	2,3200 + 2,2578	28,7458	0,0369
6	-2,1740 + 4,3097	12,0257	0,7986
7	3,0645 + 1,9784	32,8573	0,0118
8	5,3174 + 0,9283	13,1074	0,7290
9	-3,5403 + 4,9817	23,2813	0,1403
10	-5,2639 + 5,2717	15,2294	0,5790
11	-7,2666 + 5,7568	10,5703	0,8780
12	-7,6356 + 5,8624	7,5962	0,9744
13	-7,8457 + 5,7462	7,4165	0,9775
14	-8,8208 + 5 8534	3,4969	0,9998
15	-10,7802 + 6,4090	12,4514	0,7721
16	-12,6541 + 7,1142	10,2915	0,8909
17	-13,9048 + 7,5694	2,0147	1,0000
18	-21,6868 + 10,2276	0,9277	1,0000
19	-11,8530 + 6,1956	3,9888	0,9995
20	Non-parametric	99,39%	
21	-21,1008 + 10,0502	19,1984	0,3173
22	-5,3053 + 3,2844	7,1789	0,9811
23	-6,5767 + 3,5594	5,0141	0,9977
24	-6,1233 + 3,5639	11,4476	0,8324
25	-6,6287 + 3,5395	15,9517	0,5273
26	-9,2304 + 4,0812	1,4949	1,0000
27	-8,5704 + 3,6317	5,0863	0,9975
28	-8,2950 + 3,5665	3,2123	0,9999
29	-4,5052 + 2,3730	2,4067	1,0000
30	-2,5156 + 1,7253	3,7296	0,9997
31	-1,5520 + 1,3816	5,5557	0,9957

4.5 SUPPLEMENTARY ITEMS IN BLACK GROUP

Item	Probit Function	Chi-Square	P-value
1	5,4429 - 0,6567	7,4535	0,9769
2	7,2993 - 0,6215	17,0439	0,4514
3	3,9222 + 1,1595	1,5432	1,0000
4	2,6974 + 0,7731	1,4940	1,0000
5	1,9167 + 0,9381	21,5211	0,2038
6	N/A		
7	1,1044 + 0,7762	24,4717	0,1072
8	Non-parametric	94,88%	
9	-0,0524 + 1,1600	1,5289	1,0000
10	1,3663 + 0,8996	3,4656	0,9998
11	0,3072 + 0,8903	6,8453	0,9855
12	Non-parametric	98,90%	
13	Non-parametric	97,70%	
14	-0,7880 + 1,0904	6,0720	0,9931
15	Non-parametric	98,57%	
16	0,1051 + 0,8256	8,0952	0,9645
17	Non-parametric	98,24%	
18	Non-parametric	98,59%	
19	Non-parametric	99,06%	
20	Non-parametric	98,73%	
21	0,8116 + 0,1537	19,8742	0,2807

4.6 SUPPLEMENTARY ITEMS IN WHITE GROUP

Item	Probit Function	Chi-Square	P-value
1	4,7723 - 0,3691	15,0571	0,5914
2	7,1633 - 0,5694	13,6088	0,6946
3	2,6500 + 1,7101	0,1806	1,0000
4	3,0530 + 0,6523	5,8251	0,9943
5	1,6905 + 0,8598	7,5681	0,9749
6	6,9070 + 0,0172	27,4825	0,0514
7	0,7986 + 0,5133	7,4354	0,9772
8	Non-parametric		
9	1,1841 + 0,8000	14,8202	0,6084
10	0,8829 + 1,0080	2,0708	1,0000
11	-0,1931 + 0,8949	20,7955	0,2356
12	0,5595 + 0,8132	15,9281	0,5289
13	Non-parametric		
14	-1,3309 + 0,9725	5,5166	0,9959
15	-2,0914 + 3,5326	10,2933	0,8909
16	-0,4574 + 0,8002	5,8811	0,9939
17	0,4871 + 0,4963	11,3281	0,8390
18	1,0220 + 0,4276	20,8763	0,2319
19	-1,9520 + 0,6077	4,6808	0,9985
20	-2,9977 + 0,6285	1,4999	1,0000
21	0,8852 + 0,1619	5,1315	0,9974

