SPECIAL REPORT

Reuse

4

PERS 261 PSYCHOMETRIC ASSESSMENT OF THE LONG-TERM EFFECTS OF KWASHIORKOR

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

CSIR Special Report PERS 261 (pp. i - ix ; 1 - 33)
UDC 616.39:159.922.7](680=963)
Johannesburg, Republic of South Africa, March 1977

SPECIAL REPORT

PB

PERS 261 PSYCHOMETRIC ASSESSMENT OF THE LONG-TERM EFFECTS OF KWASHIORKOR

LESLEY S. BURNETT

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

CSIR Special Report PERS 261 (pp. i - ix ; 1 - 33)
UDC 616.39:159.922.7](680=963)
Johannesburg, Republic of South Africa. March 1977

ISBN 0 7988 1099 8 CSIR Special Report PERS 261

Published by

National Institute fir Personnel Research
Council for Scientific and Industrial Research
P.O. Box 10319
Johannesburg 2000
Republic of South Africa 1977

Printed in the Republic of South Africa by
National Institute for Personnel Research

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance and advice of the following :

Dr G.K. Nelson, Director, NIPR.

Mr B.D. Murdoch, Head of the Division of Neuropsychology, NIPR.

Prof. I. Freiman, Principal Paediatrician, Baragwanath Hospital, Johannesburg.

Mrs S. Mashigo, Social Worker, Department of Paediatrics, Baragwanath Hospital, Johannesburg.

This study was partially financed by a grant from the South African Medical Research Council to Prof. J.D.L. Hansen of the Department of Paediatrics, Medical School, University of the Witwatersrand, Johannesburg.

This study was authorized by Mr D.J.M. Vorster, past Director, NIPR, and forms part of project 700/5503.3, Neuropsychological Development.

The cooperation of the subjects and their parents is much appreciated.

SUMMARY

A great deal of the research effort in the field of malnutrition and human development has been focussed on the performance of nutritionally disadvantaged children on standard measures of cognitive performance. These studies have produced equivocal results and many of them have been criticized for using inappropriate control groups.

The aim of the present study was to assess the effects of kwashiorkor 4-12 years after the acute episode using testing instruments likely to be culture-fair and control groups of comparable socio-economic background to the experimental group. The tests applied were a number of subtests from the Reitan-Indiana and Halstead Neuropsychological Test Batteries. Several different abilities (e.g. motor speed and strength, intersensory-integration and visual spatial ability) thought to be localized in different areas of the brain were assessed.

An experimental group of 31 children aged 6-14 years who had been hospitalized for the treatment of kwashiorkor during the first 27 months of life was compared with two age-matched control groups : a group of siblings and a group of yardmates, neither of whom had been exposed to acute infantile malnutrition. Numerous biographical variables were assessed relating to the child's developmental and family history and the child's school performance. The child's current physical status was also assessed. The kwashiorkor group was also investigated to determine the long-term influence of variables such as time of onset of malnutrition and length of stay in hospital on test performance.

The results clearly showed that the three groups were equivalent in respect of the biographical variables assessed. The groups also did not differ statistically significantly in physical status or test performance. Furthermore, variables relating to the kwashiorkor episode were not found to have any significant influence on test performance.

These findings were interpreted as showing that the kwashiorkor subjects had recovered any earlier deficits in the abilities assessed by these tests. While variables such as socio-economic status were controlled for, the possible influence of variables such as maternal and social deprivation could not be assessed. The results are seen as further testimony to the efficacy of modern treatment methods and the resilience of the human organism.

OPSOMMING

'n Groot gedeelte van die navorsing op die gebied van wanvoeding en die ontwikkeling van die mens, is gerig op kinders, met 'n agterstand op voedingsgebied, se prestasie op standaardmetings van kognitiewe vermoë. Hierdie studies het teenstrydige resultate opgelewer en baie van hulle is gekritiseer vir hul gebruik van ongeskikte kontrolegroepe.

Die doel van die huidige studie was om die uitwerking van kwasjiorkor, 4-12 jaar na die akute fase, te bepaal deur die gebruik van toetse wat waarskynlik kultuuronsydig is, asook deur kontrolegroepe, wat vergelykbaar is met die eksperimentele groep ten opsigte van sosio-ekonomiese stand, in te sluit. Die toetse wat toegepas is, is 'n aantal subtoetse van die Reitan-Indiana- en Halstead Neuropsigologiese toetsbatterye. Verskeie vermoëns (bv. motoriese spoed en krag, tussen-sensoriese integrasie en visuele ruimtelike vermoë) wat vermoedelik in verskillende areas van die brein gelokaliseerd is, is gemeet.

'n Eksperimentele groep bestaande uit 31 kinders van 6-14 jaar, wat tydens die eerste 27 maande van hul lewe gehospitaliseer was vir behandeling van kwasjiorkor, is vergelyk met twee kontrolegroepe, afgepaar ten opsigte van ouderdom : 'n groep bestaande uit broers of susters van die eksperimentele groep en 'n groep bestaande uit werfmaats. Nie een van die kontrolekinders was aan akute wanvoeding tydens kleinkinderjare blootgestel nie. Talryke biografiese veranderlikes rakende die kind se ontwikkeling en familie-agtergrond, asook skoolprestasie, is ondersoek. Die kind se huidige fisieke status is ook bepaal. Die kwasjiorkorgroep is ook ondersoek om die langtermyn invloed van veranderlikes soos tyd van aanvang van wanvoeding en duurte van hospitalisasie op toetsprestasie te bepaal.

Die resultate het duidelik getoon dat die groepe gelykwaardig was ten opsigte van die biografiese veranderlikes. Die groepe het ook nie statisties beduidend verskil ten opsigte van fisieke status of toetsprestasie nie. Voorts is gevind dat veranderlikes wat verband hou met die kwasjiorkor-fase ook geen beduidende invloed op toetsprestasie gehad het nie.

Hierdie bevindinge is geïnterpreteer as 'n aanduiding dat die kwasjiorkor-persone van enige vroeëre tekorte in vermoëns, gemeet deur hierdie toetse, herstel het. Hoewel veranderlikes soos sosio-ekonomiese stand gekontroleer is, kon die invloed van veranderlikes soos die houding van die moeder teenoor die kind en sosiale ontneming, egter nie bepaal word nie. Die resultate word gesien as verdere bewys van die doeltreffendheid van moderne metodes van behandeling en van die menslike organisasie se vermoë tot herstel.

CONTENTS

LIST OF TABLES

1. INTRODUCTION

A review of the literature in the field of malnutrition and human psychomotor development has been given previously (Bartel et al., 1977[1]). The present report concerns an investigation of the effects of malnutrition on human brain function as assessed by a number of subtests from the Halstead/Reitan Neuropsychological Test Batteries.

