A cross-cultural study of young children's mapping abilities

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The mapping abilities of four-year-old children in York, England, Durban, South Africa, Tehran, Iran, Mexico City, Mexico and Evanston, Illinois, USA were investigated, using a methodology involving air-photo identification and simulated navigation on an air photo. The results show that essential mapping abilities (perspective and scale transformations) are well developed by the age of four in these cultures, and provide some evidence in support of the hypothesis that mapping abilities emerge without training in very young children of all cultures.

key words mapping abilities of preschoolers cognitive development cross-cultural environmental psychology

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Introduction

We report here the results of a limited cross-cultural study of the mapping abilities of four-year-old children. The research was carried out in York, England, Durban, South Africa, Tehran, Iran, Mexico City, Mexico and Evanston, Illinois, USA, and sought to determine whether children can interpret a vertical aerial photograph and carry out a make-believe navigation task on the photograph. If they can do so, they have demonstrated an ability to engage in a simple form of map-reading and simulated map-use; simple in the sense that it does not depend on an ability to read text and interpret conventional signs, although it does depend on an ability to perform the basic mapping transformations of perspective rotation and scale reduction. If these children can indeed read and 'use' maps in this sense, then we will have obtained good evidence that mapping abilities of people in these communities are well developed by the age of four. We will also have obtained evidence that has a strong bearing on several important theoretical issues, among them the question of whether the development of spatial (macro-environmental) cognition proceeds more rapidly than is postulated in Piagetian theory, and the question of whether early development of mapping abilities is a cross-cultural universal.

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Before the 1960s, very little research was done on the development of mapping abilities in young children, and it was broadly assumed that children cannot learn how to read and use maps before the age of about eight (Fairgrieve 1930; Shryock 1939) or later (Renner 1951). Piaget's theory of the development of spatial cognition, which became widely known in the late 1950s (see especially Piaget and Inhelder 1956), postulated that children younger than about seven are 'preoperational', hence cannot perform the cognitive 'operations' involved in map-reading. This provided support for the prevailing view that map-learning is a late attainment in children, and quickly gave the Piagetian point of view the status of a hegemonic paradigm (see Prior 1959; Satterly 1964; Almy 1967; Eliot 1970; Rhys 1972; Graves 1975; Robinson and Petchenik 1976; Gerber 1981; Naish 1982; Boardman 1983; Petchenik 1987; Winn 1987; Downs *et al.* 1988). In the late 1960s and early 1970s, a few studies carried out by Piagetian geographers claimed to find that young children do not possess mapping abilities (Miller 1967; Towler and Nelson 1968; Towler 1970; 1971), but these studies were crudely designed and are unpersuasive. A more important group of studies from the Piagetian perspective was carried out by Downs and Liben in the 1980s. They concluded from these studies that most children younger than about seven cannot perform the perspective and scale transformations to a map-like view of the world (Downs and Liben 1988; Liben and Downs 1989; Downs *et al.* 1988; Liben 1991; Liben and Downs 19911, a conclusion consistent with Piaget's postulate that children younger than this age cannot perform spatial operations, and do not possess spatial concepts, both of which are needed for map comprehension. However, Blaut (1997a; 1997b) has criticized some aspects of the methodology used in these studies, and suggests that the data do not support the negative conclusions that have been drawn from them. (See Conning and Byrne 1984; Matthews 1992; Spencer *et al.* 1989; and Spencer and Darvizeh 1981 on tendencies to underestimate pre-school children's macrospatial abilities.) Thus, there is at present little empirical evidence against the view that young children possess significant mapping abilities.

Research by a number of geographers and psychologists has produced strong evidence that young children do, indeed, possess significant mapping abilities. For example, Blaut, Stea and their co-workers investigated the mapping abilities of young children in several studies in the late 1960s and early 1970s, using air photos as map surrogates (Blaut *et al.* 1970; Blaut and Stea 1971; Stea and Blaut 1973). They found that the five- and six-year-olds whom they studied in the United States, Puerto Rico and St Vincent could, in a limited sense, read vertical black-and-white air photos with scales ranging from about 1:1000 to 1:5000, and they found that this ability does not depend on prior experience with an aerial view. Children identified landscape features and landscape complexes (e.g. towns), and in one test they made a tracing over the photo and then, after the photo had been removed, drew a route on the tracing. Muir developed a successful first-grade map-skills curriculum based on air-photo interpretation (Muir and Blaut 1970). Spencer *et al.* (1980) found that children as young as three can identify features on a vertical black-and-white air photo; Walker (1980) and Matthews (1985a; 1985b) obtained comparable results with children aged five and older.

