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THE DEVELOPMENT OF CONSERVATION IN ABORIGINAL CHILDREN¹

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Deux groupes d'enfants aborigènes australiens (âge 8-15 ans) subissent les épreuves mises au point pour l'étude de la conservation de la quantité, du poids, du volume, de la longueur, de la surface et du nombre. Les résultats montrent que les enfants aborigènes réussissent ces problèmes à des âges plus élevés que les enfants européens et que dans certains cas, la notion de conservation n'est pas atteinte. On constate également des différences significatives chez les enfants aborigènes selon qu'ils sont de souche pure ou non. Les résultats confirment dans l'ensemble la théorie des stades de développement, mais on observe que l'ordre des stades dont l'invariance est postulée par Piaget et Inhelder présente quelques variations. L'A. commente ces résultats et évoque les différents facteurs qui peuvent être responsables du retard observé dans le développement des enfants aborigènes.

Conservation is an important concept in Piaget's theory of intellectual development. It marks the beginning of logical thinking and the transition from a pre-operational to an operational level of thought, and it has been taken as one of the main criteria for the achievement of Piaget's stage of concrete operations. As such, it has been the subject of a number of investigations. The main findings of Piaget (1952) and Piaget and Inhelder (1962) on the ages at which conservation is achieved and the invariant order of development in the case of conservation of quantity, weight and volume have been confirmed in a number of replication studies (Lovell and Ogilvie, 1960, 1961a, 1961b; Elkind, 1961a, 1961b; Uzgris, 1964), although some minor discrepancies with regard to the ages of achievement and the consistency of performance over a series of tests have been reported (Dodwell, 1960; Lovell and Ogilvie, 1961b). The majority of replication studies have been carried out on children of West European origin, but some studies have also been reported on children from other cultural backgrounds. In most cases a retardation in the development of conservation has been reported among children from less developed societies (Hyde, 1959;

¹ This report is based on a Ph.D. thesis submitted to the Australian National University, the research being carried out during the tenure of a Research Scholarship at the Australian National University.

Greenfield, 1964; Prince, 1968; Boonsong, 1968), although Price-Williams (1961) has reported contrary findings.

The aim of the present study was to investigate the development of the concept of conservation among Australian Aboriginal children. According to Piaget's theory the stages of development and their order of succession should be invariant, since these are determined by biological structures and functions that are independent of the environment. However, the rate of development would be determined by the child's interaction with his environment, so that social and cultural factors may influence the age at which the stages are achieved, or even the achievement or non-achievement of the higher levels. One would therefore expect to find the same stages of development and the same order of succession in Aboriginal children as in European, but these need not necessarily be achieved at the same ages.

The study involved the application of Piaget's tests of conservation of quantity, weight, volume, length, area and number to two groups of Aboriginal children living in the Northern Territory of Australia. One group was tested at Elcho Island mission in the North East of Australia, and one group at Hermannsburg mission in central Australia. Although traditionally a hunting and nomadic people, the majority of Aborigines today live on government settlements or missions, mainly in the northern and central areas of Australia. These settlements generally provide food, clothing, housing and in some cases also employment. However, they are usually situated some distance from the centres of European population, and the influence of European contact has therefore been limited. Living conditions are generally poor, and material possessions few. The majority of adults are illiterate, and tribal customs and traditions have been retained to a greater or lesser degree, depending on the length of contact with the settlement. In some areas settlements have only recently been established, and in these cases the tribal life and customs would remain strong. Although schools have now been established on all missions and settlements, the standards and levels of achievement are not comparable with those in normal Australian schools.

There were some differences in the backgrounds of the two missions from which the samples in this study were drawn. Hermannsburg has had a longer and closer contact with European influence, being the first mission to be established in the Northern Territory (in 1877) and being within fairly easy reach of Alice Springs, the second largest centre of European population in the Northern Territory, and a winter tourist centre. Elcho Island mission has been more recently established and is more isolated, being reached only by sea or by air, and has therefore had relatively little European contact. The climatic conditions of the two areas also differ, Hermannsburg being in a semi-desert area, while Elcho Island is in an area of high summer rainfall.

