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How Significant Are Cultural Differences in Spatial Cognition?

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Abstract. In this essay, I critically discuss ideas about cultural differences in spatial cognition. A critique of the traditional empiricist framework for understanding the development of cognitive structures and processes is described. An evolutionary framework is provided as an alternative. The ambiguity between culture-related and culturally caused differences is also elaborated. Reasons for cultural universality in spatial cognition are then considered. With these ideas as background, some aspects of spatial cognition are enumerated that I believe are largely culturally universal. Following that, aspects that may show more significant cultural variability are discussed. In particular, the relationship of spatial language to spatial thought is addressed in some depth. I conclude that cultural differences in spatial cognition are not nearly as substantial as is often claimed. Finally, the extent to which cultural differences in spatial cognition are important for geographic information system (GIS) research and design is considered.

1 Introduction

It is often proposed that people living in different cultural groups are brought up to perceive and think about the world in very different ways. According to this view, the structures and processes of the mind develop primarily in response to unique experiential and socialization forces that are quite different in different cultures, particularly in widely separated cultures that have had little contact with each other. These include *spatial* structures and processes, of course. To the extent that this view is true, it has important theoretical and practical design consequences for the internationalizing efforts of the spatial and geographic information community. An extreme view of cultural variability in spatial cognition (probably rarely held) implies that such design efforts must be taken up virtually anew, from scratch, for each cultural group that will use these systems. That is, if the "Western" concepts of spatial information and analysis inherent in such systems can even be comprehended by all cultures.

My purpose in this essay is to explore the idea that there are significant cultural differences in spatial cognition. I intentionally approach the idea with an attitude of skepticism. Discussions of cultural differences in spatial cognition typically lack skepticism, in my experience, leading to exaggerated and unbalanced claims about the magnitude and importance of cultural differences. To bolster the skepticism, I will briefly describe a framework for thinking about cognition and its development that differs from the framework commonly associated historically with most ideas about cultural differences. I will critically review some hypotheses and empirical evidence for and against the idea of significant cultural differences. As a way of structuring the essay, I will list aspects of spatial cognition that I think are actually universal or variable across cultures. My conclusion will be that ideas about cultural differences in spatial cognition are often exaggerated, and perhaps not as deserving of careful scrutiny in the GIS research and design communities as is sometimes suggested (e.g., Egenhofer & Golledge, 1994).

Although empirical evidence is discussed below, I will not simply evaluate the significance of cultural differences in spatial cognition according to the evidence provided by specific research studies. Assumptions underlying various positions will also be evaluated, as will issues of conceptual coherency and consistency with existing theories. Empirical evidence is certainly important but cannot be the sole basis for an answer to the question. This is true for several reasons. The issue is broader than a specific theory or hypothesis. To a large extent, it is really a question about a framework for thinking about thinking. Virtually all modern philosophers of science, who otherwise disagree about many things, recognize that scientific debates about such broad theoretical frameworks do not hinge exclusively on an examination of empirical evidence (Kuhn, Feyerabend, Laudan, etc.). In addition, the structure of induction and the *modus tollens* logic used in hypothesis testing result in a great asymmetry between the empirical evaluation of the hypotheses of cultural universality and difference (*ceteris paribus*, supporting the latter is much easier). And of course, much relevant empirical investigation of cultural differences in cognition has yet to be conducted. It is not my intention here to argue for a cessation to such investigation. I am simply proposing that examination of these issues will benefit by looking at them through the lens of an alternative framework, a different set of assumptions. In this way, we will achieve greater balance in our conceptions of cultural universality/difference.

This is certainly not a "yes-or-no" issue I am addressing. There is no question that both cultural universals *and* differences in spatial cognition exist. At the very least, cultural differences in spatial cognition are evident because cultural differences in spatial language plainly exist. But how substantial or superficial are cognitive differences, including those implied by linguistic differences? What are their consequences for GIS researchers and designers? It also bears emphasizing that I have tried to keep my focus on *spatial cognition.* There are many other cultural issues surrounding GIS, especially of a practical nature, that remain important concerns no matter what one's view of the significance of spatial cognitive differences (e.g., Campari and Frank, 1993; A. U. Frank, personal communication, March 20, 1995). These include issues of data quality and standards, administrative procedures, organizational structures, etc.