Studies employing other methodologies have also provided strong evidence of significant mapping abilities in pre-schoolers. In a toy-play study with three- to five-year-old children, about half of the threes and most of the fours and fives constructed very simple landscapes in freeplay with toys (Blaut and Stea 1974). Bluestein and Acredolo (1979) asked three- to five-year-old children to use a very simple map to find a hidden toy in a room; half the threes and most of the fours succeeded in the task when it was aligned, map to room, and most of the fives succeeded with an unaligned map. Blades and Spencer (1986) showed, further, that fours can use a (simple) unaligned map after instruction. Rieser *et al.* (1982) showed that two-year-olds can use an aerial (overhead) view to plan a route in a simple maze. Blades and Spencer (1986), DeLoache (1989) and others have shown that three-year-olds can relate a scale model of a room to the room itself in toy-finding tasks. Reviews of this literature are to be found in Spencer *et al.* (1989), Matthews (1992) and Blades and Spencer (1994). Thus, there is substantial evidence that young children have mapping abilities.

The research reported in the present paper sought to extend our knowledge of young children's mapping abilities in several ways. We employed a research design that provided more definitive evidence than had been obtained in previous studies concerning a child's comprehension of an aerial photograph as an iconic map. We obtained this evidence for very young children: children between the ages of 48 and 55 months (4,0–4,11), and we tested children from five cultures, although from roughly comparable social fractions in these cultures. The research may bring us closer to an adequate understanding of the manner in which mapping behaviour develops in humans everywhere.

Conceptual foundations and purposes of the research

A very general hypothesis guided this research. We think it likely that mapping behaviour – the thinking and action involved in reading, making and using map-like models – is a cognitive and cultural universal, an ability that responds to universal ecological needs and is acquired very early in childhood by human beings of all cultures. We allow for both strong and weak versions of this hypothesis. For example, it may be true that clearly identifiable maps (or map-like models) are made and understood in all cultures; or it may be true that people in all cultures have a basic mapping ability, but some do not put it to much use. If the latter is true, we should expect to find at least some recognizable mapping everywhere – most conspicuously in children's representations of the geographic landscape in toy-play – but specialized development of mapping only in some cultures and some ecological contexts. For another example, mapping behaviour may depend heavily on innate precursors, or it may emerge from early learning and experience, with only minor contribution from innate precursors (such as an awareness of verticality and horizontality). For still another example, mapping behaviour may or may not depend, as argued in Piagetian theory, on the prior acquisition of spatial-cognitive operations, but Piagetians would have to accept the evidence that such operations or abilities appear in early childhood (not as late as seven or thereabouts, as they suggest). Such differing viewpoints are consistent with the general hypothesis of universality. On the other hand, the old but still widely accepted belief that people in some non-Western cultures cannot deal with complex and abstract ideas about space (Werner 1961; Sack 1980; Deregowski 1989) is not consistent with the hypothesis.

This general hypothesis presupposes some measure of agreement on the characteristics of typical, ordinary, traditional maps. They depict (model) a portion of the Earth's surface as it would be seen from far overhead, thus a view that has been rotated in perspective about 90 degrees from the horizontal and greatly reduced in scale. Such maps generally model areas too large to be seen as a whole from any one earthbound vantage point. They represent features and areas with signs that may be iconic (pictorial), abstract (in the sense of reduced information) or purely symbolic (having no resemblance to that which they signify). They may be two- or three-dimensional models; most, of course, are two-dimensional, but we also use dioramas, raised-relief maps and the like. More fundamentally, three-dimensional scale models of landscapes, viewed ordinarily from overhead, hence map-like, are very widespread in culture. Indeed, when a child constructs a landscape on the floor or ground with toys or other symbolic objects, that child is making a map-like model. In this paper, we will use 'map' to mean any such map-like model, while noting that very different and more complex and sophisticated models, from ancient world maps to modern location diagrams, are produced by cartographers.