METHOD

Sample

A total of 145 children were tested, 65 at Elcho Island and 80 at Hermannsburg. The children were aged from 8 to 15 years. It was originally intended to test ten children at each age level in

each group, but as it was not always possible to obtain a sufficient number of children at each age, as many children as were available were tested. No children at 15 years were available in the Elcho group. All the children tested were attending the mission schools. These provided only a primary level of education. The children were in Grades 1 to 6, but these grades did not necessarily correspond to the same grades in normal Australian schools.

In the Elcho Island group all the children were classified as full-blood Aboriginals, although it was known that in some cases there was some Malay ancestry. In the Hermannsburg group approximately half the children were classified as part-Aborigines and half as full Aborigines². Among the children classified as part-Aborigines the degree of European ancestry was small, the majority being classified as 7/8 th Aboriginal. The European ancestry was therefore several generations removed from the present group. There were no apparent differences in the present environment of the part-Aboriginal and full-Aboriginal children in the Hermannsburg group. Part-Aborigines and full Aborigines formed a single integrated community, and the children were brought up under the same mission conditions and attended the same school.

In addition to the main sample, some supplementary testing was carried out on a group of unschooled children at Elcho Island, and a group of unschooled adults on a cattle station in central Australia.

Procedure

The tests were based on those described by Piaget and his collaborators. The procedure was standardised to the extent that the same basic problem and questions were put to each child, but the flexibility of Piaget's clinical method was retained in that individual children were questioned further according to their particular response, and suggestions and counter-suggestions were made to test the stability of their answers.

The tests selected and the questioning procedures adopted were decided after preliminary trial testing. Some changes were made in the materials and procedures following this testing. Since the children showed some difficulty in understanding the tests of quantity and weight using the plasticine balls as in the classical procedure, these materials were substituted. For the test of quantity, sugar was poured into glasses of different shapes, while for the test on weight tea leaf was poured into plastic bags of different sizes. Since sugar and tea leaf were included in the basic rations supplied by the mission, these substances were familiar to the children, and being foodstuffs of value in the community, it was hoped that the problems using these materials would be more easily understood by the children. It was also found that it was not possible to pose questions containing more than one alternative, since the children frequently answered simply "yes" or "no", presumably to the last alternative mentioned in the question. Each alternative was therefore always put as a separate question.

For each test, the child was asked to make some preliminary judgements of equality or non-equality with the particular materials used in the test. This was found necessary to check the children's use and understanding of the terms used, and also helped the children to grasp the basic problem. Questions were repeated or rephrased as necessary, particularly when asking the children to justify their judgements, when it was often necessary to repeat the question several times before receiving a reply. Where children gave non-conservation answers, they were always questioned as to the original equality of the quantities compared, and in the case of weight and volume, they were also questioned on the amount of the substances compared.

Tests

A summary of each of the test situations is given below. The detailed procedures are reported in full elsewhere (de Lemos, 1966).

1. *Quantity*. This test was based on the test of conservation of continuous quantity described by Piaget (1952, Chapter 1), but sugar was substituted for liquid, and two black dolls were used, the problem being posed in terms of giving sugar to the dolls to eat. Equal quantities of sugar were first poured into equal shaped glasses. After the child had agreed that these quantities were the same, the sugar from one glass was poured into a long thin glass, a short wide glass, and

² The classification was based on the mission records, and later checked with Mr T.G.H. Strehlow, of Adelaide University, who is presently carrying out a genealogical study of the Hermannsburg people.

four small glasses. In each case the child was questioned as to whether the quantities of sugar were still the same, or if one glass had more sugar. After each transformation the sugar was returned to the original glasses, and the child again questioned as to the equality. He was asked for an explanation for each judgement.

2. *Weight*. This test was based on the test of conservation of weight described by Piaget and Inhelder (1962, Chapter II), but tea leaf poured into plastic bags was substituted for the plasticine balls. The child was first shown a balance scale, and its working was demonstrated. Tea leaf was then poured into equal sized plastic bags, and weighed on the scale. When the child had agreed that the quantities weighed the same, the bags were taken off the scale, and the tea leaf from one bag was poured into a much larger bag, a long thin bag, and six small bags. In each case the child was asked if he thought the two sets of tea leaf would still weigh the same if they were placed on the scale. After each transformation the tea leaf was returned to the original identical bags. The child was asked for an explanation for each judgement.