In recent years evidence has accumulated to show that undernutrition during the critical or vulnerable period of most rapid brain growth in animals results in permanent deficits in brain development, e.g. deficits in the total number of brain cells attained. This has been indicated, for instance, by biochemical measurements of cellularity, myelination and other developmental events in the brain (Dobbing, 1968[2]; Winick et al., 1968[3]). Similar findings have been reported in autopsy studies of the brains of children who have died from extremely severe protein-calorie malnutrition (PCM), usually marasmus (Winick and Rosso, 1969[4]; Rosso et al., 1970[5]).

The question of whether less severe forms of PCM have long-term or permanently retarding effects on the brain development of the millions of children who survive infantile PCM has yet to be convincingly answered (Frisch, 1970[6]). Many researchers have used cognitive test performance as an indicator of the integrity of the brain in previously malnourished subjects. Problems have been encountered in applying cognitive measures in cultures different to those in which the tests were originally standardized and in some instances it has been necessary to develop tests for illiterate samples (Champakam et al., 1968[7]). An additional problem which has afflicted all studies in this field has been to find adequate control groups with which to compare the performance of malnourished subjects (see Bartel, 1976[8], pp. 11-13). A number of studies have failed to take cognizance of these problems and have been severely criticized (Hertzig et al., 1972[9]).

A pioneering and much quoted longitudinal study of the effects of infantile marasmus on cognitive test performance was commenced in Cape Town in 1955 (Stoch and Smythe, 1963[10], 1967[11], 1968[12]).

Markedly lower IQ scores were reported for the malnourished group as compared to the control group throughout the 11 year follow-up period. On the basis of this evidence and findings of reduced head circumference and EEG abnormalities in the marasmic group, the authors consider that malnutrition may be followed by organic brain damage.

Champakam et al. (1968[13]) assessed the cognitive ability of a group of Indian children, aged 8-11 years, who had been admitted to hospital suffering from kwashiorkor when between 18 and 36 months old. Each kwashiorkor subject was matched with three controls on a wide range of variables. The kwashiorkor group scored markedly lower on the IQ tests. The deficits were particularly marked in the younger subjects but tended to diminish in the older subjects. The authors mentioned a number of factors other than nutritional ones which may have accounted for the findings, e.g. a loss of learning time due to the long period of immobilization associated with both the acute and treatment phase of kwashiorkor.

In a carefully designed study Chase and Martin (1970[14]) assessed the effects of malnutrition during the first year of life on the physical and intellectual development of children 2-5 years after discharge from hospital. The control group consisted of children of similar socio-economic status and matched for age, weight, sex and race. The previously malnourished subjects had markedly lower developmental quotients than the controls. In view of the many adverse social factors, e.g. social deprivation, involved in a malnourished child's background, the authors suggested the term "psycho-nutritional deprivation".

Hertzig et al.(1972[15]) compared cognitive test scores of a group of 5-10 year old children who had suffered from infantile PCM and two control groups : a group of siblings nearest in age to the malnourished subject and a group of unrelated class mates or neighbours matched for age and sex. The results showed that the Full-Scale, Verbal and Performance WISC means were significantly lower for the malnourished group.

Evans (1973[16]) investigated the relationship between malnutrition and retarded intellectual development by comparing the performance of each of four children, from the same family, but having experienced different degrees of malnutrition during infancy. A comprehensive analysis of the IQ subtest scores indicated that nutritional factors played a significant role in verbal ability. However, in the case of non-verbal ability factors such as medical care and "environmental stimulation" seemed to be just as important as nutrition. Malnutrition seemed to be related to specific deficits in abstract reasoning and learning ability. Conventional measures of "brain damage", e.g. the Bender Gestalt Test, failed to discriminate between the groups. The duration of malnutrition, rather than its severity, as indicated by the kwashiorkor episode, appeared to make the more significant contribution to the intellectual deficit.

A few studies have reported the absence of significant differences in IQ test scores for malnourished and control groups. Evans et al. (1971[17]) administered the New South African Individual Scale (NSAIS) to a group of previously malnourished Cape Coloured children and to a control group comprised of siblings who had never shown clinical evidence of severe PCM. No significant differences were found between the groups on full-scale IQ score, verbal or non-verbal NSAIS score. This intelligence scale had been standardized for the cultural group in question.

Valman's (1974[18]) study was able to separate the effects of malnutrition, on the one hand, and chronic food shortage and social deprivation, on the other. This was achieved by employing an experimental group comprised of children 3-14 years of age who survived a period of malnutrition following extensive resection of the ileum during the neonatal period and then returned to normal upper-class homes. The performance of these subjects on the "draw-a-person" test was compared with that of a group of normal controls and a group of children with cystic fibrosis of the pancreas. The scores for the three groups were not significantly different. The author concluded that malnutrition in infancy alone "had no effect on later intelligence" (p. 427).

Commencing in the 1950's, Cravioto and his associates have conducted a series of studies in Mexico making a major contribution to research in the field of malnutrition and cognitive functioning. In several studies Cravioto investigated intersensory integration functions in malnourished and non-malnourished children.

In his earlier studies, (see Cravioto et al., 1966[19]), subjects who had experienced malnutrition were identified on the basis of a markedly low height for age relative to the total population of a rural village in Guatamala. The intersensory integration ability of children drawn from the lowest quartile of height distribution was compared with that of children from the tallest quartile for age. To control for genetic factors information on the stature of the parents of both groups was obtained. The short stature group performed significantly more poorly than the tall group on the intersensory integration tests. The selection of malnourished subjects on the basis of height for age has, however, been severely criticized (Pollitt and Ricciuti, 1969[20]).

Cravioto and De Licardie (1970[21]) studied the developmental course of auditory-visual equivalence in a group of 39 children aged 5-13 years who had recovered from kwashiorkor. The control group consisted of like-aged siblings without a history of kwashiorkor. The malnourished subjects performed significantly more poorly than the sibling group and well below the expected values for their socio-economic class. Similar results were found for measures of visuo-kinaesthetic integration.

Champakam et al. (1968[22]), working in India, assessed the visual, kinaesthetic and haptic sensory integration ability of 8-11 year old children who had recovered from kwashiorkor and of normal controls. Scores were markedly poorer for the kwashiorkor group, especially in the younger subjects, and tended to improve in the older age group.

Brockman and Ricciuti (1971[23]) studied the effects of PCM on the child's cognitive development as assessed by categorization behaviour, i.e. the "manipulative organization of sorting task objects". Subjects with PCM showed marked deficits as compared to healthy controls.

In summary, the majority of researchers using IQ tests have reported markedly lower scores in previously malnourished children as compared to controls not exposed to acute PCM. Follow-up studies have extended for as long as 11 years.

The deleterious effects of PCM on intersensory integration ability have been shown to persist at least until school-going age in children apparently successfully treated for PCM. Longer-term follow-up studies are necessary to determine whether these effects are transitory or not.

Similarly, the psychomotor development of children exposed to acute PCM has been shown to be retarded. However, follow-up studies have been of short duration and the long-term effects of PCM have not been assessed (see Bartel et al., 1977[24]).

