Berry's (1971) model of ecological functionalism is extended to Piagetian developmental psychology. It is predicted that the rate of development of concrete operations may be partly determined by ecological and cultural factors. In particular, if three subsistence-economy populations are placed on an ecocultural scale, with low food-accumulating, nomadic, hunting groups at one extreme, and high food-accumulating, sedentary, agriculturalist groups at the other extreme, the former are expected to develop spatial concepts more rapidly than will the latter, whereas the sedentary group is expected to attain concepts of conservation of quantity, weight, and volume more rapidly than nomadic groups will. The model is largely supported by the results of a study involving 190 children (aged six to fourteen from three cultural groups: Canadian Eskimos, Australian Aborigines, and Ebrié Africans. The discussion centers on ambiguous results obtained in the age range eight to eleven years for the conservation tasks.

CONCRETE OPERATIONAL DEVELOPMENT IN THREE CULTURES

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Within the renewed tradition of ecological cultural functionalism, Berry (1966, 1971) has suggested a model linking individual behavioral development to the "ecological demands" placed on a group of people, partly through the mediation of cultural adaptation to this ecology ("cultural aids").

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> Specifically, it is argued, persons who inhabit ecologies where hunting is the mode of sustenance should develop perceptual discrimination and spatial skills adapted to the ecological demands of hunting. . . . Their cultures are expected to be supportive of the development of these skills through the presence of a high number of "geometrical spatial" concepts, a highly developed and generally shared arts and crafts production, and socialization practices whose content emphasises independence and self reliance, and whose techniques are supportive and encouraging of separate development. Implicit in this argument is the expectation that as hunting diminishes in importance across samples ranked in terms of this ecology dimension, the discrimination and spatial skills will diminish, as will each of the three cultural aids [Berry, 1971: 328-329].

Thus an ecology dimension was defined by placing low food-accumulating, migratory, hunting and gathering, low population density groups at one end of the scale, and high food-accumulating, sedentary, agricultural, high population density groups at the other extreme. Sociocultural characteristics which are known to vary fairly consistently with this ecological dimension are socialization practices, family structure, social structure, and social relations (Berry, 1975).

This model was largely supported by a comparative study (Berry, 1966) of Temne (Sierra Leone) and Eskimos (Baffin Island), which was later expanded (Berry, 1971) to include two populations considered to be at intermediate positions on the ecology dimension: Australian Aborigines and Melanesians (New Guinea). Both traditional and transitional samples were included, and their results were analyzed separately. The rankings of the dependent variables (scores of perceptual discrimination, EFT, Kohs Blocks, and Raven's Matrices) followed the rankings on the ecology dimension with only one exception. The model received further partial support across more restricted ecocultural ranges through a study of spatial skills, affective style, and acculturative stress in three Amerindian populations (Berry, 1975), and a study of spatial test performance in Gilbertese and Fijians (Bennett and Chandra, 1974).

Since the model is appealing and has a wide scope, an extension to a variety of dependent variables, and to Piagetian developmental psychology in particular, seems warranted. In addition to providing a theoretical background to the choice of the dependent variables, the Piagetian framework has the advantage of focusing on the developmental process itself, thus increasing our chances to discover when and how these ecological and cultural influences occur. Furthermore, Piagetian methodology is flexible enough to be easily adaptable for cross-cultural use (Dasen, 1972); it has, however, the disadvantage of requiring lengthy, individual testing of the subjects.

The extension of Berry's model to the Piagetian area suggests that, although the sequence of stages in the development of concrete operations may prove to be universal, the rate of development may be partly determined by ecological and cultural factors. Thus the first of two hypotheses is advanced: if three subsistence-economy populations are placed on an ecocultural scale, with low food-accumulating, nomadic, hunting groups at one extreme (e.g., Eskimos and Australian Aborigines), and high food-accumulating, sedentary, agriculturalist groups at the other extreme (e.g., Ebrié of Ivory Coast), the former are expected to develop spatial concepts more rapidly than the latter will. The choice of tasks assessing the development of spatial concepts would be based on Piaget and Inhelder's (1948) analysis of topological, projective, and Euclidean spatial representation in children.

Furthermore, it seemed reasonable to expect that the African group, under the pressure of its own ecocultural milieu, would develop other concepts more rapidly than would the Eskimo and Aboriginal groups. This leads to the second hypothesis: because of the agricultural production, accumulation, and exchange of food in the African group, its members are expected to attain concepts of conservation of quantity, weight, and volume (Piaget and Inhelder, 1941, 1963) more rapidly than would Eskimos and Aborigines. A similar hypothesis could be formulated for the concept of number (Piaget and Szeminska, 1941), but will not be tested here.