3. *Volume*. This test was based on that described by Piaget and Inhelder (1962, Chapter III). The materials used were the same as those used by Piaget and Inhelder, since in this case the children showed no particular difficulty in understanding the problem. Two glasses about one third filled with coloured water were placed in front of the child, and he was asked to predict the rise in water level when equal and unequal sized balls of plasticine were placed inside the glasses. The displacement of the water in the glasses was demonstrated with two unequal sized balls. The child was then shown two equal sized balls, and after he had judged that these balls would make the water rise to the same level, one of the balls was flattened, rolled into a sausage, and broken into little pieces, and for each transformation the child was asked to predict if the transformed plasticine would make the water rise to the same level as the ball. The plasticine was rolled back into a ball after each transformation. To check the children's verbal judgements a series of sketches representing each situation were prepared, and the child was asked to draw a line to indicate the water level in each case. The child was asked for an explanation for his judgements.

4. *Length*. The test on length was based on that described by Piaget, Inhelder and Szeminska (1960, Chapter IV). Two sticks of equal length were placed in front of the child, parallel and with ends coinciding. One stick was then displaced from left to right so that it overlapped the other by about one to two centimetres. The child was asked if the two sticks were still the same length, if it would be the same distance to walk from one end to the other on the two sticks, and if it would take the same time to walk. The sticks were also rearranged in other positions and the questions repeated, and the child was asked for an explanation of his judgements.

5. *Area*. The test on area followed the procedure described by Piaget *et al.* (1960, Chapter XI). Two pieces of green cardboard, first of unequal size and then of equal size, were placed in front of the child, who was told that these represented fields or paddocks of green grass. A toy cow was placed in each field, and the child asked if the two cows would have the same amount of green grass to eat. When the child had judged that the cows would have the same amount of grass to eat in the equal sized fields, a small wooden block representing a house was placed in one field, thus covering a part of the grass, and the child was asked if the two cows still had the same amount of grass to eat. Once it was clear that the child understood that the field with the house had less grass, a second house was placed on the other field. The test was then continued by adding one house simultaneously to each field, the houses on one field being placed in a row in a corner of the field, and on the other field being scattered at random, thus giving the illusion of a greater expanse of green grass on one field than on the other. In each case the child was questioned on the equality of the remaining grassland in the two fields, and he was also questioned as to whether the number of houses on the two fields was the same. If the child judged one field to have more grass, houses were then added to that field until the child changed his judgement, while if the child continued to show conservation up to about 16 or more houses, two houses were then added alternately to each field. The child was asked for an explanation for his judgements.

6. *Number*. The test on conservation of number was based on Piaget's test of conservation of volume, using unit blocks made up into various constructions on different sized bases. This test is described in Piaget *et al.* (1960, Chapter XIV). Two constructions of 36 unit blocks were built on cardboard bases, 3 units by 4 units. One construction was then broken down and the same unit blocks were used to make constructions on bases of 3 units by 2 units, 2 units by 2

units, and 2 units by 6 units. The standard model was reconstructed after each transformation, and for each construction it was emphasised that exactly the same blocks had been used, and that none were left over. In each case the child was asked if the number of blocks in the two constructions was the same and he was asked for an explanation for his judgements.

Testing conditions

The children were tested individually, each test being presented in a separate session, with an interval of 7 to 10 days between each session. The children were questioned in English, which was the medium of instruction in the schools. The tests were presented in the standard

TABLE 1
PERCENTAGE OF CHILDREN SHOWING CONSERVATION ON EACH TEST¹
ELCHO GROUP (N = 65)

Tests	Age groups						
	8 (N = 12)	9 (N = 10)	10 (N = 10)	11 (N = 10)	12 (N = 10)	13 (N = 8)	14 (N = 5)
Quantity	—	—	10 (1)	30 (3)	70 (7)	50 (4)	60 (3)
Weight	—	10 (1)	20 (2)	60 (6)	80 (8)	62.5 (5)	80 (4)
Volume	—	—	10 (1)	40 (4)	60 (6)	50 (4)	40 (2)
Length	17 (2)	30 (3)	30 (3)	40 (4)	50 (5)	62.5 (5)	40 (2)
Area	—	—	—	30 (3)	50 (5)	12.5 (1)	40 (2)
Number	8 (1)	20 (2)	30 (3)	50 (5)	60 (6)	75 (6)	60 (3)

HERMANNsburg GROUP (N = 80)