ADDENDUM 5 : PRE-TERM INFANTS

5.1 BLACK PRE-TERM INFANTS - NUMBER OF DAYS PRE-TERM c/f PERCENTILE WEIGHT GROUP AT TIME OF TESTING

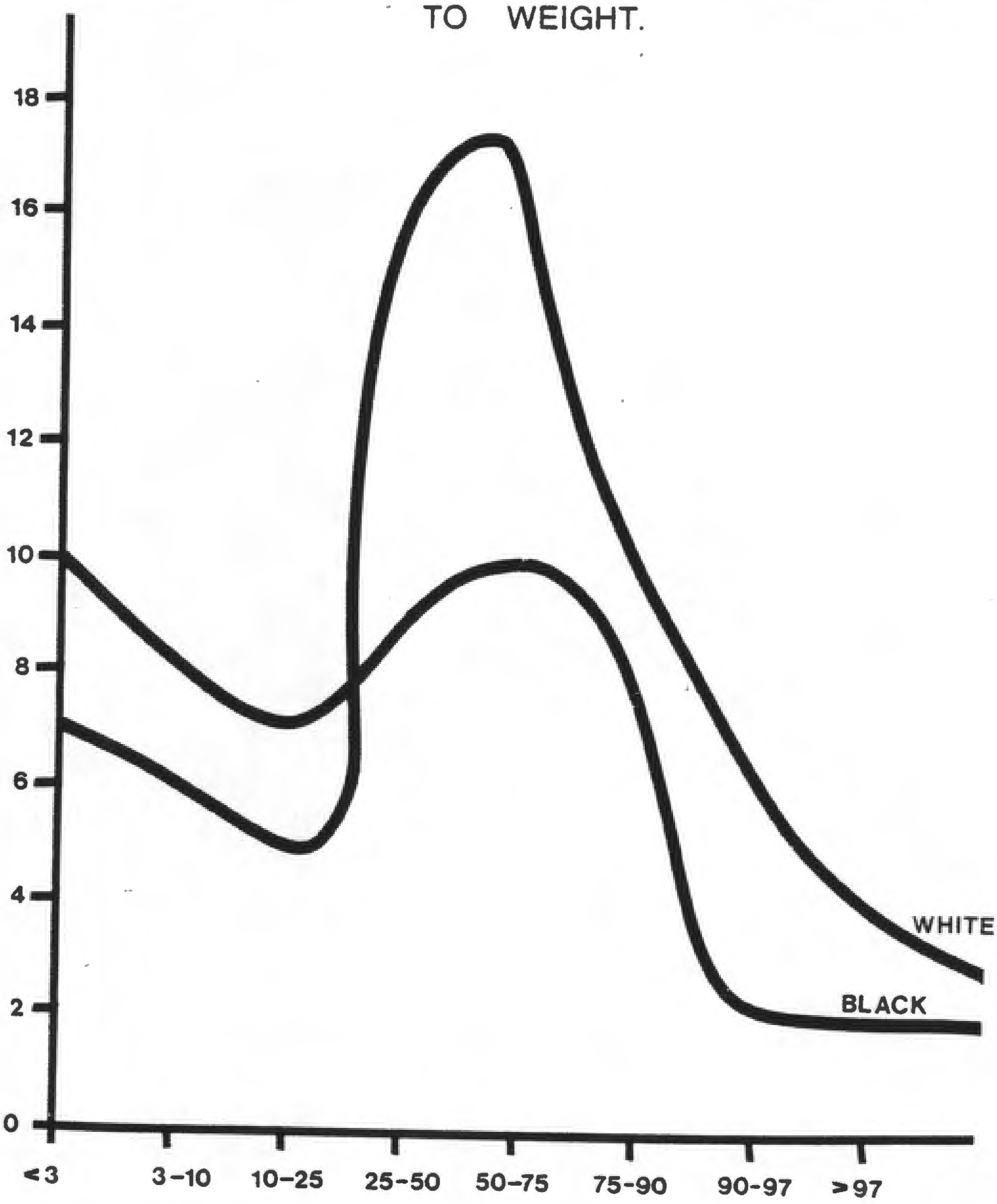
Days pre-term	Weight %	Days pre-term	Weight %
84	25-50	28	25-50
56	50-75	28	25-50
56	25-50	28	10-25
49	50-75	28	10-25
49	50-75	28	10-25
49	< 3	28	10-25
49	< 3	28	10-25
49	< 3	28	3-10
42	25-50	28	3-10
42	10-25	28	3-10
42	< 3	28	3-10
42	< 3	28	3-10
35	75-90	28	3-10
35	75-90	28	< 3
35	25-50	28	< 3
35	10-25	28	< 3
35	3-10	28	< 3
28	> 97	28	< 3
28	90-97	21	> 97
28	75-90	21	90-97
28	50-75	21	75-90
28	50-75	21	75-90
28	50-75	21	75-90
28	50-75	21	75-90
28	50-75	21	25-50
28	50-75	21	25-50
28	50-75	21	3-10
28	25-50		