2 Evolution and the Standard Social Science Model

The thesis of this essay rests partially on a claim that belief in substantial cultural differences in cognition derives, to a large extent, from belief in a framework for understanding learning and cognitive development that is largely incorrect. This framework is essentially a traditional nurture or empiricist framework for thinking about cognition. Historically, the framework has been developed and expressed in the contributions of such notable thinkers as Locke, Durkheim, Marx, Boas, George

Mead, Margaret Mead, Watson, Skinner, and many others. It has been this century's dominant theoretical framework in most of the social and behavioral sciences, especially within the "Anglo-American" tradition.

Tooby and Cosmides (1992) extensively discuss this framework and its continued influence today. They label it the "Standard Social Science Model" (SSSM). Here is a partial list of the characteristics of the SSSM, according to Tooby and Cosmides:

1. Human groups have a culture, which is a virtually group-universal set of beliefs, behavioral practices, symbol systems, etc. These common elements are maintained and transmitted by the group, which has cross-generational continuity.
2. This transmitted culture is the sole explanation for observed within-group similarities and between-group differences.
3. Cultural transmission is maintained through learning, which can be seen as the group-organized process of socialization, imposed by the group on the child. The individual is thus a more or less passive recipient and product of culture. What is organized and contentful in the individual's mind comes from culture and is socially constructed.
4. Features of a particular culture emerge at the sociocultural level of the group and are not given specific shape or content by human biology, nature, or inherited psychological design. The evolved mechanisms of the human mind are content-independent and content-free.

In sum, the SSSM embodies a set of beliefs about virtually unlimited behavioral plasticity as a function of experience, a nearly unbounded range of possible solutions by different cultures to the problems of survival, the critical and overriding importance of childhood experience, and the irrelevance of human evolutionary history. Several of the papers I cite below serve as evidence that some version of the SSSM, usually in a less extreme form, is echoed in the writings of researchers in spatial cognition.

Some writers have recently recognized that the SSSM constitutes a set of assumptions that has served as a barrier to seeing universal aspects of human cognition. Sheets-Johnstone (1990) refers to this consequence of the SSSM as "steadfast cultural relativism". Notably, the SSSM fails to incorporate the insights of Darwin's theory of evolution. This oversight has left the social and behavioral sciences unconnected from biology and from each other, apparently without need for mutual compatibility (Cosmides et al., 1992). Darwin himself applied the theory of evolution by natural selection to mental and behavioral phenomena, not just to physiology and anatomy. And within the last decade or so, a flurry of work has been produced on evolutionary aspects of human personality, mating behavior, kinship relations, and so on (e.g., Buss, 1989; Kenrick et al., 1985).

Of special interest to us, the role of evolution in human cognition has also been recently explicated. Tooby and Cosmides (1992), for instance, provide a model of the human brain as a collection of *domain-specific modules* that evolved in specialized ways to solve particular behavioral problems of enduring importance to humans over hundreds of thousands of years (see also, Fodor, 1983). There are numerous such domains: obtaining food and shelter, construction and repair of material artifacts, metaphysics and ethics, social alliances, communication, mating, status and dominance hierarchies, etc. This contrasts with the SSSM view of the brain as a general all-purpose problem solver that acquires its content and functioning primarily as a result of highly variable exposure to processes of cultural transmission.

3 Cultural Differences, Cultural Universals

Before proceeding, brief definitions of culture and of spatial cognition are in order. *Culture* refers to a body of knowledge and beliefs that is more or less shared between individuals within a group and transmitted across generations. Essentially, culture specifies preferred or accepted patterns of ideation and behavior dealing with religious and value systems, social systems, and material/technological systems. *Cognition* deals with knowledge: its acquisition, storage, retrieval, manipulation, and use by organisms or machines to achieve behavioral goals. Defined in this broad and theoretically neutral way, cognition includes structures and processes involved in perception, learning, thinking, memory, reasoning and problem-solving, and language. *Spatial* cognition refers to these structures and processes when they deal with spatial knowledge: knowledge of location (including distance and direction), size, shape, and pattern, as well as changes in these properties across time.