	8 (N = 12)	9 (N = 9)	10 (N = 11)	11 (N = 10)	12 (N = 9)	13 (N = 10)	14 (N = 7)	15 (N = 12)
Quantity	8 (1)	11 (1)	36 (4)	20 (2)	44 (4)	40 (4)	43 (3)	50 (6)
Weight	25 (3)	33 (3)	73 (8)	60 (6)	67 (6)	60 (6)	57 (4)	67 (8)
Volume	8 (1)	11 (1)	9 (1)	20 (2)	—	10 (1)	29 (2)	25 (3)
Length	33 (4)	67 (6)	54.5 (6)	50 (5)	22 (2)	50 (5)	57 (4)	42 (5)
Area	—	33 (3)	9 (1)	10 (1)	22 (2)	10 (1)	29 (2)	42 (5)
Number	8 (1)	—	9 (1)	20 (2)	22 (2)	20 (2)	29 (2)	42 (5)

¹ Number of children given in brackets.

order: quantity, length, weight, area, volume, with the test of number being presented first in the series in the Hermannsburg group and last in the series in the Elcho-group.

Scoring and classification

The responses of the children were recorded on specially devised score sheets. The responses were then classified into Piaget's three stages of development. Children showing clear non-conservation, or inconsistencies which appeared to be due to random answering, were classified as non-conservation. Children showing a clear conflict between conservation and non-conservation were classified as transitional. Children showing clear conservation, usually supported by an adequate explanation, were classified as conservation. In some cases children who showed initial non-conservation or transitional responses, and then went on to show clear conservation with an adequate explanation, were also classified as conservation.

Supplementary testing

In the supplementary testing, the tests of conservation of quantity and length were applied to a group of unschooled children at Elcho and a group of unschooled adults in central Australia. In addition, a choice situation was devised in which unequal quantities of sugar were poured into unequal shaped glasses, and the subjects were invited to take whichever glass of sugar they wanted. One measure of sugar was poured into a long, thin glass, and one and a half measures were poured into a wider, shorter glass, the level of sugar being higher in the long glass. The subject's attention was directed to the measuring glass while the sugar was being poured out. This test was applied to 12 adult women in the central Australian group.

All the unschooled adults and children were tested through an interpreter.

RESULTS

The number and percentage of children achieving conservation at each age level on each of the tests is shown in Table 1 (p. 259). A 50% level of success was not usually achieved before 10 to 12 years and in some cases was not achieved at all. While there was a general tendency for conservation to be achieved with increasing age, this did not necessarily show a uniform progression, particularly

TABLE 2
TOTAL PERCENTAGE OF CONSERVATION RESPONSES

Tests	Elcho group	Hermannsburg group	
	8 - 14 yrs N = 65	8 - 14 yrs N = 68	8 - 15 yrs N = 80
Weight	40	53	55
Length	36	47	46
Quantity	28	28	31
Volume	26	12	14
Area	17	13	18
Number	40	13	18

in the Hermannsburg group where some of the younger age groups showed performances equal to or better than those of the older age groups.

The total percentage of conservation responses for each test is shown in Table 2. In both groups the greatest number of conservation responses were found for the test on weight. Next in order of difficulty was the test on length,

the younger children tending to perform relatively better on this test than the older children (see Table 1). Third in order of difficulty for both groups was the test on quantity, while the tests of volume and area were the most difficult, the test of volume being relatively more difficult in the Hermannsburg group than in the Elcho group. The test on number was found to be one of the easiest tests in the Elcho group, where this test was presented at the end of the series, and one of the most difficult tests in the Hermannsburg group where it was presented at the beginning of the series. The order of difficulty of the tests was therefore approximately the same in the two groups, with the exception of the test on number, which was presented in a different order. An examination of the percentage of conservation responses according to the order of presentation indicates that there was an improvement in performance with order of presentation for the first three tests: quantity, length and weight. There was then a marked drop in performance for the last two tests, area and volume. These results suggest that experience on the tests can lead to improved performances in some cases, but that conservation of area and volume is not affected by experience on the other tests.

A Guttman scale analysis was applied to the results to determine whether or not the concepts studied conformed to a unidimensional scale. Such a scale would be assumed by Piaget's theory of stage sequences. The results of this analysis are shown in Table 3. Coefficients of reproducibility were calculated

TABLE 3
ANALYSES OF RESULTS
Guttman Scale analysis & Plus Percentage Ratios (a); Loevinger's Ht (b).