Furthermore, many of the older studies have been criticized for failing to control for many non-nutritive factors such as socio-economic status. The most persistent problem has been to find suitable control groups. The more recent, better designed studies have tended to produce equivocal results.

The aim of the present study was to attempt to assess any effects of PCM which can be found from 4-12 years after the acute episode, using testing instruments likely to be culture-free and control groups of similar socio-economic background.

2. SUBJECTS

The Department of Paediatrics, Baragwanath Hospital, Johannesburg, diagnoses a malnourished child as suffering from kwashiorkor if the child's weight is 60-80 percent of the expected weight and the child has oedema. A child is described as having marasmic kwashiorkor if the weight is below 60 percent of the expected weight and the child has oedema. (See Figure 1).

	OEDEMA	NO OEDEMA
80% of expected weight		
	Kwashiorkor	Underweight Child
60% of expected weight		
	Marasmic Kwashiorkor	Marasmus

Figure 1. Classification of the Underweight Child

The records of Baragwanath Hospital were searched to identify patients admitted to the Department of Paediatrics, 5-10 years before the commencement of the study, suffering from kwashiorkor or marasmic kwashiorkor. This group is older than has been previously studied and should provide a better estimate of the long-term effects of kwashiorkor. The hospital is the only one which serves the area in which the subjects live, either directly or by means of its clinics.

The hospital records of such former patients were carefully examined by a paediatrician. Any indication of "cerebral problems", i.e. brain damage, fits, birth trauma, coma while in hospital, or any indication of hypoglycemia, led to the potential subject being excluded from the investigation.

A list of former patients who met the above requirements was drawn up and a social worker attempted to locate the subjects in Soweto. Once the subject had been located and the parents had agreed to his/her participating in the study a further requirement had to be met. A sibling, reasonably close in age, who had not suffered from acute PCM, had to be available for inclusion in the study. Parents were closely cross-examined and hospital records were carefully scrutinized to ensure that the sibling had not been hospitalized for infantile malnutrition.

The second control group was constituted from yardmates of the probands, were of similar age and like the siblings had not been hospitalized for the treatment of infantile malnutrition.

The final sample consisted of three groups, each of 31 children between the ages of 6-14 years.

The following information on the kwashiorkor subjects was extracted from the hospital records : category of malnutrition, prognosis (determined by paediatricians) and age of onset of malnutrition. (Bartel, 1976[25], p. 15).

Criteria for determining the category of malnutrition have been mentioned previously. For two subjects this distinction could not be made, although there was no doubt that they had experienced PCM.

Patients were described as having a poor prognosis if, on admission to hospital, they had jaundice and/or an abnormally large liver. A poor prognosis was also indicated by the need for intravenous therapy and/or a hospital treatment period of longer than 30 days.

Subjects suffering from kwashiorkor below 16 months of age were described as having an early onset of kwashiorkor, while those hospitalized at 16 months of age or over were described as having a late onset of kwashiorkor. This follows the procedure of Evans (1973[26]).

Numerous biographical data were collected for each subject in respect of his/her developmental history, family history, school performance, physical status, age, sex and handedness. This permitted an estimation to be made of the equivalence of the experimental and control groups in terms of these variables which have often been ignored in previous studies.

School performance was an additional independent variable, but was not used for matching the groups. In the comparison of the groups equivalent educational status was, however, taken into consideration. Likewise, physical status was not used to exclude subjects but as an additional independent variable.

These data are presented in Bartel, 1976[27], pp. 25-35.

3. METHOD

Testing took place in a well-ventilated and illuminated mobile laboratory at Baragwanath Hospital, Johannesburg.

The children were tested individually by the same experimenter who was unaware of the subject's group affiliation. An interpreter was available to explain the requirements of each test in the child's home language.

Information regarding the handedness and footedness of each subject was obtained prior to testing by means of the Reitan-Klove Lateral Dominance Examination (Reitan and Davison, 1974[28]).

The tests were administered according to the instructions in the test manuals, in the same sequence for all subjects. Whenever signs of fatigue were observed in a subject rest periods were allowed. Tests were scored in accordance with instructions in the test manuals.

The scores of the three groups for each item and subitem, and also their total raw score, were compared by using a one-way analysis of variance incorporating Bartlett's test for homogeneity of variances (Guilford, 1956[29]). Where the analysis of variance indicated a statistically significant difference ($p<0,05$) among the groups, pairs of group means were compared by using Scheffé's multiple comparison test. In view of the extremely conservative nature of Scheffé's test a p-value of $<0,10$ was accepted as being statistically significant (Scheffé, 1959[30]).

The scores of the kwashiorkor group were subjected to an intragroup comparison after dividing the group into subgroups on the basis of : poor prognosis and not poor prognosis in hospital ; marasmic kwashiorkor and kwashiorkor ; late and early onset of kwashiorkor. The subgroup means were compared by using a t-test for groups with unequal Ns. This t-test included Welsh's correction for unequal variances (Kendall and Stuart, 1967[31]). The significance level was set at $p<0,05$).

The variable of length of stay in hospital was correlated with each test score using Pearson's r. The variable of recovery period, i.e. time between discharge from hospital and testing in the present study, was similarly correlated with each test score but with the variable of age partialled out (Guilford, 1956[32]). This was necessary because of a development factor influencing performance on the tests used.

In the analysis of results of the experiment a "blind" approach was employed throughout so that the group identities of individual subjects were not known whilst scoring test results.

4. TESTS

The first neuropsychological laboratory for the study of brain-behaviour relationships in humans was established by Halstead at the University of Chicago in 1935.

The battery of tests was originally developed as a means of investigating "biological intelligence" rather than the effects of brain damage (Halstead, 1947[33]). Halstead wanted to avoid the learning-innateness controversy in which "psychometric intelligence", as measured by the usual intelligence tests of the 1920's and 1930's had become enmeshed. Biological intelligence was regarded as something different, being relatively free of cultural influences, and more closely related to nervous system function (Russell et al., 1970[34]).

In his attempt to establish the validity of the concept of biological intelligence, Halstead created an impairment index for brain damage. He regarded performance on paper-and-pencil IQ tests as being relatively unaffected by brain damage, especially that restricted to the frontal areas. If it could be demonstrated that Halstead's tests of biological intelligence were sensitive to brain damage, then a closer link with brain functioning would have been established than had been possible with conventional psychometric tests. Subsequent research using Halstead's battery established that it discriminated between brain damaged and non-brain damaged subjects better than any other measure could (Russell et al., 1970[35]).

The Halstead battery has since been modified by Reitan who was more concerned with the nature of any brain dysfunction and the assessment of brain damage rather than with biological intelligence per se.

