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ABSTRACT

A geographer and a developmental psychologist collaborated on an investigation of the development of children's ability to comprehend, produce, and use graphic representations of space. Such representations are called "geo-graphics" in this paper. The researchers held that children's mastery of maps is dependent on their developing understanding of symbols in general, of logical reasoning, and of integrated spatial conceptual systems. Evidence for children's misunderstanding of both the duality and arbitrariness of symbols was derived from responses showing children's failure to separate graphic characteristics of the symbol from physical characteristics of the referent. This could be seen first in children's overextension of iconic qualities, and second, in their oversubscription to graphic conventions. Many situations were observed in which the child identified some characteristic of the symbol, and then inappropriately inferred from that characteristic that the referent must be characterized in the same way. Evidence indicated that children appeared to adhere rigidly to certain graphic rules that may come from other graphic forms than maps. There were many indications of children's confusion in understanding the scale and viewing angle of maps. There was informal evidence that adults, too, may overextend qualities of the representation to the referent. (RH)

Developing Map Concepts in Children and Psychologists: Going Beyond Maps as RE-presentations[1]

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The work that I am going to describe as a part of today's symposium on "The Emergence of Symbolic Thought" is part of a collaborative project with Roger Downs concerned with children's growing ability to comprehend, produce, and use graphic representations of place, or what we have called **geo-graphics**. The most common form of geo-graphic is, of course, the two-dimensional map. While such maps have been a major focus of our work, we have also investigated children's developing mastery of other kinds of place representations, including other graphic forms (such as photographs and line drawings) and three-dimensional representations (such as scale models and plastic relief maps).

AN INTERDISCIPLINARY APPROACH

At the most general level, our conceptualization is depicted in Figure 1. It should be noted that this figure is drawn with particular reference to the geographic domain, but the general model can be readily applied to domains discussed by other presenters in this symposium as well.

See Figure 1

From our interdisciplinary perspectives of geography (RMD) and developmental psychology (LSL), we have been especially concerned with emphasizing the importance of simultaneous consideration of <u>both</u> sets of links depicted in the figure. One set of links connects the KNOWER and the REPRESENTATION. In particular, we have been interested in studying ways in which general progressions in children's logical and spatial concepts underlie progress in their understanding of geo-graphics. The importance of these links is usually not problematic (or surprising) for audiences of developmental psychologists, but it is often ignored or misunderstood by audiences of geographers.

The second set of links connect the referent--here some portion of the "GEO" or "WORLD"--and the representation. Not surprisingly, the inverse regarding audiences holds: geographers are typically deeply knowledgeable about

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these relationships, whereas developmental psychologists often have a "naive cartographic view" of maps (see Downs, 1981). Like many other non-geographers, they seem to hold a belief that maps are simply miniaturizations of the "real" world, that is, that maps are simply RE-presentations of it, albeit in smaller form. Our position (although not a unique one, e.g., see Treib, 1980) is that geo-graphics are not simply replicas of the world, but are instead symbolic, creative statements about it. Maps permit one person--the cartographer--to project his or her view or vision about the world to others.

CARTOGRAPHIC VISIONS

Given that the SRCD audience has few geographers and many psychologists, I will elaborate briefly on the non-replica interpretation of maps. One means of arguing for the inadequacy of a RE-presentation view of maps is by noting that a map can depict any given portion of the world from different viewing distances, angles, and azimuths, as illustrated in Figure 2.

See Figure 2

The particular combinations of distance, angle, and azimuth features (i.e., geometric correspondences), as well as of content, level of generalization, and symbol systems (i.e., representational correspondences) will depend upon the purpose for which the cartographer is preparing the map. A small-scale map of the earth, for example, would be of little use for selecting available routes between one's hometown and Seattle but might be highly valuable for identifying possible shipping routes (although of course at a general level, i.e., not for actual ship navigation).

A second means of suggesting the inadequacy of a RE-presentation view of maps is to examine place representations that are less hackneyed than those we are accustomed to seeing. An example is shown in Figure 3. This map is modified from one by Richard Edes Harrison that appeared in The Fortune Atlas of the World published during World War II (1944).

See Figure 3

Importantly, there is nothing "less correct" about a map of Europe in this projection and orientation than the one we usually see. Equally importantly, this particular map conveys a different vision of the corridor-like relationship between the Soviet Union and Western Europe than that conveyed by the more commonly encountered map. Maps can, indeed, provide creative visions of the world, new ways of understanding person-environment relationships.