Series of tests	(a)				(b)
	3 categories		2 categories		Ht
	Coeff. Rep.	PPR	Coeff. Rep.	PPR	
Elcho group					
All items	.78	.55	.90	.68	.74
Q.W.V.A.N.	.82	.64	.94	.80	.83
Q.W.V.N.	.82	.67	.94	.82	.83
Q.W.V.	.85	.72	.96	.87	.85
L.A.N.	.82	.62	.92	.74	.68
Hermannsburg group					
All items	.75	.59	.90	.66	.72
Q.W.V.A.N.	.80	.49	.96	.84	.75
Q.W.V.N.	.83	.60	.97	.89	.84
Q.W.V.	.83	.62	.99	.97	.95
L.A.N.	.80	.46	.97	.89	.61

for all the items in the series, and also for various combinations of items using three scoring categories (conservation, transitional and non-conservation) and two scoring categories (conservation and non-conservation/transitional). Guttman's

method of scale analysis has been criticized (Festinger, 1947; Loevinger, 1948), mainly on the grounds that his coefficient of reproducibility does not take into account all the relevant data. For this reason a plus percentage ratio (PPR) based on that of Jackson (see White and Saltz, 1957) was also calculated. This takes into account the minimal marginal reproducibilities and has fixed minimum and maximum values at zero and one. Loevinger's (1947, 1948) test for homogeneity was also applied to the results. Her definition of homogeneity is exactly parallel to Guttman's definition of a unidimensional scale, and her method of calculating homogeneity takes into account all the data and has a fixed minimum at zero and maximum at one. The plus percentage ratios (PPR) and homogeneity scores (Ht) are also shown in Table 3. The high coefficients of reproducibility obtained indicate that the tests are scalable by Guttman's criteria. High plus percentage ratios and homogeneity coefficients were also obtained, giving further support for the unidimensionality of the concepts studied.

A comparison was made between the performances of the full Aboriginal and part Aboriginal children in the Hermannsburg group. This is shown in Table 4. The part Aboriginal children showed markedly better performances,

TABLE 4
COMPARISON OF THE NUMBER OF PART ABORIGINAL AND FULL ABORIGINAL CHILDREN (HERMANNSBURG GROUP) SHOWING CONSERVATION

Test	Full Abor. N = 38	Part Abor. N = 34	χ^2	<i>p</i>
Quantity	4	18	15.214	< .001
Weight	16	25	7.227	< .01
Volume	2	8	3.595	.05 < <i>p</i> < .10
Length	12	20	5.365	< .05
Area	3	10	4.225	< .05
Number	3	9	3.22	.05 < <i>p</i> < .10
Total	40	90	36.141	< .001

the differences being significant or approaching significance on all the tests, while the difference in the total number of conservation responses achieved was highly significant.

Supplementary testing

Relatively few unschooled children up to the age of 15 years show conservation of quantity or length (*cf.* Table 3), while among the adults conservation of length is achieved more frequently than conservation of quantity (quantity : for N = 26, 13 show non-conservation, 6 are transitional and 7 achieve conservation; length : for N = 24, 3 show non-conservation, 3 are transitional and 18 achieve conservation). The choice test was applied to 12 adult women in the central Australian group. Of these, 8 women chose the sugar in the long glass, that is, the glass

which had less sugar, but where the level was higher. These results indicate that among unschooled Aborigines the concept of conservation does not seem to be generally developed, although a number of individuals do show clear

TABLE 5
NUMBER OF UNSCHOOLED CHILDREN CLASSIFIED AT EACH STAGE OF DEVELOPMENT ON TESTS OF QUANTITY AND LENGTH

Tests and stages	Age group						Total
	10	11	12	13	14	15	
Quantity	(N = 3)	(N = 8)	(N = 6)	(N = 13)	(N = 4)	(N = 3)	(N = 37)
NC	3	7	4	6	2	1	23
T	—	1	1	4	2	2	10
C	—	—	1	3	—	—	4
Length	(N = 2)	(N = 8)	(N = 6)	(N = 13)	(N = 4)	(N = 3)	(N = 36)
NC	2	6	6	8	2	3	27
T	—	—	—	3	—	—	3
C	—	2	—	2	2	—	6

conservation. The difference in the achievement of conservation of quantity and length among the adults also suggests that environmental factors may affect the development of conservation in particular areas.