Cross-cultural research (or just cultural research) is simply research that incorporates cases from two or more cultural groups. Such research implies the possibility of identifying cultural differences *or* universals; it does not necessarily entail a focus on differences. It is critical to remember that two individuals from different cultural groups may differ for a host of reasons aside from their cultural group membership (just as two individuals from the same group may differ a great deal). Any variables upon which the two individuals differ could potentially explain a difference in their spatial cognition. A comprehensive list of possible explanatory variables would essentially be infinite; in addition to culture, there is genetic constitution, physiology and anatomy, sex, gender, age, education, expertise, socioeconomic status, family membership, residential environment, and so on. Frequently, a statistically identified cultural difference is actually due to some other variable that covaries with culture. We might speak of "culturally caused differences", a term referring to differences caused by culturally transmitted ideology, artifacts, rules and mores. Alternatively, we might be dealing with "culture-related differences", differences that are caused by some variable other than cultural group but covary with it (Gentile [1993] discusses a similar distinction with respect to sex and sex-related differences).

When understood in a causal sense, I would argue that cultural differences are typically among the weakest and least important explanations for individuals differing in spatial cognition. Several variables listed above have more substantial effects. Unfortunately, the identification of caused as opposed to culture-related differences is very problematic and difficult to disentangle (D. M. Mark, personal communication, September 21, 1994). This problem is one of the most profound of several thorny interpretive and methodological difficulties in cross-cultural research, such as communication ambiguities between researcher and subject (Hazen, 1983; Pick & Pick, 1978). Covarying factors are often thought to be responsible for observed cultural differences. For instance, Pick and Pick (1978) discussed the likelihood that observed cultural differences in picture perception are really educational differences within cultures. As another example, a difference in the perception of depth due to different residential environments (if it exists; see below) is not a culturally caused difference if it is contained in the visual system and not in the body of culture.

An excellent example of this point for our purposes involves the "amazing feats" of the South Pacific navigators described in the much cited works of Gladwin (1970) and Lewis (1978). As these authors clearly document, the ability to use the subtle and varied cues of the ocean environment, the extensive star patterns, and so on, depends on extensive training. This is true just as competence at reading topographic maps and using compass and sextant depends on training in our own culture (and either system can be readily learned by members of the other culture). In other words, these differences are expertise differences, not culturally caused differences.

3.1 What Aspects of Spatial Cognition Are Culturally Universal?

There are several reasons to expect considerable cultural universality in human spatial cognition. First is the largely common gene pool distribution of the human species and the resulting near universality in nervous system organization and activity. As described above, there is good reason to believe that the nervous system is specialized to solve domain-specific problems that confronted the human species over hundreds of thousands of years of evolution. The problems of learning spaces, navigating in spaces, etc., are excellent candidates for the kinds of pervasive and fundamental problems that we would expect to find reflected in the modularized structure of the nervous system (Lewis-Williams & Dowson, 1988; Neisser, 1987).

A second reason for universality is one that is often overlooked, perhaps in part because of its immediacy and near constant relevance to cognition. That is the fact that humans everywhere have largely the same body structures and processes, including the same motor and sensory systems. Excepting disabilities, humans practice upright bipedality, are bilaterally symmetrical, have heads at the tops of their bodies, have frontally-aligned eyes with similar light sensitivities, have transversely-aligned ears that respond to similar frequency ranges, sense gravity and body movement via proprioceptive senses, can run at about the same speed, are fairly close in body size, have dexterous hands useful for gestures and precise manipulation, can form spoken words with their vocal tracts, and so on. The importance of the concept of "embodied" thinking is eloquently expressed by Lakoff (1987) in his theory of *experiential realism*. "The core of our conceptual systems is directly grounded in perception, body movement, and experience of a physical and social character" (p. xiv). Cultural universals in bodily experience and the use of concrete imagery lead to the universal importance of "kinesthetic image schemas" in language and thought. Apparently independently, Sheets-Johnstone (1990) has organized observations like these in an interesting discussion of the role of the human body in the phylogenesis and ethnogenesis of cognition. She refers to "corporeal thought", siting the origin of human cognition in our shared animate forms and "tactile-kinesthetic correlates".