A number of subtests from the Reitan-Indiana Neuropsychological Test Battery (RINTB) for children aged 5-8 years and from the Halstead Neuropsychological Test Battery (HNTB) for children aged 9-14 years, were selected on a logical a priori basis as being relatively culture free. A further consideration was to select tests assessing several different abilities thought to be localized in specific areas of the brain. Any deficits in performance would then give some indication of any specific areas of the brain affected by PCM.

The six tests administered in this study were :

(a) Grip Strength.

(b) Finger Tapping Test.

(c) Tactual Performance Test.

(d) Tactile Form Recognition.

(e) Halstead Category Test.

(f) Maze Test of WISC.

(a) Grip strength, measured by means of a Smedley Hand Dynamometer, is a test used for the evaluation of "pure" motor functioning in terms of "power". A mean score for the dominant and non-dominant hands was derived from two trials with each hand. The difference between the mean scores for each hand was also recorded.

(b) The Finger Tapping Test (FTT) is a test of fine motor speed. In the HNTB a mounted manual tapper is used, while in the RINTB an electric counter and tapping key is used which does not traverse as wide an arc as that used for older children and adults. The subject completes 5 consecutive

10s trials with the preferred hand and then with the non-preferred hand. Only the index finger of each hand is used to tap as quickly as possible. The mean score for each hand and the difference between the mean scores was recorded.

Both grip strength and FTT scores have been found to discriminate between brain damaged and non-brain damaged subjects (Reitan, 1970[36]). In spite of its simplicity the FTT has been found to be one of the most sensitive tests for the lateralization of brain damage in the entire RINTB (Reitan, 1964[37]).

(c) The Tactual Performance Test utilizes a modification of the Seguin-Goddard form board. This test measures the subject's ability to fit blocks into their correct spaces on the board while blindfolded. The time required to correctly locate the blocks using the preferred hand, non-preferred hand and finally both hands is recorded. Differences in left-right functioning can be determined. At the end of the test the blindfold, board and blocks are removed and the subject is asked to draw a diagram of the board representing the blocks in their correct spaces. A memory component is calculated on the basis of the number of blocks correctly reproduced in the drawing and the localization component is based on the number of blocks approximately correctly localized.

The same board is used in both tests, but in the RINTB it is positioned horizontally so that it can be easily reached by smaller children, while in the HNTB it is positioned vertically.

This is a complex test in terms of its requirements. Ability to perform this test successfully depends upon tactile form discrimination, coordination of movement of the upper extremities, manual dexterity and visuo-spatial ability.

(d) The Tactile Form Recognition Test utilizes four flat plastic shapes (cross, square, triangle and circle). These objects are placed in the subject's hand behind a wooden board and must then be matched against a set of visually exposed stimulus figures. The test is similar to tests of haptic-visual integration as used by Cravioto in his studies of malnutrition. The time taken to identify the shapes with the right hand, the left hand, the total time and the difference in time for the right and left hands is recorded. This latter measure has been claimed to be a valuable indicator of the relative efficiency of sensory-motor function of the two hands in this testing situation (Reitan and Heineman, 1968[38]).

(e) The Category Test utilizes a slide projector for the presentation of stimulus figures on a milk-glass screen. An answer panel consisting of four levers is located below the screen. The subject views each stimulus figure and then depresses one of the four levers. If the lever selected corresponds to the correct answer a gong sound is produced while a wrong answer results in a harsh buzzing noise. In the RINTB the response levers are identified by four colours while in the HNTB the levers are numbered 1-4. The RINTB comprises 80 stimulus figures divided into five groups with a common response principle. There are 168 stimulus figures in the HNTB version with six response principles. The subject is allowed to respond only once to each stimulus figure and the "correct" lever is alternated randomly to prevent a positional set.

At the start of any group of stimuli, the subject can only guess with regard to the correct answer, but as the test progresses the occurrence of the gong or buzzer indicates whether the guesses are right or wrong. The test procedure therefore allows the subject to test various principles until an hypothesis is arrived at which receives consistent positive reinforcement.

This test is a relatively complex concept formation task which requires "fairly sophisticated ability" in detecting similarities and differences in the stimulus material, formulating hypotheses that seem reasonable with regard to differences and similarities that recur in the stimulus material, testing these hypotheses with respect to positive and negative reinforcement and then changing these hypotheses when necessary. The test requires competence in abstraction ability because the subject has to formulate possible solutions "in a structured rather than permissive context." (Reitan and Davison, 1970[39]).

Three scores were derived from this test : the total error score, prorated on the basis of the version of the test used ; the error score in the third subtest, which subjects found particularly difficult, and again prorated on the basis of the version of the test used ; the number of concepts successfully formulated before failing to identify one.

In predicting brain damage, the Category Test alone has been shown to be almost as sensitive as the impairment index itself (Reitan, 1955[40])

Studies have suggested that the children's version of the Category Test reflects a level of intellectual ability similar to that assessed by standard IQ tests (Knights and Tymchuck, 1968[41]).

(f) The WISC Maze Test measures visuo-spatial and visual sequential ability. Both the raw score and the score scaled according to the WISC manual was recorded for each subject.

Maze test performance has been shown to be a potent measure of visual sequential ability (Reitan and Davison, 1974[42]).

5. BIOGRAPHICAL RESULTS

No statistically significant results were found in respect of any of the biographical variables assessed. The variables assessed relating to the child's developmental history, family history, school performance and physical status are described elsewhere (Bartel, 1976[43], pp. 25-35).

6. HALSTEAD/REITAN TEST RESULTS

6.1 Intergroup Comparisons

The means and SDs for each variable are summarized in TABLE 1.

TABLE 1. MEANS AND SDs : HALSTEAD/REITAN SUBTESTS

TEST	ITEM	KWASH			SIB			YM		
		MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
GRIP STRENGTH (kg)	DH	14,80	5,24	31	16,59	6,22	31	15,15	5,41	31
	NDH	13,93	4,78	31	16,04	6,41	31	14,10	4,91	31
	DH - NDH	0,86	1,48	31	0,54	2,46	31	1,05	1,72	31
FINGER TAPPING (Mean No. of oscillations in 10s)	DH	34,47	6,35	31	37,25	8,22	31	35,21	5,17	31
	NDH	32,20	5,57	31	33,61	6,83	31	32,87	4,84	31
	DH - NDH	2,23	3,61	31	5,23	11,61	31	2,34	3,23	31
MAZES (No. of errors)	Raw Score	9,20	4,90	29	10,48	5,48	29	10,40	4,68	30
	Scaled Score	6,45	2,40	31	6,87	3,04	31	7,29	2,35	31
TACTUAL PERFORMANCE (time in min.)	Total Time	13,24	5,46	26	10,97	4,85	25	12,30	6,55	22
	Memory for Blocks (No. correct)	4,15	1,22	26	4,60	1,19	25	4,77	1,23	22
	Location of Blocks (No. correct)	1,38	1,38	26	2,52	1,61	25	1,72	1,88	22
	Time for DH	5,89	2,48	28	5,17	2,71	28	6,45	3,12	29
	Time for NDH	4,68	2,50	26	4,00	1,96	25	4,67	2,97	22
	Time for Both Hands	2,83	1,88	26	2,37	1,71	25	2,07	1,25	22
	DH - NDH	1,06	2,77	26	0,47	1,97	25	0,75	2,34	22
	DH - Both Hands	2,88	2,86	26	2,21	1,88	25	3,57	2,45	22
	NDH - Both Hands	1,85	2,31	26	1,62	2,16	25	2,69	2,98	22