DISCUSSION

These results raise a number of questions, relating first to the stages and orders of development postulated by Piaget, and second to the factors affecting the development of conservation in these children.

Stages and orders of development

In general, it was found that the three stages of development described by Piaget could be clearly distinguished, and that the responses and explanations given by the Aboriginal children revealed the same processes of development that Piaget has described for European children. Non-conservation responses were invariably justified with reference to the perceptual features of the immediate situation, indicating the child's inability to free himself from his immediate perception, while conservation responses were justified with reference to past or future situations, indicating the child's ability to link these together in a system of reversible transformations. Some of the explanations given by the children also showed the same confusion in their notions of physical concepts as those described by Piaget. For example, the confusion between weight and density described by Piaget was expressed by the child who said that one bag of tea leaf was heavier because it was "tight", and the tendency to regard displace-

ment of water in terms of a force that is applied to the water rather than in terms of the volume occupied by the object was expressed by the child who stated that the plasticine made the water rise "because it's strong". Such responses can hardly be attributed to specific teaching, and therefore suggest that the processes of development described by Piaget are not the product of particular cultural, linguistic or educational factors, but are common to all societies. Our findings are therefore in agreement with those of Hyde (1959), who reports that Arab, Indian and Somali children living in Aden showed the same type of responses as those described by Piaget, often giving explanations in Arabic which were almost word for word translations of the explanations given by Swiss children. However, we found no evidence of the type of explanation interpreted by Greenfield (1964) as due to magical thinking.

While our results offer general support for Piaget's stages of development, we found some discrepancies with regard to the orders of development. We did not find the invariant order of development for conservation of quantity and weight postulated by Piaget and Inhelder, since we found more children succeeding on the test of weight than on that of quantity. We also found that, contrary to Piaget's findings, conservation of area was not achieved at the same age as conservation of quantity and length, but was a much later achievement. The invariance of the order of development for the tests of quantity, weight and volume is important to Piaget's theory of stage sequences, although later testing has indicated that the interval between conservation of quantity and weight is not as great as originally reported (Inhelder and Vinh Bang, reported in Piaget and Inhelder, 1962). This order of development has been confirmed in a number of other studies (Lovell and Ogilvie, 1960, 1961a, 1961b; Elkind, 1961a; Uzgirls, 1964), although Boonsong (1968) has reported the simultaneous development of conservation of quantity and weight in Thai children. It is possible that the reversal of order found in this study may have been due to the effects of experience on the tests. The tests were administered in a standard order such that the tests of quantity and length always preceded the test of weight. Since the results of the test on number indicated that the order of presentation had a marked effect on the difficulty of the test, it is possible that the better performance on weight was due to the children's experience on the tests of quantity and length, and in the Hermannsburg group also the test on number.

The question of order effects in the presentation of a series of Piaget-type tests has not received much attention in the literature. The usual practice has been to randomise or counterbalance the orders of presentation to control for order effects. However, in such cases it is possible that experience on previous tests may be affecting the children's performances to an unknown degree, and these effects may account for some of the inconsistencies in performance or in the invariance of certain orders of development that have been reported (Dodwell, 1960; Lovell and Slater, 1960; Kofsky, 1966). It is probable that the effects of experience would be more marked in Aboriginal children than in European, since these children are facing problems and situations that are quite new and unfamiliar to them. Because of the importance of conservation concepts in European society, and particularly in the schooling situation, it is likely that these concepts are achieved as soon as the child develops the operational capacity to handle them. However, because the Aboriginal society does not appear to

recognise or encourage the development of concepts of conservation, these may not be clearly formulated even when the operational capacity is present. In this case it is likely that a little experience with the test situation would be sufficient to develop the concepts. This also appears to occur with children who have not had normal schooling, since Inhelder (in Tanner and Inhelder, 1956) has reported that refugee children frequently showed less advanced responses than expected for their age at the beginning of a test, but during the test session achieved more advanced responses.