Note that these hypotheses deal with the quantitative aspects of cognitive development, the differential rate of development of various areas of concrete operational reasoning, and not with the qualitative aspects of structure and hierarchical ordering of stages. Note also (see Berry, 1971) that the model is functional, emphasizing interactions rather than causal sequences, and that it applies only to subsistence-economy populations, for which the "ecological demands" are expected to be more uniform than in technological societies. For these and other methodological reasons, any comparison with a Western "norm" will be avoided.

Earlier support for a hypothesis stemming from the combination of Berry's model and a Piagetian framework came from the finding that Australian Aborigines, in two specific samples, acquired a particular set of spatial operations before they acquired a particular set of conservation concepts, whereas the reverse was found to be true in a European sample (Dasen, 1970, 1974). This demonstration, however, required the use of an arbitrary scoring system in order to combine the results of several tasks into a single measure, and it had the drawback of using a Western comparison group. Later (Dasen, 1973), these inconveniences were overcome by comparing directly the results of the Aboriginal sample with those of an Ebrié African sample (Adiopodoumé). However, the design was not yet judged to be satisfactory, in view of Campbell's (1961) suggestion that at least three points are required to make meaningful cross-cultural comparisons.

Note, however, that the above hypotheses do not clearly specify the ranking of the Eskimo and Aboriginal samples on the independent variable. Berry (1971) has placed his Eskimo samples at one extreme of the ecology scale, and the Australian Aboriginal samples at a more intermediate position, but definitely on the nomadic/hunting/low food-

accumulating side; his results clearly support this ranking. We could add, therefore, to our first hypothesis the prediction that the rate of spatial concept development should be greater in the Eskimo than in the Aboriginal sample. Anthropological evidence in regard to this ranking seems to be equivocal, however, particularly if we wanted to include a similar distinction in the second hypothesis.

METHOD

SUBJECTS

The subjects were six- to fourteen-year-old schooled rural children drawn from three cultural groups:

(1) *Central Eskimo.* The settlement of Cape Dorset is situated on the southwest tip of Baffin Island in the Northwest Territories of Canada. Its population is about 600. Cape Dorset Eskimos are well known for their artistic achievements; stone carvings and prints provide a large part of the income, together with local service jobs and welfare. But part of the food is still provided by hunting and fishing. Every family owns a house in the village, but during hunting expeditions they may still live in igloos in winter and in tents in summer. Some families live part of the year in isolated hunting camps. An excellent study of the village of Sugluk, very similar to Cape Dorset, has been provided by Graburn (1969).

(2) *Australian Aborigines.* The settlement of Hermannsburg Mission is situated seventy miles west of Alice Springs in the center of Australia (Northern Territory). Its population was 554 in 1969. The cultural background of Aranda (Arunta) Aborigines has been described by Spencer and Gillen (1927), Strehlow (1947, 1965), and many others. Present-day Aborigines at Hermannsburg rely only occasionally on hunting and gathering for their livelihood; most of the income comes from local service jobs, welfare, and cattle raising. Although the population has become mainly sedentary, many Aborigines tend to travel frequently to other settlements and to maintain their knowledge of a large area around them and to keep the skill of finding their way in the seemingly monotonous desert or semi-desert.

(3) *Ebrié Africans.* The village of Adiopodoumé is situated seventeen kilometers west of Abidjan, the capital city of Ivory Coast. Its population is about 7,000. Most of its inhabitants are Ebrié, although some other ethnic groups are also present. The main activity is the raising of staple food (yams, plantain, and various vegetables), as well as cash crops (coffee, cacao, and bananas). There is also some fishing in the lagoon, and some paid jobs are available in the city or at a nearby research station.

It should be noted that the cultural characteristics of the three samples come close to the requirements of Berry's model, but are not absolutely ideal. The Eskimos and Aborigines no longer rely exclusively on hunting and gathering and have become partly sedentary, whereas the African sample is somewhat heterogeneous as to ethnic background and parents' occupation.

The three samples will be labeled by the names of the locations in which they were obtained, to indicate that they are not necessarily representative of the whole ethnic groups. In particular, results may be influenced by acculturation (Dasen, 1973, 1974); the three samples were chosen to represent approximately equal levels of acculturation, as far as this could be done across different historical and cultural backgrounds. However, no measure of acculturation, other than the author's casual observations, can be offered.

In each sample, ten subjects (as nearly as possible five of each sex) were sampled randomly within each given age group. All subjects attended the local primary school, where teaching took place in a second language, and their ages were known from reliable school records. The sample characteristics are summarized in Table 1.