5.2 WHITE PRE-TERM INFANTS - NUMBER OF DAYS PRE-TERM c/f PERCENTILE WEIGHT GROUP AT TIME OF TESTING

Days pre-term	Weight %	Days pre-term	Weight %
70	25-50	28	3-10
56	50-75	28	<3
56	25-50	21	>97
56	10-25	21	90-97
56	3-10	21	90-97
56	<3	21	90-97
56	<3	21	90-97
42	>97	21	90-97
42	10-25	21	90-97
42	<3	21	75-90
42	<3	21	75-90
42	<3	21	75-90
28	>97	21	75-90
28	>97	21	75-90
28	75-90	21	75-90
28	75-90	21	75-90
28	50-75	21	75-90
28	50-75	21	50-75
28	50-75	21	50-75
28	50-75	21	50-75
28	50-75	21	50-75
28	50-75	21	50-75
28	50-75	21	50-75
28	50-75	21	50-75
28	25-50	21	25-50
28	25-50	21	25-50
28	25-50	21	25-50
28	25-50	21	25-50
28	25-50	21	25-50
28	25-50	21	25-50
28	10-25	21	25-50
28	10-25	21	25-50
28	10-25	21	3-10
28	3-10	21	3-10
28	3-10	21	<3

5:3

DISTRIBUTION OF PRE-TERM INFANTS ACCORDING TO WEIGHT.



5.4 PRE-TERM BLACK GROUP - FINE MOTOR ITEMS

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	30	36
NO. CHILDREN IN GROUP:	3	4	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
1. Follows to midline	3	4	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
2. Equal movements	3	4	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
3. Follows past midline	2	2	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
4. Hands together	3	3	6	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
5. Follows 180°			1	7	7	5	6	6	3	8	9	2	3	1	5	1	4	3	4
6. Grasps rattle		1	5	6	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
7. Regards raisin			1	2	6	3	6	6	3	8	9	2	3	1	5	1	4	3	4
8. Reaches for object				2	3	4	6	6	3	8	9	2	3	1	5	1	4	3	4
9. Passes cube hand to hand					1	1	4	6	3	8	9	2	3	1	5	1	4	3	4
10. Sitting - looks for yarn					2	2	4	6	2	8	9	2	3	1	5	1	4	3	4
11. Sitting - takes 2 cubes							4	6	3	8	8	2	3	1	5	1	4	3	4
12. Rakes raisin - attains								4	2	8	9	2	3	1	5	1	4	3	4
13. Thumb-finger grasp								1	2	8	9	2	3	1	5	1	4	3	4
14. Bangs 2 cubes held in hands							1	2	1	5	7	2	3	1	5	1	4	3	4
15. Neat pincer grasp of raisin									1	6	9	2	3	1	5	1	4	3	4

5.4 PRE-TERM BLACK GROUP - FINE MOTOR ITEMS (cont.)

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	30	36
NO. CHILDREN IN GROUP:	3	4	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
16. Tower of 2 cubes									1				3		4	1	4	3	4
17. Dumps raisin from bottle (demonstrated)													2		4	1	4	3	4
18. Scribbles spontaneously											1		3	1	3	1	4	3	4
19. Tower of 4 cubes															2	1	4	3	4
20. Dumps raisin from bottle (spontaneously)															2	1	3	3	4
21. Imitates vertical line within 30^{0}															1		2	2	4
22. Copies circle																		2	4
23. Tower of 8 blocks																	4	3	4
24. Imitates bridge																		1	4
25. Picks longer line																			2
26. Copies cross																			4
27. Draws man - 2 parts																			1
28. Imitates square (demonstrated)																			1
29. Copies square																			1
30. Draws man - 6 parts																			