EMPIRICAL ILLUSTRATIONS

Having provided a mini lesson in cartography, I shall turn to providing some brief illustrations of children's developing understanding of geo-graphics from our empirical research. The general thrust of our work as been to study children's developing understanding of geo-graphics in relation to their conceptual development. Our view is that children's mastery of maps is dependent upon their developing understanding of symbols more generally, of logical reasoning, and of integrated spatial conceptual systems.

The data I will use to illustrate these points come from three major sources. First are data from an interview study of 30 preschool children who were shown a variety of different kinds of place representations (e.g., aerial photographs, state road maps, city tourist maps, see Downs & Liben 1987) and asked questions about their content, functions, and origins.

Second are data from classroom activities in which we combined educational instruction with data collection. Over the course of more than a half-dozen years, we have worked with students as young as kindergartners, and as old (and expert!) as geography graduate students. Intertwined with geography lessons were a variety of exercises such as asking students to draw maps (e.g., sketch maps of their classroom and school); to examine locations that had been indicated on one representation, and show the isomorphic locations on another representation (e.g., by placing stickers on a contour map to show the locations of flags planted on a scale model); to indicate viewing azimuths (e.g., by placing arrows on a map of the school neighborhood to show the direction from which photographs of the school had been taken); and similar tasks (Liben & Downs, 1986, 1989a). Third are data from more traditional laboratory tasks in which children were asked to show locations of objects placed in a room under various mapping conditions (e.g., Liben & Yekel, 1990).

Illustrative Symbolic Immaturities

The various kinds of data collected in these different settings are consistent with the general conclusion that most children in the preschool and early elementary school grades have difficulty in fully appreciating symbols' duality and arbitrariness. By middle childhood, however, there is generally good understanding of these basic properties of symbols. (There also appears to be a developmentally growing appreciation for the power or utility of place representations, although this point is not considered further here; see Liben & Downs, 1989b.)

Evidence for misunderstanding both the duality and arbitrariness of symbols is derived from responses showing children's failure to separate graphic characteristics of the symbol from physical characteristics of the referent. This can be seen first, in the child's **over-extension of iconic qualities** (either from the symbol to the referent or from the referent to the symbol); and second, in children's **over-subscription to graphic conventions.**

With respect to **iconicity**, we observed many situations in which the child identified some characteristic of the symbol, and then inappropriately inferred from it that the referent must be characterized in the same way. Iconic extension occurred on the basis of both color and shape of the symbol. For example, a number of preschool children thought that a road shown in red on the map meant that if you went to that road, it would actually be red. Other preschoolers apparently found the color iconicity so powerful that they inferred a referent of the same color, even though that referent was absurdly unlikely in the context of a road map. Illustrative were two preschoolers who thought that the yellow areas on the map (standing for built-up areas such as Harrisburg) showed "Eggs" and "Firecrackers." Likewise, children overextended symbols' shapes, as in thinking that the Rand McNally compass rose showed the "Sun," "A basketball stadium," or "The place where the lifeguard sits."

Expectations of iconic matches between referent and symbol likewise also occurred in the reverse direction, such that the child assumed that some characteristic of the referent should be evident in the symbol. Thus, for example, some preschoolers rejected the possibility that a red line could show a road "Because roads are grey."

With respect to **conventions** we have seen evidence that children appear to adhere rigidly to certain graphic rules, rules that may come from other graphic forms (especially "drawings") in addition to maps per se. An example of interpretations that can be understood in this way were preschoolers' responses to our request to find "grass" on a vertical aerial photograph of Chicago. Although many asserted that they could not find grass ("It would be green"), some did point to areas at the bottom of the photograph. One preschooler's response was especially revealing in that her identification of sky and ground reversed after she (spontaneously) rotated the photograph 180°.

We have seen parallel overextension of conventions with respect to orientation in first- and second-grade children who commonly believe that North must be at the top of the map. Likewise, we have observed many children producing canonical representations of generic places even when asked for representations of a particular place from a specified viewpoint. For example, when asked to show what their school building would look like to a bird flying overhead, looking straight down, many children produced generic frontal elevations of several story buildings (see Figure 4a) rather than a roughly correct u-shaped plan view of their two-story school (as in Figure 4b). Similarly, when asked to produce a map of the section of Chicago based on an aerial photograph, some children produced generic representations of "city" with cars, roads, and houses (e.g., Figure 4c) rather than an orthogonal map (e.g., Figure 4d).