Since we changed the materials in our tests of quantity and weight, it is also possible that the reversal in the order of difficulty may have been due to the difference in materials used. From a theoretical point of view, such an explanation would be more critical to Piaget's theory of invariant development, since if the achievement of these concepts is dependent on the particular type of material used, then the theory is of very limited validity. Uzgiris (1964) has reported some reversals for the orders of development of quantity, weight and volume across different materials, but these are very slight and could be due to the effects of order of presentation. Subsequent testing with European children (de Lemos, 1968) has revealed no significant differences in difficulty for the tests of quantity and weight with the materials used in this study as compared with the materials used by Piaget and Inhelder. It therefore seems unlikely that the difference in materials could account for this reversal of order. Boonsong's (1968) finding that conservation of quantity and weight develop simultaneously in Thai children suggests however that the decalage between these concepts usually found in European children may not necessarily occur in other cultural groups. In his study, Boonsong used the same materials as used by Piaget and Inhelder, and counterbalanced the order of presentation of the tests, thus eliminating effects of experience or differences in materials as possible sources of variation.

The other main discrepancy between our findings and those of Piaget is the later development of conservation of area in Aboriginal children. While contrary to Piaget's own findings, this is in agreement with his theoretical expectation that conservation of area in this particular situation should be found at a later stage of development, since it depends on the understanding of coordinate systems of reference, which is not developed until about 9 years. This could explain the greater difficulty of this test for the Aboriginal children, but it is not clear why this test is no more difficult for Swiss children than the tests of quantity and length.

Factors affecting the development of conservation in Aboriginal children.

The interpretation of the retardation in development in Aboriginal children raises a number of complex questions. While this retardation is probably due largely to the extreme differences in the physical and cultural background of these children as compared with normal European children, it is necessary to consider the significance of these differences and the particular factors that might account for them. The results of the study clearly indicate that conservation is developed much later in Aboriginal children than in European, and in some cases appears not to develop at all. According to Piaget's theory, the failure to achieve conservation would indicate a pre-operational level of thinking, implying

an inability to form logical concepts or to apply logical operations to the organization and systematization of concrete data, and affecting the level of logical thinking in all areas. This inability would be attributed to the lack of an underlying operational structure allowing the mobility and reversibility of the internal actions or operations required in the construction of logical relationships. The failure to achieve conservation would therefore have important implications for the level of intellectual functioning achieved.

It could however be argued that the stages of development described by Piaget are simply the product of Western culture and training, and are not general stages characteristic of all cultures. This view has been taken by Prince (1968) to explain his findings on New Guinea children. He claims to find a closer relationship between conservation and grade level than between conservation and age, and accordingly attributes the development of conservation to the influence of Western schooling. While Western schooling may have some effect on the development of conservation concepts, it does not seem to provide a sufficient explanation. Our results indicate that a number of children who had attended school for up to 8 years still showed consistent non-conservation throughout the series of tests, despite the fact that experience on the tests was shown to have a marked learning effect, while on the other hand a number of the adults and children who had had no schooling whatsoever showed clear conservation. Other investigators have also found evidence of conservation concepts in unschooled children who have had little Western contact (Price-Williams, 1962; Greenfield, 1964; Bovet, 1968), while Prince himself reports an instance of clear conservation in an illiterate tribal elder with little Western contact. Goodnow (1962) has found no differences in the development of conservation concepts in schooled and unschooled Chinese boys, while Mermelstein and Shulman (1967) have also found no differences in the understanding of conservation between 9 year old Negro children who had missed several years of early schooling as compared with children who had had normal schooling. There does not therefore appear to be a direct relationship between the development of conservation concepts and Western-type schooling.

Attributing the development of conservation to Western schooling also does not take into account the processes underlying conservation. Our own results and those of other workers (Hyde, 1959; Price-Williams, 1961; Greenfield, 1964) have shown that the responses and explanations of children from other cultural backgrounds reveal the same processes of development that Piaget has described in Swiss children, thus tending to support his view that conservation is dependent on underlying internal processes that are developed as a result of the child's interaction with his physical environment, and are not due to specific teaching. While the development of conservation does not appear to be directly related to schooling, the school situation may help to provide the kinds of experiences that are necessary for its development. Thus Greenfield (1964) has found that while only about half of her unschooled children at 13 years had developed conservation, virtually all her schooled children had achieved conservation by this age.

Our results also suggest that newer methods of teaching based on activity with concrete materials may be more effective in helping children to achieve conservation than older methods based on verbal instruction and rote learning.