TASKS

Although the individual studies from which this report is drawn included several other perceptual and operational

TABLE 1
Sample Characteristics

Age Groups (Years)	Central Eskimos of Cape Dorset Baffin Island: Sex M	F	Mean (Years and Months)	Range (Years and Months)	Australian Aborigines of Hermannsburg Central Australia: Sex M	F	Mean	Range	Ebrié Africans of Adiopodoumé Ivory Coast: Sex M	F	Mean	Range
6	5	5	6; 0	5;10- 6;5	5	5	6; 3	5; 7- 6;5				
8	6	4	8; 1	7; 7- 8;4	5	5	8; 1	7; 8- 8;6	4	6	8; 1	7;7- 8;6
9	6	4	8;11	8; 7- 9;6	5	5	9; 1	8; 7- 9;5				
10	5	5	10; 2	9;10-10;5	5	5	10; 1	9; 7-10;6	5	5	9;11	9;7-10;4
11	4	6	11; 1	10; 8-11;6	5	5	10;11	10; 7-11;4				
12	5	5	12; 0	11; 7-12;4	5	5	12; 0	11; 8-12;6	6	4	12; 1	11;7-12;6
13	5	5	13; 1	12; 8-13;6								
14	5	5	14; 0	13; 7-14;7	5	5	13; 7	12;11-14;6	5	5	14; 1	13;7-14;6
n	41	39			35	35			20	20		

tasks, this presentation will be restricted to six tasks which are directly relevant to the hypotheses. These tasks, summarized below, are based on Vinh Bang's standardization of the tasks originally described by Piaget and Inhelder (1941, 1948), with minor adaptations to make them more suitable to a cross-cultural study. The procedures were standardized insofar as the same basic questions were put to each child, but the flexibility of Piaget's clinical method was retained in that children were questioned further according to their particular response. More detailed descriptions of the tasks and procedures have been provided previously (Dasen, 1970, 1974).

Space

(1) *Linear, reverse, and circular order.* The subject has to copy a linear display of nine objects, reverse this order, and finally change a circular display into a straight line. The task assesses topological spatial relationships of neighborhood and order, and one-to-one correspondence.

(2) *Rotation of landscape models* (localization of topographical positions). The subject has to locate on one landscape model rotated by 180⁰ seven successive positions and orientations of a corresponding object placed on an unrotated landscape model. The models and objects used were adapted for each cultural group, but retain the same spatial features as originally used by Piaget and Inhelder (1948 [1956: 421]). The task assesses topological, projective, and Euclidean (metric) spatial relationships, the construction of a coordinate system, and the flexibility of spatial operations.

(3) *Horizontality.* This task assesses the coordination of two spatial (Euclidean) reference systems. The subject is required to draw, on corresponding outline figures, the level of water in a half-filled bottle tilted in various positions. The complete task consists of three parts: (1) the water level is hidden (anticipation); (2) the water level is visible (copy); (3) the level is hidden again (anticipation after copy). However,

results will be reported for part 1 only, reflecting the spontaneous performance level, as with the other tasks, without any additional learning effect.

Conservation

(4) *Conservation of quantity* (liquids).
(5) *Conservation of weight* (plasticine).
(6) *Conservation of volume* (water displaced by plasticine).

These tasks are widely known and their description need not be repeated here.[1] The scoring was based on the spontaneous answers of the child on two situations for each task; the child was also asked to give a reason for his answer, but this was not used in the scoring. It was considered that requiring an adequate reason for each answer would disadvantage those less fluent in the second language used for testing; this may artificially inflate the number of conservers to some extent, but Kiminyo (1973) and Brainerd (forthcoming) have provided evidence that judgments alone can be as reliable as when explanations are used as well. No countersuggestions were used, because these are likely to be taken as criticism and are thus not suitable to test the stability of the answers in a cross-cultural situation (see Dasen, 1974: 389).

Concurrently, other tasks which are not relevant to the present hypotheses were used with some of the samples. These included conservation of length, mental imagery, and opticogeometrical illusions. The only other tasks administered to all three samples were seriation of lengths and reclassification (Nixon test; de Lacey, 1970). On both tasks the rate of attainment of concrete operations was the fastest in the Cape Dorset sample, followed by the Hermannsburg and Adiopodoumé samples. The differences are statistically significant beyond the .05 level, except for the Hermannsburg/Adiopodoumé comparison on reclassification.