5.5 PRE-TERM WHITE GROUP – FINE MOTOR ITEMS

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	24	30	36
NO. CHILDREN IN GROUP:	9	1	7	9	8	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
1. Follows to midline	9	1	7	9	8	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
2. Equal movements	9	1	7	9	8	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
3. Follows past midline	7	1	7	9	8	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
4. Hands together	6	1	7	9	8	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
5. Follows 180^{0}			2	7	7	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
6. Grasps rattle		1	2	7	7	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
7. Regards raisin				5	7	12	12	9	8	5	8	6	5	3	11	5	3	4	6	4
8. Reaches for object				2	3	11	10	9	8	5	8	6	5	3	11	5	3	4	6	4
9. Passes cube hand to hand						7	10	9	8	5	8	6	5	3	11	5	3	4	6	4
10. Sitting - looks for yarn						6	8	6	8	5	8	6	5	3	11	5	3	4	6	4
11. Sitting - takes 2 cubes						2	6	7	6	5	8	6	4	3	11	5	3	4	6	4
12. Rakes raisin - attains							6	5	7	5	8	6	5	3	11	5	3	4	6	4
13. Thumb-finger grasp							1	1	4	5	8	6	5	3	11	5	3	4	6	4
14. Bangs 2 cubes held in hands							3	1	4	4	6	5	4	3	10	5	3	4	6	4
15. Neat pincer grasp of raisin									2	3	3	6	3	3	11	5	3	4	6	4

5.5 PRE-TERM WHITE GROUP - FINE MOTOR ITEMS (cont.)

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	24	30	36
NO. CHILDREN IN GROUP:	9	1	7	9	8	13	12	9	8	5	8	6	5	3	11	5	3	4	6	4
16. Tower of 2 cubes										1			1	3	9	4	3	4	6	4
17. Dumps raisin from bottle (demonstrated)												1	2	2	10	5	3	4	6	4
18. Scribbles spontaneously													3	3	9	4	2	4	6	4
19. Tower of 4 cubes														1	3	3	3	3	6	4
20. Dumps raisin from bottle (spontaneously)													1	1	5	4	2	3	6	4
21. Imitates vertical line within 30^{0}																1	1	3	3	4
22. Copies circle																	1	1	2	3
23. Tower of 8 blocks																	1	2	6	4
24. Imitates bridge																			3	3
25. Picks longer line																			1	3
26. Copies cross																				2
27. Draws man - 2 parts																			1	3
28. Imitates square (demonstrated)																				2
29. Copies square																				1
30. Draws man - 6 parts																				2

5.6 PRE-TERM BLACK GROUP - GROSS MOTOR ITEMS

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	30	36
NO. CHILDREN IN GROUP:	3	4	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
1. Prone - lifts head	3	4	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
2. Prone - head up 45°	1		6	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
3. Prone - head up 90°	1		2	6	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
4. Sitting - head steady		1	2	6	6	5	6	6	3	8	9	2	3	1	5	1	4	3	4
5. Prone - chest up, arm-support			1	4	6	5	6	6	3	8	9	2	3	1	5	1	4	3	4
6. Rolls over					2	3	6	6	3	8	9	2	3	1	5	1	4	3	4
7. Pull to sit - no head lag		1		2	6	3	6	6	3	8	9	2	3	1	5	1	4	3	4
8. Bears some weight on legs	3	2	7	7	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
9. Sits without support						3	5	6	3	8	9	2	3	1	5	1	4	3	4
10. Stands holding on							2	5	3	8	9	2	3	1	5	1	4	3	4
11. Pulls self to stand								2	3	8	8	2	3	1	5	1	4	3	4
12. Gets to sitting									3	6	8	2	3	1	5	1	4	3	4
13. Walks holding onto furniture									3	6	8	2	3	1	5	1	4	3	4
14. Stands momentarily									1		3		3	1	5	1	4	3	4
15. Stands alone well									1		1		3	1	5	1	4	3	4
16. Stoops and recovers									1		1		3	1	5	1	4	3	4

5.6 <u>PRE-TERM BLACK GROUP - GROSS MOTOR ITEMS</u> (cont.)