See Figure 4

Illustrative Spatial Immaturities

In addition to observing children's difficulty in understanding the general nature of symbols, we have observed young children's difficulties in understanding the spatial structure of place representations. Consistent with Piaget and Inhelder's (1956) position that children only gradually master metric and projective spatial concepts, we have seen many indications of children's confusions in understanding the **scale** and **viewing angle** of the map.

Scale confusions were evident on a variety of place representations. Preschoolers denied that a line on the Pennsylvania road map could be a road with reasons such as "It's not fat enough for two cars to go on." Another denied that a rectangular shape on an aerial photograph of the local community could be his father's office building "Because his building is HUGE...it's as big as this whole map!" Spontaneous misidentifications likewise demonstrate scale confusions, as when boats in Lake Michigan of the Chicago aerial were interpreted as "Fish," "Snowflakes," "Bugs," "Toads," and "Stars."

Demonstrations of young children's difficulties in understanding the **viewing angle** may be found in the sample errors to the Chicago aerial in which buildings lined in parallel were interpreted as "Bookshelves," a parking area bounded by an oblique line was interpreted as a "Hill," tennis courts were thought to be "Doors," and a baseball field was interpreted as an "Eye." In each of these cases, the child's interpretation would be sensible _if_ the component of the place representation in question were a _frontal or elevation_ view, rather than an _overhead or plan_ view. Thus, for example, an overhead view of tennis courts on an aerial photograph and a plan view of a double sink on a classroom map (see Liben & Yekel, 1990) do, indeed, _look_ like elevation views of paneled doors.

ADULTS' MISCONCEPTIONS AND THE ROLE OF EXPERTISE

So far my comments have been focused on errors made by young children. Indeed, in our work we have seen significant progress between lower and upper elementary school grades. For example, fifth-grade children routinely produce the very same kinds of arbitrary symbols (e.g., asterisks for file cabinets) that children only two years younger had rejected as hilariously funny (see Downs, Liben, & Daggs, 1988).

But to note that there is age-linked progress, and to contend that this progress is in part attributable to underlying progression of representational, logical, and spatial concepts more generally is not to assert that older children and adults never make the kinds of errors we have found common among children. On the contrary, from our experiences working with adults (e.g., in workshops with teachers and classes with college students) we have seen informal evidence that adults, too, may over-extend qualities of the representation to the referent. For example, many adults appear to believe that Greenland is larger than Brazil, presumably as a consequence of having been exposed primarily to Mercator projections; or that Alaska is far from the Soviet Union, presumably as a consequence of seeing world political maps that divide the world at the Bering Strait.

Similarly, we have encountered many strong opinions even among adults about the <u>necessity</u> of following certain conventions. Many teachers, for example, insist that North <u>should</u> be at the top of <u>all</u> maps (see also Rhodes, 1970, a book for children about maps that asserts that "North is always at the top of the map," p. 46); that water <u>must</u> be shown in blue; and the like (see Liben & Downs, 1989b). These examples and others suggest that it is not only cognitive immaturity, but also restricted experience with different forms and functions of maps that constrain individuals' understanding of place representations.

CONCLUSIONS

Taken together, the findings across a variety of tasks are consistent with our general position that the ability to understand, produce, and use geo-graphics emerges gradually. Place representations are not simply **RE**-presentations of pieces of the world (Downs, 1981). As a consequence, they cannot be "read" perceptually in precisely the same ways that the real, encountered environment can be "seen" visually. Instead they must be understood as symbolic representations and interpreted within a symbolic context.

Second, we would argue that our data are consistent with the notion that the kinds of errors made by young children are those that might be expected on the basis of more general limitations of their cognitive systems. Elsewhere we have provided some empirical data linking children's performance on mapping tasks to their performance on tasks designed to assess their spatial concepts (Liben & Downs, 1986) and their logical skills (Downs et al., 1988).

Third, however, we believe that structural limitations are only a <u>part</u> of the explanation for children's difficulties. Another large part of the explanation lies in the fact that most individuals encounter only a very limited sub-set of geo-graphic forms and functions. In conceptualizing developmental progression, then, we argue for the simultaneous contributions of both ontogenetic development and domain-specific expertise, as modeled in Figure 5. Those of us concerned not only with the theoretical implications of this work, but also with the educational applications at both elementary and advanced levels must attend to both factors (Downs et al., 1988; Downs & Liben, in press).