A vertical aerial photograph is a highly iconic map-like model. It is a rotated, scale-reduced representation of the landscape, hence it has the basic syntactic properties of a map. It does not employ arbitrary or linguistic signs, although it presents a slightly abstracted image in the sense that any photograph is an abstracted (or degraded) image of the scene being photographed. If its scale is large enough for a child to distinguish features with which they are familiar (when seen from the ground-level view), it serves as a useful map-surrogate for testing the ability of pre-school children to perform the map-syntactic transformations of rotation and scaling. If a not-yet-literate child who has never seen the world from this perspective, and has been given no instruction on how to read an air photo, can, indeed, read an air photo – identifying landscape features and areas on it – then the child can successfully engage in the form of map-reading that involves a recognition of the Earth's surface when seen from the map perspective. If, in addition, a child can play navigation games on the air photo, correctly showing a route that one would follow (by car or on foot) between two distant points on the photo, then that child can read the air photo as a whole, as a landscape-gestalt, and can 'use' the map in make-believe way-finding. This reasoning led us to employ air photos as instruments for probing the mapping behaviour of very young children.

The purpose of the study reported here was to discover whether a four-year-old child can read an air photo and perform a simulated navigation task on it, hence engage in mapping behaviour at an elementary level. Prior research, cited above, has given some evidence that pre-school children can do these things, but the experimental designs used to test the ability have been somewhat imprecise, and very little research has been done with children younger than five years of age.

In the framework of our universality hypothesis, we sought to discover whether mapping ability is widely cross-cultural; that is, whether it occurs in four-year-olds from a number of very different cultures. The decision to work with children in York, Durban, Tehran, Mexico City and Evanston mainly reflected the fact that we live and work in these areas. The five cases do not give us cross-cultural universality. However, the children studied in all five cities come from communities that can be described (on local criteria) as middle class to upper lower class, in which there is a high level of adult literacy: hence there is some similarity among the communities in social terms. The fact that these cultures exhibit great diversity, combined with the fact that we studied children from roughly the same social fraction in each culture, suggests that some degree of cross-cultural generalization is warranted.' Future research will take place in other cultures and social fractions, but evidence of universality will still remain limited and partial for various reasons, not least of which is the fact that truly culture-neutral research designs have not been devised for cross-cultural psychological research with children (see Cole 1996). This limitation is of very great relevance for the present research, so much so that we must caution readers not to infer cultural differences from the (rather small) quantitative differences in performance by the five groups of children. Our specific goal was to find out whether mapping can be carried out by the four-year-old children studied in each of the five cultures.

Methods[2]

Subjects

A total of 144 four-year-old children were studied individually in nursery schools in York, Durban, Tehran and Mexico City, and in a university psychology laboratory in Evanston. Approximately even numbers of males and females were tested. Information on the socio-economic background of children was not sought, but it was clear that the York and Evanston children came from middle-class communities, the Durban and Tehran children came from lower middle-class communities and the Mexico City children came from a community that was slightly poorer, though not a slum. In Durban, nineteen children were of Indian descent and one was of Zulu descent. Testing was done in English in York, Durban and Evanston, in Farsi in Tehran, and in Spanish in Mexico City, by native speakers of each language.