(TABLE 1 continued on p. 15)

TABLE 1 (continued)

TEST	ITEM	KWASH			SIB			YM		
		MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
TACTILE FORM RECOGNITION (time in s)	Time for RH	21,75	6,16	29	19,16	6,18	31	19,77	5,45	31
	Time for LH	18,24	6,17	29	16,19	5,77	31	18,85	5,63	31
	LH - RH	-3,44	5,40	29	-2,96	4,74	31	-1,37	5,25	31
	Total Time	40,00	11,10	29	35,35	10,99	31	38,30	9,96	31
CATEGORY TEST	Total Errors	42,60	25,32	29	41,00	29,69	28	37,30	19,91	29
	Errors in Sub. 3	18,63	11,06	27	18,07	9,51	27	14,80	10,25	25
	No. of Concepts Correct	2,13	0,69	29	2,17	0,94	28	2,17	1,07	29

DH = Dominant Hand

NDH = Non-Dominant Hand

DH - NDH = Difference between Scores for Dominant and Non-Dominant Hands

RH = Right Hand

LH = Left Hand

LH - RH = Difference between Scores for Left and Right Hands

The one-way ANOVA revealed a statistically significant F-ratio ($p<0,05$) for only one variable, namely memory for location of blocks in the Tactual Performance Test (see TABLE 2). Scheffes Multiple Comparison Test failed to reveal any statistically significant differences between pairs of means, however.

TABLE 2. ONE-WAY ANOVA

TEST	ITEM	SOURCE OF VARIANCE	DF	MEAN SQUARES	F
TACTUAL PERFORMANCE	Memory for Location of Blocks	Between Groups	2	8,5665	3,25*
		Within Groups	70	2,6393	

*$p<0,05$

6.2 Intra-Kwashiorkor Group Comparisons

6.2.1 Category of Malnutrition

The means for the marasmic kwashiorkor and the kwashiorkor subgroups differed in respect of one variable, i.e. memory for the location of blocks in the Tactual Performance Test. The mean number of blocks correctly remembered in the correct location by the kwashiorkor subgroup was statistically significantly higher ($p<0,05$). See TABLE 3.

TABLE 3. INTRA-KWASHIORKOR GROUP COMPARISONS (t-TESTS) : DIFFERENT CATEGORIES OF KWASHIORKOR

TEST	ITEM	MARASMIC KWASH			KWASH			t
		MEAN	SD	N	MEAN	SD	N	
GRIP STRENGTH (kg)	DH	14,33	4,32	12	15,41	5,60	16	0,535
	NDH	13,80	3,99	12	14,23	5,24	16	0,230
	DH - NDH	0,52	1,23	12	1,17	1,59	16	1,127
FINGER TAPPING (Mean No. of Oscillations in 10s)	DH	33,15	5,83	12	34,40	6,40	16	0,511
	NDH	31,50	4,78	12	32,28	6,06	16	0,358
	DH - NDH	1,56	3,17	12	2,11	3,58	16	0,402
MAZES (No. of errors)	Raw Score	9,18	4,80	11	8,60	4,84	15	0,291
	Scaled Score	6,16	2,30	12	6,43	2,44	16	0,286

(TABLE 3 continued on p. 17)

TABLE 3 (continued)

TEST	ITEM	MARASMIC KWASH			KWASH			t
		MEAN	SD	N	MEAN	SD	N	
TACTUAL PERFORMANCE (time in min.)	Total Time	14,80	5,42	11	13,09	4,90	12	0,759
	Memory for Blocks (No. correct)	3,90	0,99	11	4,25	1,42	12	0,631
	Location of Blocks (No. correct)	0,54	0,65	11	1,83	1,40	12	2,731*
	Time for DH	6,28	2,09	11	6,21	2,45	14	0,072
	Time for NDH	5,05	2,53	11	4,65	2,45	12	0,367
	Time for Both H	3,37	2,34	11	2,59	1,27	12	0,941
	DH - NDH	1,33	2,53	11	1,21	3,03	12	0,098
	DH - Both H	3,00	3,20	11	3,20	2,55	12	0,161
	NDH - Both H	1,67	2,29	11	2,05	2,45	12	0,372
TACTILE FORM RECOGNITION (time in s)	Time for RH	21,77	4,76	11	23,13	6,47	15	0,566
	Time for LH	18,27	4,19	11	19,50	6,87	15	0,504
	RH - LH	3,31	4,31	11	3,63	6,30	15	0,137
	Total Time	40,04	7,95	11	42,63	11,76	15	0,606
CATEGORY TEST	Total Errors	42,00	11,87	12	45,25	12,62	14	0,416
	Errors in Sub. 3	16,63	8,37	11	21,69	12,40	13	1,099
	No. of Concepts Correct	2,08	0,49	12	2,07	0,79	14	0,043

*$p<0,05$

6.2.2 Prognosis in Hospital

There were no statistically significant differences between any means of the poor prognosis and the not poor prognosis subgroups. See TABLE 4.

TABLE 4. INTRA-KWASHIORKOR GROUP COMPARISONS (t-TESTS) : DIFFERENT PROGNOSES

TEST	ITEM	NOT POOR PROG			POOR PROG			t
		MEAN	SD	N	MEAN	SD	N	
GRIP STRENGTH (kg)	DH	13,19	4,55	12	15,81	5,26	19	1,374
	NDH	12,36	4,00	12	14,92	4,84	19	1,483
	DH - NDH	0,83	1,25	12	0,88	1,58	19	0,095
FINGER TAPPING (Mean No. of Oscillations in 10 s)	DH	35,56	6,71	12	32,73	4,96	19	1,219
	NDH	33,52	5,94	12	30,11	3,82	19	1,712
	DH - NDH	1,98	3,52	12	2,61	3,56	19	0,464
MAZES (No. of errors)	Raw Score	8,30	4,26	10	9,68	5,02	19	0,715
	Scaled Score	5,75	2,68	12	6,89	2,02	19	1,305
TACTUAL PERFORMANCE (Time in min.)	Total Time	12,65	4,23	11	13,68	6,01	15	0,470
	Memory for Blocks (No. correct)	4,09	0,79	11	4,20	1,42	15	0,239
	Location of Blocks (No. correct)	1,09	1,24	11	1,60	1,40	15	0,921
	Time for DH	6,17	2,33	12	5,68	2,49	16	0,507
	Time for NDH	4,62	2,45	11	4,72	2,45	15	0,091
	Time for Both H	2,11	0,80	11	3,35	2,18	15	1,938
	DH - NDH	1,28	2,95	11	0,89	2,51	15	0,353
	DH - Both H	3,79	2,00	11	2,20	3,10	15	1,426
	NDH - Both H	2,51	2,32	11	1,36	2,10	15	1,258
TACTILE FORM RECOGNITION (Time in s)	Time for RH	21,04	3,97	11	22,19	6,99	18	0,544
	Time for LH	17,13	4,06	11	18,91	6,92	18	0,748
	RH - LH	3,90	4,27	11	3,16	5,83	18	0,353
	Total Time	38,18	6,81	11	41,11	12,66	18	0,781