See Figure 5

Finally, we would suggest that our work--like that of others in today's symposium--may fit within the following (tentative) model of levels of mastery of representation.

At first, the child's approach to representations may be characterized by **SYNCRETISM.** At this level, insofar as the child interprets the representation at all, he or she reacts to it as if it were the referent itself. This reaction is probably evident in pure form only among infants, as when infants try to pick patterns off a crib sheet. There is a complete lack of differentiation between the symbol-as-object from the symbol-as-symbol. (Again, it should be noted that even more sophisticated knowers may momentarily respond in this way. For example, in coding video tapes, I have occasionally found myself moving my head to the side to "see" a different angle of the scene. Initial, transient reactions to trompe d'oeil may likewise be classified in this way.)

In **SYNCRETIC REPRESENTATION**, the individual correctly understands that the symbol "stands for" the referent, but incorrectly fuses aspects of the symbol and referent. Included are fusions in both directions. Individuals may infer that what are in actuality only arbitrary qualities of the representation are in fact qualities motivated by the referent, and thus that these qualities of the symbol depict qualities of the referent (as in inferring that a red line used to stand for a road must mean that the road, too, is red). Similarly, individuals may infer that known qualities of the referent should be evident in the representation (as in insisting that grass must be shown in green; or as in thinking that a photograph of an ice cream cone will be cold, see Beilin, in press).

In **NAIVE CONVENTIONAL REPRESENTATION** there is an understanding that relationships between symbol and referent are arbitrary ones. At the same time, however, there is only a naive (or novice) understanding of those relationships such that certain aspects of the representational system are thought to be necessary, or at least preferred (e.g., North at the top). For the most part, such naive beliefs are probably implicit, and readily given up upon reflection and/or instruction.

Finally, with adequate reflection or instruction, individuals can reach the final level of **META-REPRESENTATION**, in which one understands the varieties of representations; the relative utility and power afforded by different representation systems; the circumstances under which one might use one rather than another; and so on. In short, with meta-representation we are in a position to appreciate the contributions of the various presentations in this symposium, and thus a level that I hope all have achieved here today.

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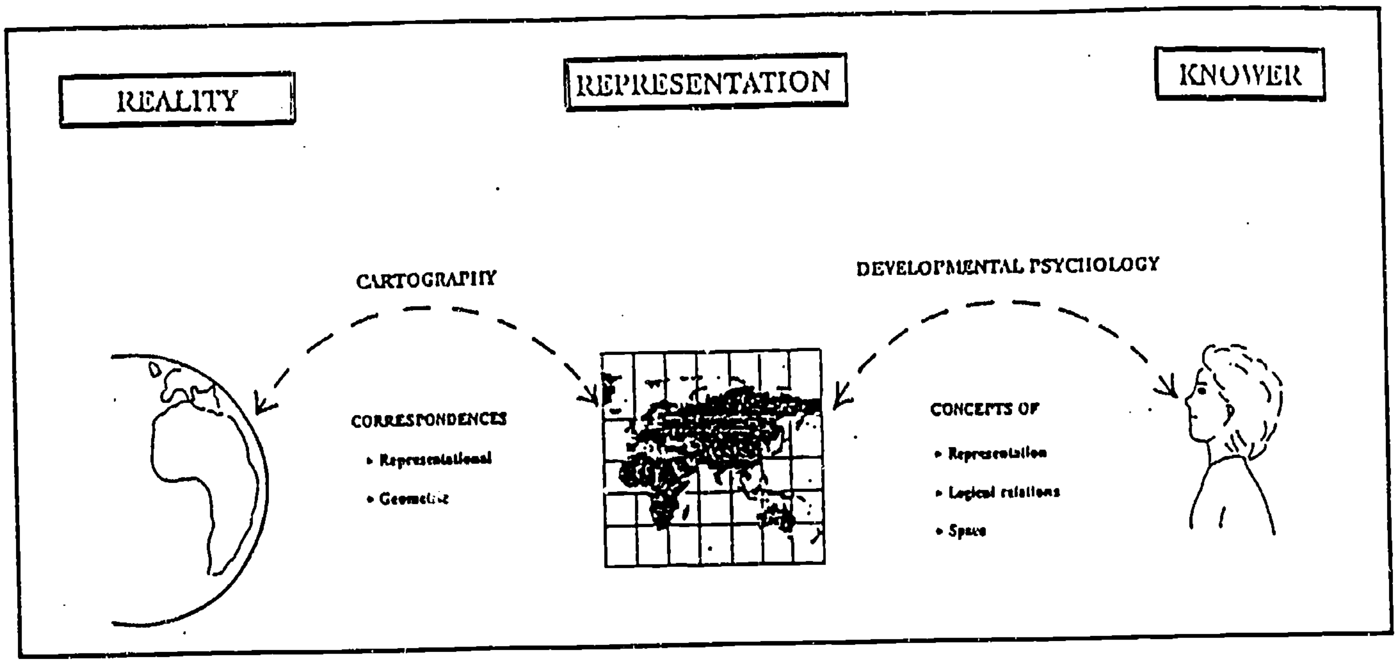