Materials

Children were tested with vertical aerial photographs. Different photographs were used in the different areas. We had rejected the idea of testing all children with a single photograph, since the characteristics of the depicted landscape would be more familiar to children of some cultures than to those of others. Initially, our intention was to test with photographs of the areas surrounding the nursery schools, at a common scale, but these were unavailable in some areas and unobtainable with our limited resources in others; in the end we used a variety of images. In one sense, this is a limitation on the cross-cultural generality of the study, but the use of images of an unfamiliar landscape should have the effect' of reducing, not enhancing, the children's performance. York children and Tehran children were tested with a black-and-white photo of a portion of Sheffield, England, at a scale of approximately 1:1300.[3] Durban children were tested with a black-and-white photo of the portion of the city of Durban in which their nursery school is located, at a scale of approximately 1:4000. Mexico City children were tested with a 1:1100 colour air photo of another (very dissimilar) part of Sheffield. Evanston children were tested with a 1:720 black-and-white photo of their neighbourhood. In the portion of the test that involved make-believe navigation on the photo, children in York, Durban and Tehran used a felt-tipped marker, drawing on a transparent overlay placed rigidly on the photo and retained as a record of the child's performance. Mexico City children also drew on a transparent overlay; most drew their routes on it with a felt-tipped marker, but a few children, who had not yet acquired competence with writing instruments, navigated by moving a tiny toy car across the photo, the experimenter carefully marking the routes used by these children. In the Evanston study, children navigated with a tiny toy car or a tiny toy bird. Testing was recorded with camcorder and tape recorder.

Procedures

The children were tested individually. A single basic methodology was used in the York, Durban, Tehran and Mexico City studies. The Evanston study was the last to be carried out, and the methodology was varied slightly in the light of our experience in the other localities. The procedure that was used in York, Durban, Tehran and Mexico City can be described as follows.

The experimenters had visited the schools previously and were well-known to the children. Before testing began, experimenters gave the children a brief practice session with the writing implement to confirm their competence in its use. The same instructions (as phrased in the different languages) were used for all children. The experimenter first showed the air photo to the child, and asked, 'What is this called?'. If the child replied either 'a photograph' or 'a picture', or used other language conveying comprehension, the experimenter then asked, 'What is this a photograph (picture) of?', followed by, 'Where do you think the person was who made this photograph (picture)?'. Next, the experimenter asked, 'What can you see in the picture?'. If the child named a feature and pointed to it, the experimenter asked, 'What else can you see?'. This continued until the child no longer spontaneously mentioned and pointed to new features on the photo. At this point, the experimenter began to point to features on the photo and asked, 'Can you tell me what this is?' (or words to that effect). Next, the experimenter said, 'Let's play a game. Let's pretend that this is where you live'. The experimenter pointed to a predetermined starting point (a house) and then asked, 'What's the name of your best friend?'. The child replied with a name. The experimenter then pointed to a predetermined finishing point (another house) and said, 'Let's pretend that this is where [the person named] lives'. The same two houses were used for all children in a given community; the houses were on opposite sides of the photo, and would not have been intervisible on the ground. The experimenter next evaluated the child's understanding of the instructions by pointing to the starting point and asking, 'Now, in our game, who did we say lives here?'. If the child replied correctly, the experimenter pointed to the finishing point and asked, 'And who did we say lives here?'. The experimenter then gave the pen or toy to the child and said, 'Suppose you wanted to visit [the person named as best friend], can you show me by drawing with your pen how you would go from where you live?'. After the child had performed the navigation task, correctly or incorrectly, the experimenter asked, 'Can you tell me what you have just done?'. Very minor variations in wording were allowed.

The verbal responses were scored as correct or incorrect, according to the words used by the child. If the child did not say that the image was a map or a photograph or picture taken from the air, this response was scored as incorrect, unless the child conveyed the same basic meaning with different words. Identification of a feature was scored as correct if the child named the feature with an appropriate word (e.g. house, building) or used a word or words that would be a reasonable alternative (e.g. a house being called 'where people live'). In this paper, we aggregate the free identifications ('What can you see?') and prompted identifications ('Can you tell me what this is?') into a single score. The route navigated by the child was scored as correct if the line drawn by the child followed roads and did not cross over rooftops (except where this clearly represented a slip of the child's hand, as confirmed on the video tape). Given the instructions, many different routes were equally valid, so the child's scoring on the task did not depend on the route chosen, as long as it would be an appropriate one in the real landscape.

In the Evanston study, the navigation test employed a somewhat more elaborate design. Children were randomly assigned to two testing groups. Children in one group navigated with a tiny toy bird; those in the other group, with a tiny toy car. After a child had finished the feature-identification task, the experimenter placed small sticky markers on two houses on the photo.