(TABLE 4 continued on p. 19)

TABLE 4 (continued)

TEST	ITEM	NOT POOR PROG			POOR PROG			t
		MEAN	SD	N	MEAN	SD	N	
CATEGORY TEST	Total Errors	41,09	14,63	12	46,00	15,84	17	0,730
	Errors in Sub. 3	19,20	10,34	10	18,29	11,13	17	0,201
	No. of Concepts Correct	1,91	0,64	12	2,29	0,66	17	1,474

6.2.3 Time of Onset of Kwashiorkor

Early onset and late onset subgroup means were not statistically significantly different. See TABLE 5.

TABLE 5. INTRA-KWASHIORKOR GROUP COMPARISONS (t-TESTS) DIFFERENT AGE OF ONSET OF KWASHIORKOR

TEST	ITEM	EARLY ONSET			LATE ONSET			t
		MEAN	SD	N	MEAN	SD	N	
GRIP STRENGTH (kg)	DH	13,97	3,98	12	15,32	5,72	19	0,692
	NDH	13,16	3,50	12	14,41	5,27	19	0,702
	DH - NDH	0,80	0,88	12	0,90	1,73	19	0,207
FINGER TAPPING (Mean No. of Oscillations in 10 s)	DH	33,13	6,35	12	35,31	6,03	19	0,929
	NDH	30,78	4,73	12	33,10	5,72	19	1,135
	DH - NDH	2,35	3,58	12	2,15	3,53	19	0,141
MAZES (No. of errors)	Raw Score	10,25	4,98	12	8,47	4,56	17	0,960
	Scaled Score	7,50	2,02	12	5,78	2,33	19	2,025

(TABLE 5 continued on p. 19)

TABLE 5 (continued)

TEST	ITEM	EARLY ONSET			LATE ONSET			t
		MEAN	SD	N	MEAN	SD	N	
TACTUAL PERFORMANCE (Time in min.)	Total Time	14,58	6,56	11	12,26	3,99	15	0,994
	Memory for Blocks (No. correct)	4,27	1,21	11	4,06	1,18	15	0,417
	Location of Blocks (No. correct)	1,36	1,36	11	1,40	1,35	15	0,064
	Time for DH	6,41	2,58	12	5,49	2,24	16	0,963
	Time for NDH	5,14	2,82	11	4,34	2,07	15	0,798
	Time for Both H	2,96	2,44	11	2,73	1,23	15	0,278
	DH - NDH	1,33	3,24	11	0,85	2,22	15	0,431
	DH - Both H	3,51	3,71	11	2,41	1,74	15	0,868
	NDH - Both H	2,17	2,09	11	1,61	2,36	15	0,607
TACTILE FORM RECOGNITION (Time in s)	Time for RH	20,70	5,81	10	22,31	6,10	19	0,664
	Time for LH	17,40	8,78	10	18,68	3,86	19	0,418
	RH - LH	3,10	5,64	10	3,63	5,11	19	0,247
	Total Time	38,10	13,83	10	41,00	8,84	19	0,573
CATEGORY TEST	Total Errors	44,29	14,62	12	42,77	15,86	17	0,458
	Errors in Sub. 3	16,63	9,25	11	20,00	11,63	16	0,770
	No. of Concepts Correct	2,16	0,68	12	2,11	0,67	17	0,184

6.2.4 Length of Stay in Hospital

The length of the subject's stay in hospital for the treatment of kwashiorkor did not correlate statistically significantly with any of the test scores.
See TABLE 6.

TABLE 6. CORRELATION COEFFICIENTS : THE KWASHIORKOR SUBJECTS' LENGTH OF STAY IN HOSPITAL AND LENGTH OF RECOVERY PERIOD WITH TEST SCORES

TEST	ITEM	STAY IN HOSPITAL	RECOVERY PERIOD
		r	r
GRIP STRENGTH (kg)	DH	-0,00	0,14
	NDH	0,04	0,17
	DH - NDH	-0,16	-0,11
FINGER TAPPING (Mean No. of Oscillations in 10 s)	DH	-0,02	-0,74
	NDH	0,06	-0,10
	DH - NDH	-0,16	0,16
MAZES (No. of errors)	Raw Score	-0,05	0,71
	Scaled Score	0,10	0,45
TACTUAL PERFORMANCE (Time in min.)	Total Time	0,11	0,11
	Memory for Blocks (No. correct)	-0,03	0,17
	Location of Blocks (No. correct)	0,12	-0,33
	Time for DH	-0,11	0,18
	Time for NDH	0,09	0,03
	Time for Both H	0,35	0,08
	DH - NDH	-0,18	0,08
	DH - Both H	-0,31	0,05
	NDH - Both H	-0,18	-0,03
TACTILE FORM RECOGNITION (Time in s)	Time for RH	0,03	0,02
	Time for LH	0,14	-0,16
	RH - LH	0,14	-0,24
	Total Time	0,10	-0,08

(TABLE 6 continued on p. 22)

TABLE 6 (continued)

TEST	ITEM	STAY IN HOSPITAL	RECOVERY PERIOD
		r	r
CATEGORY TEST	Total Errors	-0,25	-0,06
	Errors in Sub. 3	-0,11	-0,04
	No. of Concepts Correct	0,03	0,28

6.2.5 Length of Recovery Period

The length of the subjects' recovery period, i.e. the time between discharge from hospital and testing, was not statistically significantly correlated with any of the test scores, the age variable having been partialled out. See TABLE 6.

7. DISCUSSION OF RESULTS

7.1 Biographical Results

The biographical results are discussed elsewhere in more detail (Bartel, 1976[44], pp. 117-120). These findings indicated a considerable equivalence among the groups in terms of the large number of variables assessed relating to the subjects' developmental history, their family history, school performance and their physical status.

The physical status results were particularly interesting in view of the majority of previous studies reporting marked deficits in the physical development of previously malnourished children (e.g. Stoch and Smythe, 1963[45], 1967[46]). The findings of the present study are in accordance with those of Keet et al. (1971[47]) who failed to find any significant differences, at the 10-year follow-up, between the physical development of children exposed to kwashiorkor in early life and siblings with no previous history of acute PCM. The present findings can be interpreted as supporting Stoch and Smythe's (1968[48]) suggestion that marasmus is more "damaging" than kwashiorkor.