In both the schools involved in this study new activity methods had recently been introduced in the early grades, and the relatively better performance of the younger children on some of the tests appeared to be due to these new methods. This effect was more marked in the Hermannsburg group, where a greater variety of activity materials had been introduced in the preliminary and first grades, than in the Elcho group where the Cuisenaire materials only had been used. This suggests that experience with a variety of materials may be more effective in promoting intellectual development than experience on a single set of materials.

Another factor that may be important in providing the kinds of experience that are necessary for the development of conservation concepts is contact with a technical and industrialised society. Thus Peluffo's (1962) study on the development of conservation in Southern Italian immigrant children and native born Genoan children living in Genoa has shown that there is a relationship between the development of conservation concepts and the period of residence in the industrial northern city of Genoa. This factor could account for the differences in the effects of schooling in the studies of Goodnow (1962) and Mermelstein and Shulman (1967), where the unschooled children were living in an industrialised society, as compared with the study of Greenfield (1964), where both the schooled and unschooled children were living in a rural, non-technical society. The question of the interaction between age and schooling is also important. Experimental evidence has indicated the presence of "critical periods" in development, such that certain types of experience are effective only during a certain period of growth (Scott, Fredericson, and Fuller, 1951). If such critical periods also occur in the development of the operational structures underlying conservation, this would imply that the effect of schooling would vary according to the age of the child on entering school. It could also imply that if conservation is not developed before a certain age, it may no longer be possible for it to be developed even given the appropriate experiences, or it may be achieved only with great difficulty or only partially.

The question of the influence of language on the development of conservation concepts is also important. Recent theories have placed considerable emphasis on the importance of language in the determination of thought processes (Whorf, 1956; Luria, 1961; Bernstein, 1961). Since precise terms expressing number, comparison and measurement are generally lacking in the Aboriginal languages, it is possible that language factors could account for the later development or non-development of conservation concepts in Aboriginal children. Piaget takes the position that the development of operational concepts is largely independent of language. This view is supported by Furth's (1966) studies on deaf children, which have shown that operational concepts develop in linguistically deficient deaf children either at about the same age or in some cases a little later than in normal children. It has also been shown by Sinclair (1967) that children's spontaneous use of certain terms is related to their operational level, the pre-operational child using only absolute terms (big, little, etc.) while the operational child makes use of comparative terms (more, less, etc.). She also found that while the pre-operational child could learn to use comparative terms correctly through verbal training, this resulted in very little operative improvement. These findings suggest that the development of Piagetian concepts is rela-

tively independent of language, and that in some cases it is the operational level that determines the language used rather than vice versa.

Finally, the significant differences found between the part and the full Aboriginal children tested at Hermannsburg suggest that there may also be genetic factors which could have contributed to the retardation in the development of conservation in these children. Although differences in the tested intelligence of persons of European and non-European origin have been consistently reported, these differences are usually attributed to differences in the environmental conditions of the groups compared (Klineberg, 1956; Myrdal, 1944). The significance of our results lies in the fact that in this case there were no apparent differences in the environments of the two groups. Both formed an integral part of the same community, being closely related by family and kinship ties, and living under the same mission conditions. The differences cannot therefore be attributed to environmental factors. Morant (1956) has pointed out that just as there are genetic differences between racial groups in physical characters, so there are also likely to be genetic differences in mental characters, since variation within groups is always associated with variation between groups. Such differences are likely to be most marked in groups that have developed in isolation, and in the case of Aborigines factors such as genetic drift, extreme environmental conditions and natural selection could have operated to produce differences in intellectual potential between Aborigines and other groups. It would therefore seem reasonable to attribute the significant differences between the part and the full Aborigines in this study to genetic differences between Aborigines and Europeans, resulting in the part Aboriginal children having a higher probability of inheriting a higher intellectual potential. Our results indicate that such differences are likely to be statistical differences in average potential rather than absolute differences, since some of the full Aboriginal children showed performances equal to the best performances of the part Aboriginal children. Genetic factors affecting the average intellectual potential of these children may therefore have contributed to the retardation in the development of conservation concepts. However, the retardation cannot be attributed entirely to genetic factors, and it is likely that environmental and cultural factors play an important role in the development of concepts such as conservation.

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