Table I The children and their performance

Stiidy site	*Number of children*	*Identifications (mean number correct)*	*Navigation (% correct)*
York	20	5·2	70
Durban	20	6·6	60
Tehran	60	2·1	58
Mexico City	20	3·0	80
Evanston	24	4·1	88
Overall	144	4·2	71

Note: children's ages range from 4,0 to <5,0

Children in the 'bird' group were asked to show how the bird would go from one house to the other. Children in the 'car' group were asked how the car would go from one house to the other. For each group, there were four trials, with the destination house placed successively farther from the origin house. A child in the 'bird' group was scored as having performed the task correctly if he or she 'flew' the toy bird in a more or less straight line from one house to the other. A child in the 'car' group was scored as correct if he or she 'drove' the car realistically along streets. The difference in methodology between the Evanston study and the others was rather moderate, and we have combined the data from all five areas in the following discussion of results.

Results

Results are summarized in Table I. In the following paragraphs, we report first the results obtained at each study site, then the summary data for all study sites.[4]

York

Responses to the first naming task ('What is this called?') were mixed: six children used appropriate language, ten used inappropriate language and four gave ambiguous responses. None of the children correctly answered the second naming question ('Where do you think the photo was taken from?'): three (of sixteen scored responses) gave incorrect answers and thirteen gave 'don't know' responses. Nineteen of the twenty children correctly identified at least one feature. The mean number of different features identified was 5.2. Thirteen children made no erroneous identifications; three made one error and four made two or three errors. Only two children made significant syntax errors (i.e., identifications that were not consistent with the map perspective or scale). In the navigation task, fourteen of the twenty children (70 per cent) drew an appropriate route on the photograph.

Durban

Responses to the first naming question were mixed. Seven of the twenty children gave appropriate answers (of whom four said 'map'), ten said 'don't know' and three gave ambiguous answers. Responses to the second naming question were poor: two children answered 'aeroplane' and eighteen answered 'don't know'. On the identification task, seven different landscape features were correctly identified; all children made at least one correct identification; the mean number of correct identifications was 6.6; the mean number of erroneous identifications was 0.8; the mean number of 'don't knows' was 2.1. Twelve of the twenty children (60 per cent) solved the navigation problem, drawing a realistic route on the air photo.

Tehran

Sixty children were tested. Few (15 per cent) gave appropriate answers to the naming questions; the mean number of correct feature identifications was 2·1.[5] Fifty-eight per cent of the children solved the navigation problem.'

Mexico City

Forty-four per cent of the children named the air photo with an appropriate word or phrase. A mean of 3.0 features were correctly identified. Significant syntax errors occurred in 16 per cent of the responses. Sixteen children (80 per cent) solved the navigation problem.

Evanston[7]

Fifty-eight per cent of the children correctly identified the air photo as a map-like image ('map', 'town', etc), 21 per cent responded that they didn't know what it was, and 21 per cent gave incorrect responses.' The directed identification task asked children about eight different landscape features: 51 per cent of the responses were correct, 7 per cent were ambiguous, 21 per cent were incorrect and the remaining 21 per cent were 'don't knows' and non-responses.9 Relatively few significant syntax errors were noted. Twenty-two of 24 children identified at least one landscape feature; the mean number of correct identifications was 4·1. On the navigation task, 88 per cent of the children solved the task; eleven out of twelve children in the 'bird' group were successful, while ten out of twelve children in the 'car' group were successful.

Surnmary results

Verbal responses to the naming questions varied widely among subjects and from site to site, and we do not believe that these questions yielded very useful results. Nearly all children, in all sites, identified at least one landscape feature; the means for correct identifications at the different sites ranged from 2.3 to 6.6; the mean of these site means was 4·2. Very few significant syntax errors were noted. On the navigation problem, the means of correct identification for the different sites ranged from 58 per cent to 88 per cent, and 71 per cent of the children overall (mean of the site means) solved the problem.