Figure 1. Geo-graphics: An interdisciplinary perspective.

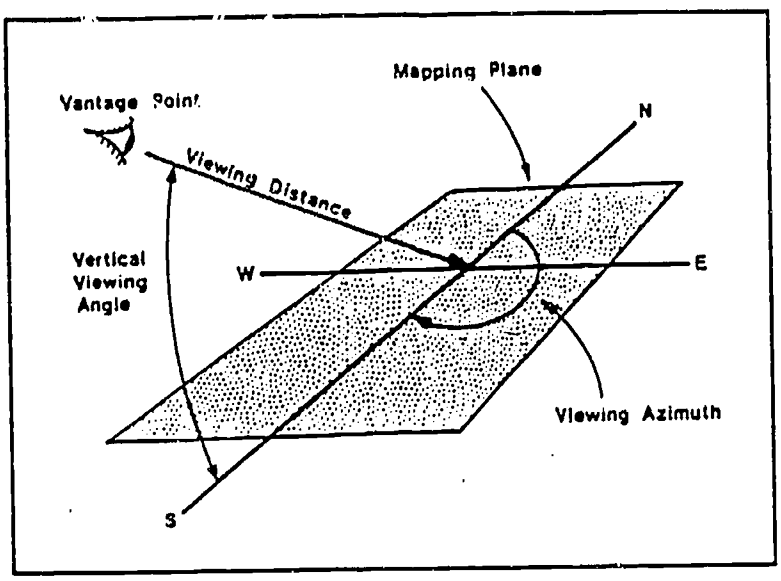

Figure 2. The elements of the vantage point: viewing angle, viewing azimuth, and viewing distance (from Downs, 1981).

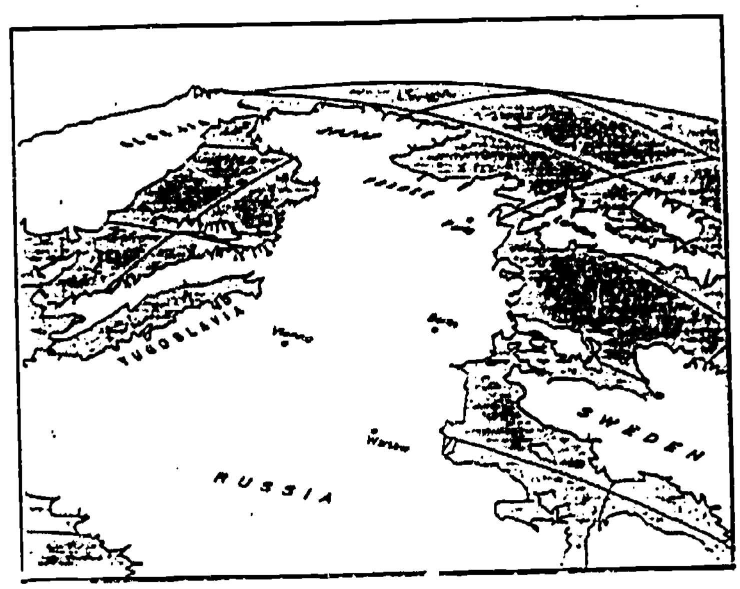

Figure 3. Europe from the East (from Downs & Liben, in press).