7.2 Test Results

The two tests assessing motor functioning, i.e. Grip Strength and the Finger Tapping Test, failed to reveal any significant differences among the groups. This finding is in agreement with the results of the Lincoln-Oseretsky Motor Development Scale administered to the same subjects (see Bartel et al., 1977[49]). This finding is also in accordance with Klein et al.'s (1974[50]) report of no significant correlations between the nutritional status of young children and their level of psychomotor development. The results of the present study lend support to Cravioto and Robles' (1965) suggestion that children exposed to PCM over the age of 6 months recover their initial deficits in psychomotor development.

Though a significant inter-group variance was found for the memory for location of blocks in the Tactual Performance Test an isolated statistically significant result against a background of so many tests must be viewed with caution. Furthermore, Scheffé's Test failed to reveal any significant differences between pairs of means for the groups on this variable. The groups did not differ significantly in performance on the Tactile Form Recognition Test. These results are interesting in view of previous reports of marked deficits in the sensory-integration ability of previously malnourished subjects (Champakam et al., 1968[52]; Cravioto and De Licardie, 1970[53]). Champakam et al. (1968[54]) reported that the deficits were particularly severe in visual-haptic ability, which was also assessed by the Tactile Form Recognition Test in the present experiment.

The three groups did not differ in performance on the Category Test. This finding suggested an equivalence among the groups in complex concept formation ability and abstraction ability. Furthermore, as this test is a sensitive indicator of brain damage (Reitan, 1955[55]), the performance of the kwashiorkor group is of great significance in view of claims that PCM may result in organic brain damage (Stoch and Smythe, 1967[56]). If the contention of Knights and Tymchuk (1968[57]) is valid that the children's version of the Category Test is a reflection of intellectual ability similar to that assessed by standard IQ tests, then the results of the present study contradict several previous studies associating lowered IQ test scores with PCM (Stoch and Smythe, 1963[58], 1967[59], 1968[60]; Champakam et al., 1968[61]; Chase and Martin, 1970[62]; Hertzig et al., 1972[63]). However, the Category Test results would support the findings of Evans et al. (1971[64]) and Valman (1974[65]) of no significant differences between the IQ test performance of previously malnourished and control subjects.

The WISC Maze Test performance of the three groups was not significantly different indicating equivalence among the groups in visual sequential ability.

The intra-kwashiorkor group comparisons revealed only one significant finding. The kwashiorkor subgroup performed significantly better than the marasmic kwashiorkor group on memory for location of blocks in the Tactual Performance Test. Once again this solitary significant finding must be assessed with caution. The results indicated that category of malnutrition, prognosis in hospital, time of onset of kwashiorkor, length of stay in hospital and length of recovery period, had no marked effect on the subject's test performance in the present study.

These results do not exclude the possibility that marasmus has a greater debilitating effect on human development than does kwashiorkor. Marasmus usually occurs before the age of 1 year when brain growth is less developed than in later years when kwashiorkor is usually found. In addition, marasmus generally lasts for longer periods than kwashiorkor (Scrimshaw and Gordon, 1968[66]).

Richardson et al. (1972[67]) found that the time of onset of PCM had no effect on later IQ test performance. The absence of significant differences between the test performance of the early and late onset subgroups in the present study supports the latter report.

Several researchers have found a marked improvement in various indices of CNS functioning after the treatment of PCM in hospital (Cravioto and Robles, 1965[68]; Engsner, 1974[69]; Nelson, 1959[70]). The failure to find significant correlations between the length of the recovery period and test performance in the present study, suggests that any deficits in the abilities assessed by these tests had been corrected by the time of testing.

7.3 Interpretation of Results

The results of the present study can be interpreted in at least three ways :

(a) The three groups' test performance was not significantly different because they had all been exposed to some degree to PCM ; the kwashiorkor group to acute PCM and the two control groups to subclinical PCM. Therefore, the experimental group on the one hand, and the control group on the other, were not sufficiently different in terms of nutritional status. This interpretation is considerably weakened by the electrophysiological results previously presented (Bartel, 1976[71]). The sibling and yardmate groups failed to differ significantly from a high socio-economic White control group, in the face of several significant differences between the control groups and the kwashiorkor group. On the other hand the present investigation, at the very least, would suggest no difference in the long-term effects of acute and subclinical PCM.

(b) The tests used in the present experiment were not sufficiently sensitive to detect subtle behavioural deficits caused by kwashiorkor. This remains to be answered by future research. The implication of this interpretation is that children recover from kwashiorkor to a far greater extent than has frequently been claimed (see Lewin, 1975[72]).

(c) The kwashiorkor group had made-up the deficits assessed by the tests used in the present experiment. This interpretation is in line with the results of two previous South African studies (Keet et al., 1971[73]; Evans et al., 1971[74]) showing the apparent recuperative ability of the human after the treatment for the drastic, debilitating effects of kwashiorkor. Keet et al.'s (1971[75]) claim that "it is clearly worthwhile to give every malnourished child the benefit of active clinical treatment" (p. 1448), has been strengthened. The exceptional redundancy factor protecting the human brain cannot be relied on alone since untreated PCM inevitably leads to extinction of the individual before this factor can begin to operate as far as brain function is concerned.

A final question which arises from the results of the present investigation concerns the overwhelming evidence that has accumulated from animal studies pointing to long-lasting and indeed "genetic" effects of early malnutrition. Many workers have drawn attention to the danger in extrapolating from animal to the human situation. Perhaps the foremost difficulties in reconciling the two types of research lie in : (a) the usually very severe degree of malnutrition (experimentally) imposed on animals <u>viz a viz</u> the ("naturally") observed malnutrition of human subjects ; (b) the relatively short period over which animal malnutrition is imposed is likely to be proportionately more damaging in view of their rapid developmental rate and short life span by comparison with human children who often are still developing in some or other respect once the acute phase of malnutrition has passed.