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	30	36
NO. CHILDREN IN GROUP:	3	4	7	8	8	5	6	6	3	8	9	2	3	1	5	1	4	3	4
17. Walks well									1				3	1	5	1	4	3	4
18. Walks backwards													3	1	5	1	4	3	4
19. Walks up steps													2	1	3	1	3	3	4
20. Kicks ball forwards													2		2	1	4	3	4
21. Throws ball overhand													2	1	4	1	4	3	4
22. Jumps in place															2	1	2	3	4
23. Pedals tricycle																		2	4
24. Balances on 1 foot (1 sec.)																		2	3
25. Broad jump															1	1	2	2	3
26. Balances on 1 foot (5 sec.)																		1	2
27. Hops on 1 foot																			2
28. Heel-to-toe walk																		1	2
29. Catches bounced ball																			
30. Balances on 1 foot (10 sec.)																			1
31. Backwards heel-to-toe																			1

5.7 PRE-TERM WHITE GROUP - GROSS MOTOR ITEMS

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	24	30	36
NO. CHILDREN IN GROUP:	9	1	7	9	8	13	12	9	8	6	8	6	5	3	11	5	3	4	6	4
1. Prone - lifts head	9	1	7	9	8	13	12	9	8	6	8	6	5	3	11	5	3	4	6	4
2. Prone - head up 45°	3		7	9	8	13	12	9	8	6	8	6	5	2	11	5	3	4	6	4
3. Prone - head up 90°	1		2	6	8	12	12	9	8	6	8	6	5	3	11	5	3	4	6	4
4. Sitting - head steady				8	3	13	12	9	8	6	8	6	5	3	11	5	3	4	6	4
5. Prone - chest up, arm-support				1	4	11	12	8	8	6	8	6	5	3	11	5	3	4	6	4
6. Rolls over						3	8	7	8	6	8	6	5	3	11	5	3	4	6	4
7. Pull to sit - no head lag				4	3	13	12	9	8	6	8	6	5	3	11	5	3	4	6	4
8. Bears some weight on legs	6	1	5	6	7	11	12	7	8	6	8	6	5	3	11	5	3	4	6	4
9. Sits without support					1	2	5	6	7	6	8	6	5	3	11	5	3	4	6	4
10. Stands holding on							2	4	5	6	8	6	5	3	11	5	3	4	6	4
11. Pulls self to stand								1	2	4	8	4	5	3	11	5	3	4	6	4
12. Gets to sitting								1	2	3	7	6	5	3	11	5	3	4	6	4
13. Walks holding onto furniture									1	2	6	4	5	3	11	5	3	4	6	4
14. Stands momentarily											2	3	3	3	11	5	3	4	6	4
15. Stands alone well											1	1	2	3	10	5	3	4	6	4
16. Stoops and recovers											1	1	2	3	10	5	3	4	6	4

5.7 PRE-TERM WHITE GROUP - GROSS MOTOR ITEMS (cont.)

ACTUAL AGE IN MONTHS:	<1	1	2	3	4	5	6	7	8	9	10	11	12	13,5	15	18	21	24	30	36
NO. CHILDREN IN GROUP:	9	1	7	9	8	13	12	9	8	6	8	6	5	3	11	5	3	4	6	4
17. Walks well											1	1	2	3	10	5	3	4	6	4
18. Walks backwards														1	7	5	3	4	6	4
19. Walks up steps															5	4	3	4	6	4
20. Kicks ball forwards														3	7	5	2	4	6	4
21. Throws ball overhand														1	9	5	3	4	6	4
22. Jumps in place															1		2	2	3	4
23. Pedals tricycle																	1	1	3	4
24. Balance on 1 foot (1 sec.)																	1	2	5	4
25. Broad jump																	1	1	2	4
26. Balance on 1 foot (5 sec.)																				4
27. Hops on 1 foot																				3
28. Heel-to-toe walk																				2
29. Catches bounced ball																				2
30. Balance on 1 foot (10 sec.)																				1
31. Backwards heel-to-toe																				

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