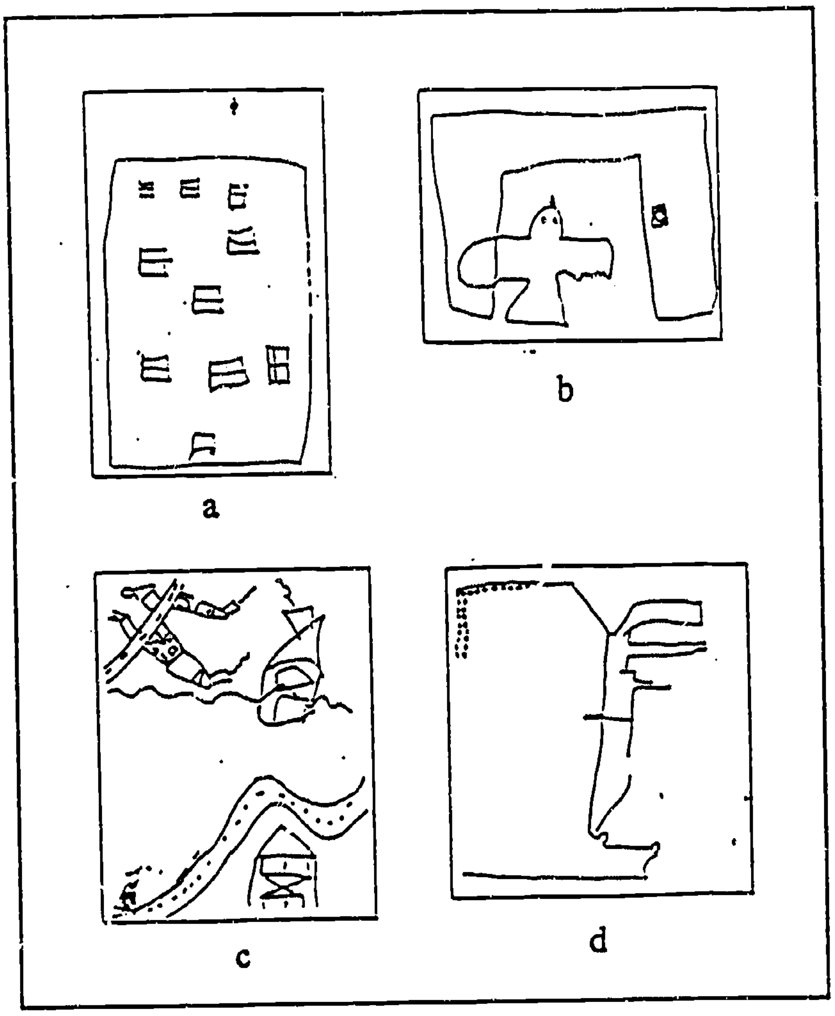

Figure 4. Sample drawings of bird's-eye view of school (a, b; both Grade 1) and of Chicago (c, d; both Grade 2).

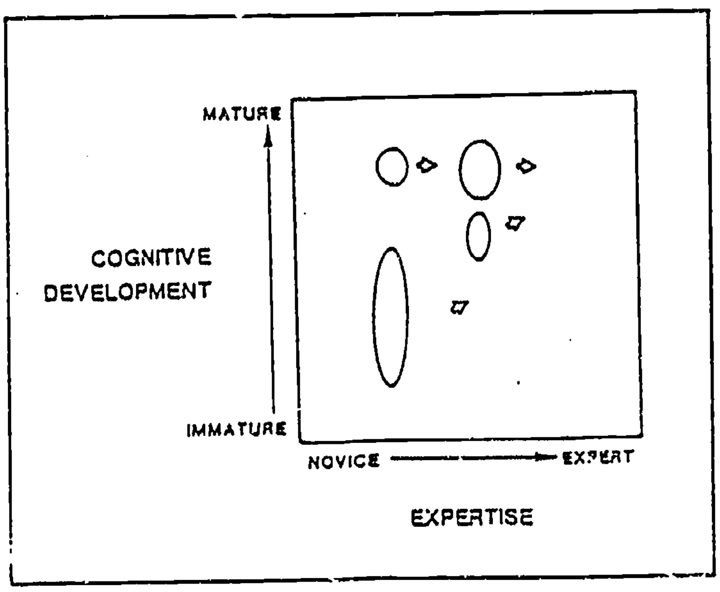

Figure 5. The simultaneous contributions of cognitive development and expertise in map understanding.