A third reason for universality is that the learning and socialization to which children are exposed actually exhibits many common features across cultures. The psychological mechanisms that allow various forms of learning to occur are culturally universal (e.g., operant conditioning). Furthermore, although the specific content of transmitted knowledge varies somewhat across cultures, much of it speaks to the same issues or provides solutions to the set of universal human problems reviewed above.

Finally, we might expect universality in human spatial cognition because of the degree of similarity in residential environments. There are in fact many similarities between human environments everywhere and at all times throughout human evolution. In an illuminating essay, Shepard (1984) discusses these "ecological constraints on internal representation". All humans are born into a spatial world that is 3-dimensional and locally Euclidean, is isotropic except for a gravitationally-defined local upright, consists of a prevailing solid terrestrial surface of support and locomotion that is approximately flat (at a suitable scale), and is generally horizontal and normal to the local upright direction. In addition, there is a cycle of directions on the 2-dimensional surface defined for all cultural groups by the earth's structure and pattern of rotation, namely the four cardinal directions (there have never been permanent residents of the poles). Because of these enduring regularities of the physical world, in conjunction with those of the human body and sensory systems, three spatial reference frames are defined for all humans: a body-centered egocentric frame, an object-centered frame, and an environment-centered frame (some additional distinctions can be made). Gibson (1979) discusses other regularities in the terrestrial environments of humans, such as the availability of objects for sitting upon and visual features for remembering as landmarks.

So there are at least four major reasons for cultural universality in spatial cognition: (1) organizational similarities of nervous systems, (2) common body structures and processes, (3) learning and socialization similarities, and (4) similar residential environments. Detailed considerations of the status of these four could obviously constitute several books. The last idea about residential environments calls for further comment here, however, because it has so often been proposed to explain cultural differences in spatial cognition.

The influence of culturally different residential environments on spatial cognition has most specifically been expressed by two ideas: the *carpentered-world hypothesis* and the *ecological hypothesis* (Deregowski, 1980; Liebowitz & Pick, 1972; Pick & Pick, 1978; Segall et al., 1966). Both have been proposed as potential explanations for cultural differences in susceptibility to visual geometric illusions (such as the Müller-Lyer and Ponzo illusions) and for other possible visual perceptual differences (e.g., distortion of angles toward 90°). The carpentered-world hypothesis states that people living in technologically-developed cultures are exposed to many straight lines and right angles prevalent in their "carpentered" built environments. That exposure will ostensibly predispose these people to see the world in "rectilinear" terms. Conversely, people from technologically-undeveloped or "traditional" cultures will not be prone to see the world in rectilinear terms because of the supposed lack of straight lines and right angles in their built environments and the assumption that the natural environment does not provide such stimuli. The related ecological hypothesis focuses on the availability of open vistas that allow perception of long views into the distance. People living in dense jungles or narrow canyons (urban streets?) will presumably not be exposed to opportunities to train their visual systems to interpret depth appropriately (and size constancy, etc.). The classic anecdote is Turnbull's 1961 observation about a BaMbuti Pygmy who temporarily confused distant buffalo for insects. People living in open savanna, tundra, etc., should have had ample opportunity to learn to see depth and not show the effects of restricted vistas.