PROCEDURE

The testing took place in the second language used in the subjects' schools (English for Eskimos and Aborigines, French for Ebrié). Adequate communication was ensured through check-items preceding each task; if communication was judged to be inadequate, results were classified separately. The testing was carried out by the author and his wife at Hermannsburg and Adiopodoumé, and by the author and Serge Rioux at Cape Dorset. The order in which the tasks were administered was randomized, except for the order of the tests of conservation of quantity, weight, and volume, which was counterbalanced within each age group. For various reasons all tasks were not administered to all age groups; this appears clearly in the presentation of the results—each percentage is calculated on an age group of ten subjects.

RESULTS

The structural properties of the stages and their hierarchical ordering were verified in each sample. Detailed analyses of the results, including frequencies of each substage, are presented elsewhere (Dasen, 1970, 1974, 1975). For the purpose of the present argument, only the rate of development of Stage 3 (the final stage of attainment of concrete operations) will be considered.

HYPOTHESIS 1: SPACE

Results on the three tasks of spatial operations are presented in Table 2 in the form of percentages of children, at each age group tested, attaining Stage 3 in the three samples.

The results clearly support Hypothesis 1. On all three tasks, the rate of development is faster in the Cape Dorset and Hermannsburg sample than in the Adiopodoumé samples. The statistical significance of the differences in the proportions of children in each age class reaching the

TABLE 2
Spatial Tasks. Percentage of Subjects in each of the Three Samples Classified at the Concrete Operational Stage

	Age Groups							
	6	8	9	10	11	12	13	14
ORDERS								
Cape Dorset	10	100		100				
Hermannsburg	50	80		100				
Adiopodoumé		50		80				
ROTATION								
Cape Dorset	10	20	40	70	80	70	70	90
Hermannsburg	0	0	20	40	50	30	80	
Adiopodoumé		0		0		20		20
HORIZONTALITY								
Cape Dorset	0	40		40		70		60
Hermannsburg	0	20		20		0		30
Adiopodoumé		0		0		10		20
HORIZONTALITY[a]								
Cape Dorset	20	90		90		100		100
Hermannsburg	0	30		50		70	70	
Adiopodoumé		10		10		40		40

a. Stage 3 and intermediate combined.

concrete operational stage was computed according to the scheme proposed by Kamara and Easley (1974). The corresponding p values appear in Table 3. For the spatial tasks, the developmental curves are all significantly different beyond the .05 level, except for the Hermannsburg and Cape Dorset samples on task 1 (linear, reverse, and circular order): topological relations are acquired early in both these samples. On the two other tasks, the rate of development is significantly faster for the Cape Dorset sample than for the Hermannsburg sample, which confirms Berry's placement of these two populations on the ecology scale.

On the most difficult task, namely, horizontality, the frequency of attainment of Stage 3 is generally low. However, the intermediate stage immediately preceding Stage 3 already reflects the emergence of concrete operations. If this intermediate stage is combined with Stage 3 (see Table 2), the differences between the three samples become even more marked, and are all statistically significant beyond the .0005 level.

TABLE 3
Level of Significance of the Differences in the Proportions of Children Reaching Stage 3 (p values)

	Tasks								
	Space 6-14			Conservation[b] 8-14			12-14		
Age Range	Orders	Rotation	Horiz.	Q	W	V	Q	W	V
Samples Compared									
A/H	.01	.05	.05	N.S.	.025	N.S.	.025	.001	.025
A/C.D.	.005	.0005	.0005	.025	N.S.	N.S.	.005	.005	.05
C.D./H	N.S.	.0005	.01	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

a. A = Adiopodoumé, H = Hermannsburg, C.D. = Cape Dorset.
b. Q = Quantity (liquids), W = Weight, V = Volume.

HYPOTHESIS 2: CONSERVATION

The results on the three conservation tasks are presented in Table 4 and the corresponding p values in Table 3. The second hypothesis receives only partial support from the data.

If the age range of twelve to fourteen years is considered alone, the order of the developmental curves is as expected from the hypothesis: the rate of development in the Adiopodoumé sample is significantly faster than in the two other samples on all three tasks.

On the other hand, if the complete age range is considered, the differences are statistically significant in two cases only, because several discontinuities occur below age twelve which are not in accordance with the hypothesis. On conservation of quantity, the percentage of conservers in the eight, nine, and ten year olds appears to be exceptionally high when compared with the results of the older children; it has not been verified whether pseudo-conservation (Bovet, 1974) might have occurred at these ages in the Hermannsburg

TABLE 4
Conservation Tasks. Percentage of Subjects in each of the Three Samples Classified at the Concrete Operational Stage

	Age Groups							
	8	9	10	11	12	13	14	
QUANTITY								
Cape Dorset	0	20	60	60	40	60		60
Hermannsburg	20	40	30	10	50		70	
Adiopodoumé	10		20		80			90
WEIGHT								
Cape Dorset	0	0	30	20	30	40		20
Hermannsburg	10	10	10	10	20		20	
Adiopodoumé	0		20		60			60
VOLUME								
Cape Dorset	0	20	50	20	30	40		30
Hermannsburg	0	30	30	10	20		20	
Adiopodoumé	0		10		60			40

sample. In any case, high percentages of conservation also occur in the Cape Dorset group at ten and eleven years; in this case, the operational character of these conservation answers has been clearly established.