8. BIBLIOGRAPHY

	Order of Appearance
BARTEL, P.R. (1976) : Long-term electrocerebral sequelae of kwashiorkor. CSIR Special Report PERS 244, NIPR, Johannesburg.	8, 25, 27, 43, 44, 71
BARTEL, P.R., GRIESEL, R.D. and BURNETT, L.S. (1977) : Long-term effects of kwashiorkor on psychomotor ability. CSIR Special Report PERS 256, NIPR, Johannesburg.	1, 24, 49
BROCKMAN, L.M. and RICCIUTI, H.N. (1971) : Severe protein calorie malnutrition and cognitive development in infancy and early childhood. Develop. Psychol., 4, 312-319.	23
CHAMPAKAM, S., SRIKANTIA, S.G. and GOPALAN, C. (1968) : Kwashiorkor and mental development. Amer. J. clin. Nutr., 21, 844-852.	7, 13, 22, 52, 54, 61
CHASE, H.P. and MARTIN, H.P. (1970) : Undernutrition and child development. New Engl. J. Med., 282, 933-939.	14, 62
CRAVIOTO, J. and DE LICARDIE, E.R. (1970) : Mental performance in school age children. Findings after recovery from early severe malnutrition. Amer. J. Dis. Child, 120, 404-410.	21, 53
CRAVIOTO, J. and ROBLES, B. (1965) : Evolution of adaptive and motor behaviour during rehabilitation from kwashiorkor. Amer. J. Orthopsychiat., 35, 449-464.	51, 68

	Order of Appearance
CRAVIOTO, J., DE LICARDIE, E.R. and BIRCH, H.G. (1966) : Nutrition, growth and neurointegrative development : an experimental and ecologic study. Pediatrics, 38, 319-372.	19
DOBBING, J. (1968) : Effect of experimental undernutrition on development of the nervous system. In SCRIMSHAW, N.S. and GORDON, J.E. (Eds), Malnutrition, learning and behaviour. Boston, MIT Press.	2
ENGSNER, G. (1974) : Brain growth and motor nerve conduction velocity in children with marasmus and kwashiorkor. In CRAVIOTO, J., HAMBRAEUS, L. and VAHLQUIST, B. (Eds), Early malnutrition and mental development. Uppsala, Almqvist and Wiksell.	69
EVANS, D.E. (1973) : Malnutrition and intellectual development. Ph.D. Thesis, University of Cape Town.	16, 26
EVANS, D.E., MOODIE, A.D. and HANSEN.J.D.L. (1971) : Kwashiorkor and intellectual development. S. Afr. med. J., 45, 1412-1426.	17, 64, 74
FRISCH, R. (1970) : Present status of the supposition that malnutrition causes permanent mental retardation. Amer. J. clin. Nutr., 23, 189-195.	6
GUILFORD, J.P. (1956) : Fundamental statistics in psychology and education. New York, McGraw-Hill.	29, 32
HALSTEAD, W.C. (1947) : Brain and intelligence : a quantitative study of the frontal lobes. Chicago, University of Chicago Press.	33

	Order of Appearance
HERTZIG, M.E., BIRCH, H.G., RICHARDSON, S.A. and TIZARD, J. (1972) : Intellectual levels of school children severely malnourished during the first two years of life. Pediatrics, 49, 814-824.	9, 15, 63
KEET, M.P., MOODIE, A.D., WITTMANN, W. and HANSEN, J.D.L. (1971) : Kwashiorkor : a prospective ten-year follow-up study. S. Afr. med. J., 45, 1427-1449.	47, 73, 75
KENDALL, M.G. and STUART, A. (1967) : The advanced theory of statistics. London, Charles Griffin.	31
KLEIN, R.E., YARBROUGH, C., LASKY, R.E. and HABICH, J-P (1974) : Correlations of mild to moderate protein-calorie malnutrition among rural Guatemalan infants and pre-school children. In CRAVIOTO, J., HAMBRAEUS, L. and VAHLQUIST, B. (Eds), Early malnutrition and mental development. Uppsala, Almqvist and Wiksell.	50
KNIGHTS, R.M. and TYMCHUK, A.J. (1968) : An evaluation of the Halstead-Reitan Category Tests for children. Cortex, 4, 402-414.	41, 57
LEWIN, R. (1975) : Starved brains. Psychol. Today, 9, 29-33.	72
NELSON, G.K. (1959) : The electroencephalogram in kwashiorkor. Electroenceph. clin. Neurophysiol., 11, 73-84.	70

	Order of Appearance
POLLITT, E. and RICCIUTI, H. (1969) : Biological and social correlates of stature among children in the slums of Lima, Peru. Amer. J. Orthopsychiat., 39, 735-747.	20
REITAN, R.M. (1955) : Certain differential effects of left and right cerebral lesions in human adults. J. comp. physiol. Psychol., 48, 474-477.	40, 55
REITAN, R.M. (1964) : Psychological deficits resulting from cerebral lesions in man. In WARREN, J.M. and AKERT, K.A. (Eds), The frontal granular cortex and behavior. New York, McGraw-Hill.	37
REITAN, R.M. (1970) : Sensorimotor functions, intelligence and cognition, and emotional status in subjects with cerebral lesions. Percept. mot. Skills, 31, 275-284.	36
REITAN, R.M. and DAVISON, L.A. (1974) : Clinical neuropsychology : current status and applications. New York, Wiley.	28, 39, 42
REITAN, R.M. and HEINEMAN, C.E. (1968) : Interactions of neurological deficits and emotional disturbances in children with learning disorders : methods for their differential assessment. In HELLMUTH, J. (Ed.), Learning disorders. Vol. 3. Seattle, Special Child Publications.	
RICHARDSON, S.A., BIRCH, H.G., GRABIE, E. and YODER, K. (1972) : The behaviour of children in school who were severely malnourished in the first two years of life. J. Hlth. Soc. Behav., 13, 276-284.	67

	Order of Appearance
ROSSO, P., HORMÁZABAL, J. and WINICK, M. (1970) : Changes in brain weight, cholesterol, phospholipid and DNA content in marasmic children. Amer. J., clin. Nutr., 23, 1275-1279.	5
RUSSELL, E;W., NEURINGER, C. and GOLDSTEIN, G. (1970) : Assessment of brain damage : a neuropsychological key approach. New York, Wiley.	34, 35
SCHEFFÉ, H. (1959) : The analysis of variance. New York, Wiley.	30
SCRIMSHAW, N.S. and GORDON, J.E. (Eds)(1968) : Malnutrition, learning and behavior. Cambridge, Mass., MIT Press.	66
STOCH, M.B. and SMYTHE, P.M. (1963) : Does undernutrition during infancy inhibit brain growth and subsequent intellectual development? Arch. Dis. Child, 38, 546-552.	10, 45, 58
STOCH, M.B. and SMYTHE, P.M. (1967) : The effect of undernutrition during infancy on subsequent brain growth and intellectual development. S. Afr. med. J., 41, 1027-1031.	11, 46, 56, 59
STOCH, M.B. and SMYTHE, P.M. (1968) : Undernutrition during infancy, and subsequent brain growth and intellectual development. In SCRIMSHAW, N.S. and GORDON, J.E. (Eds), Malnutrition, learning and behavior. Cambridge, Mass., MIT Press.	12, 48, 60

	Order of Appearance
VALMAN, H.B. (1974) : Intelligence after malnutrition caused by neonatal resection of ileum. Lancet,(March 16), 425-427.	18, 65
WINICK, M. and ROSSO, P. (1969) : The effect of severe early malnutrition on cellular growth of human brain. Pediat. Res., 3, 181-184.	4
WINICK, M., FISH, I. and ROSSO, P. (1968) : Cellular recovery in rat tissues after a brief period of neonatal malnutrition. J. Nutr., 95, 623-626.	3