Discussion

The crucial finding is that four-year-olds in all five cultures demonstrated an ability to interpret a map-like model, an aerial photograph, in the sense of being able to perceive that a downward-looking, scale-reduced image of a landscape is a representation of a landscape. Hence, these children can perform the essential syntactic transformations in map-reading: projection or perspective rotation and scale reduction. Since four-year-old children would not be able (without instruction) to interpret either conventional map-signs or written notation on a map, the research, by necessity, utilized an iconic map-like model and did not probe for the children's ability to cope with the semantics of maps (a topic that is now being investigated). However, it is clear that the crucial problem in map-reading for pre-schoolers is the interpretation of map perspective and scale. Therefore, we argue that this research demonstrates that four-year-olds in the communities studied can read a map.

Although a common protocol was used in all of the sites (with some variation in Evanston), there were several differences in the methodologies used at the various sites. As noted previously, the air photos were not comparable, although all were vertical images and all had relatively large scales. There were minor differences in test administration procedures and testing conditions. There were, we must assume, Eurocentric biases in the research design. For these reasons, comparative analysis of the performance of children in the five cultures is not warranted. (Indeed, in all cross-cultural behavioural research on pre-school children's cognitive abilities, the real methodological limitations are so serious that quantitative comparisons are generally unreliable.) We can, however, note the following: first, most of the methodological limitations would tend toward errors in the direction of underestimating the cognitive capacities of the non-Western children. Yet the non-Western children whom we studied (in Mexico, Iran and South Africa) performed very well indeed. Results from these sites clearly indicate that map-reading ability is present in these children. Second, one specific reason why these data do not warrant comparison of cognitive abilities across the five cultures is that methodological factors alone provide compelling explanations for the difference in scores. For instance, the Tehran and Mexico City feature-identification scores were undoubtedly influenced by the fact that the aerial photo displayed an unfamiliar area. By the same token, the Evanston scores must have been affected by the fact that the air photo displayed a familiar landscape at a very large scale.

These results give some support to the generalization that map-reading abilities are present, in the absence of training, in four-year-old children of all cultures. However, the results give strong support only for a more limited hypothesis: map-reading abilities are present cross-culturally in four-year-olds in urban communities with relatively high adult-literacy rates.

The findings suggest that mapping abilities, and macrospatial learning as a whole, develop much more rapidly than is predicted in classical Piagetian theory, and that if, indeed, there is a discrete developmental stage in which Piaget's concrete spatial operations emerge, they must emerge in children at or before the age of four. The findings also contradict the thesis that cognitive development in non-Western children is slower than that in Western children (Dasen 1973), and provide new evidence against the traditional eurocentric belief that the spatial-cognitive abilities of non-Western peoples are somehow inferior to those of Westerners.

Table II Identification and navigation results, Tehran

Age	*3,0–3,5*	*3,6–3,11*	*4,0–4,5*	*4,6–4,11*	*5,0–5,6*
Identifications (mean number correct)	0.6	2·0	2·2	2·0	3·5
Navigation task (% solving)	23	30	50	67	63

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Notes

1 'Culture' is used here in the traditional aggregate sense of referring to a community possessing a broadly common set of psychological, social and material characteristics.

2 The methods and results from some sites are reported in more detail in the following papers: the York study in Sowden *et al.* (1996) and the Mexico City study in Stea *et al.* (1997).

3 This air photo is reproduced in Sowden *et al.* (1996).

4 The study sites are discussed in a sequence corresponding roughly to the dates that the studies were completed.

5 Incorrect answers were not categorized in this study. The number of children who did not identify any features was not recorded. The identification score strongly reflects the fact that landscape features on the Sheffield air photo are very unfamiliar to Tehran pre-schoolers (see the reproduction of this air photo in Sowden *et al.* 1996).

6 The Tehran study, which was carried out independently by Dr Zhra Darvizeh, using only local resources, also tested 60 three-year-olds and 30 five-year-olds. The results for all ages on identification and navigation are shown in Table II.

7 A detailed report on the Evanston study is being prepared by Dr David Uttal, who designed and directed it.

8 The second naming question ('Where do you think this picture was taken from?') was not asked in the Evanston study.

9 The free identification task was not used in the Evanston study. Most incorrect responses related to four somewhat confusing features, and responses for the other four features (street, car, parking lot, house) averaged 72 per cent correct.

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