On conservation of weight, no clear differences occur between the three samples in the results of the eight- to ten-year-old children. On conservation of volume, the frequencies of Stage 3 answers are higher in the Cape Dorset and Hermannsburg samples than in the Adiopodoumé sample, at ages nine and ten. The ordering of the three samples does not occur as expected in these lower age groups: there is either no clear ordering, or it is even reversed. In the older age groups, however, Hypothesis 2 is supported.

DISCUSSION

Clear support for the model comes from the data on spatial concept development (Hypothesis 1), since the rankings of the dependent variables occur according to expectation over the whole range of development.

Further support comes from the results on the conservation tasks (Hypothesis 2) if the age range of twelve to fourteen years is considered. Not only do these data support the model, they also indicate that the relationship between ecology and culture is positive at both ends of the ecological scale, in different areas of operational development. The results are equivocal, however, insofar as the expected relationship does not occur in the younger age groups. Several alternative explanations are possible.

It could be argued, for instance, that some of the ecological pressures relevant to spatial concepts, e.g., geographical environment and the demands of nomadism, are present very early in life, even if the actual techniques of hunting and spatial orientation are acquired only later. Thus the differences in spatial concept attainment would be expected to occur over the complete range of development. On the other hand, the more economic pressures relevant to conservation concepts (the exchange of food on markets, for example) would need more sociocultural mediation, and would therefore be influential at later ages only.

Differential schooling could also explain the results if it were true that the Adiopodoumé eight to ten year olds had less, or a different kind of, schooling. Length of schooling (number of days in attendance) does not differ significantly between the Hermannsburg and Cape Dorset samples. Although no figures were available for Adiopodoumé, it is unlikely that a difference would be found in length of schooling. The school system, on the other hand, was quite different: it tended to emphasize verbal skills and rote memory rather than arithmetic and reasoning. This was also the case in the Australian and Canadian systems, but possibly to a lesser degree. Furthermore, the school at Adiopodoumé was staffed mainly by Africans, whereas all the teachers at Hermannsburg and Cape Dorset were Europeans. It is therefore possible that Western cultural values were stronger in the school environments of the latter two locations, carrying with them an increased emphasis on comparisons of

quantity, weight, and volume, reminding us of what Heron (e.g., Heron and Dowel, 1974) has called "cognitive ambience."

A further distinction which may be relevant to the results of the conservation tasks is the one recently introduced between competence and spontaneous performance (Flavell and Wohlwill, 1969; Heron and Dowel, 1974). It is suggested that the conservation tasks, in the way they have been applied here, measure the spontaneous use of the concepts; the results could be seen as measures of the probability with which these particular concepts would be used in everyday situations, and are thus meaningful. They would not necessarily be measures of the cognitive "competence" to use the conservation concepts, however. Thus in a small training experiment with the Eskimo sample (Dasen, 1975), it was shown that twelve- to fourteen-year-old nonconservers could acquire the concept of conservation of quantity (liquids) very easily; it is likely that these children had the competence to use these concrete operations, if they were placed in a favorable situation, but did not use them spontaneously. On the other hand, learning in the ten- and eleven-year-old nonconservers was much slower, suggesting that these children lacked the necessary competence (although they could acquire it with time).

If this distinction were to be supported by results of further studies, it may be necessary to modify these hypotheses accordingly. Subsequent research would have to show whether the ecocultural factors determine both the rates of development of competence and the final levels of spontaneous use of the concepts, or only one of these. The present results on the conservation tasks possibly could be explained by arguing that only the latter are ecoculturally determined, whereas competence would either be universal, or be under the influence of other cultural factors.

In any case, the present results demonstrate that rates of development are not uniform across different areas of

concrete operations, and that these rates may reflect the adaptive values of the concepts concerned.

NOTE

1. A description of the procedures and scoring of the tasks of conservation of quantity and weight appears in Inhelder et al. (1974: 333-340).

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For an expanded version of Berry's model:

BERRY, J.W. (1975). An ecological approach to cross-cultural psychology. Nederlands Tijdschrift voor de Psychologie, 30, 51-84.