The empirical evidence pertaining to these ideas is extensively reviewed by the authors cited above. All agree that the evidence is equivocal. In particular, the extensive results of Segall et al., who studied numerous cultural groups from traditional Africa, clearly show that the various illusions are culturally universal, if variable in strength. It is also clear that the various cultural groups studied differ greatly in their exposures to pictorial stimuli. All of the work on cultural differences in visual perception has involved such pictorial stimulus materials. It is well known that even people from technologically-developed cultures have to develop the ability to see a 3-dimensional world in flat pictures (Hagen, 1980). Thus, differences in experience with pictures is the most likely explanation for the modest cultural differences in visual perception that have been found. Hypotheses about residential environments do not enjoy much support (Liebowitz & Pick, 1972).

The carpentered-world hypothesis includes an assumption that natural environments do not provide a stimulus basis for learning rectilinear perception. The implication is that natural, as opposed to built, environments don't contain straight lines and right angles (see also, Couclelis, 1992). How valid is this claim? Does the natural environment contain rectangular stimuli? In response to a comment by her literature professor that "straight lines on the landscape are put there by man", Gail Jensen Sanford composed the following list of straight lines that do exist in nature (reprinted in the February 1995 issue of Harper's Magazine):

> lines along the top of a breaking wave; distant edge of a prairie; paths of hard rain and hail; snow-covered fields; patterns in crystals; lines of white quartz in a granite surface; icicles, stalactites, stalagmites; surface of a calm lake; markings on zebras and tigers; bill of a duck; legs of a sandpiper; angle of migrating birds; dive of a raptor; new frond of a fern; spikes of a cactus; trunks of young, fast-growing trees; pine needles; silk strands woven by spiders; cracks in the surface of ice; strata of metamorphic rock; sides of a volcano; wisp of windblown altocumulus clouds; inside edge of a half-moon

Although one can argue with some of these, it is difficult to avoid the conclusion that straight lines are actually easy to find in natural or noncarpentered environments. Furthermore, the projective geometry of perception provides especially important information of this type. Directions to seen or heard objects are perceived as straight. More explicitly, straight lines are revealed in visual perception when two features are brought into alignment in the visual field. This information occurs in all environments and is available to all residents without sensory impairment. Similar things could be said about right angles, given the universal availability of orthogonal cues from gravity, human body structure (e.g., eyes orthogonal to ears), and postural uprightness with respect the ground.

Given these reasons for spatial cognitive universality as a background, there are several specific ways in which I believe spatial cognition is quite similar across different cultures:

1. Existence and functionality of cognitive maps, as evidenced by the ability to remember features, routes, distances, directions, and make spatial inferences (detours, shortcuts).
2. Salience of the gravitational upright and the perception of a 3-dimensional world with horizon (ground-atmosphere boundary).
3. Differential treatment of spatial information in memory, reasoning, language, as a function of scale.
4. Categorical and hierarchical organization of regions.
5. The prominent role of recognized and labeled visual features in memory organization and problem-solving.
6. The existence and use of multiple frames of reference, varying with respect to the difficulties they engender for reasoning and communication.
7. Orthogonal-oblique differences in the accuracy and precision of angular knowledge.
8. Relative difficulty of apprehending 3-dimensional spatial relations in environmental spaces, as compared to 2-dimensional (e.g., learning 3-dimensional cave structures).
9. The use of spatial metaphors for nonspatial concepts.

Empirical evidence or conceptual arguments for some of these as universals is presented in: Appelle, 1972; Lakoff, 1987; Lynch, 1960; Montello, 1993; Shepard, 1984; Shepard & Hurwitz, 1984; Wallace, 1989. Although there is empirical evidence for the universality of parts of the list, little or none yet exists for other parts. Clearly, more cross-cultural research in spatial cognition would be valuable. The list could provide a guide for such research.

3.2 What Aspects of Spatial Cognition Are Culturally Different?

In this section, I discuss aspects of spatial cognition where I think cultural differences may be more substantial. However, even in these cases, there are important limits on the significance of the differences that should be considered. Because I elaborate on these limits, this list is discussed in more detail than was the previous list of universals. This is especially true in the case of spatial language; no other aspect of spatial cognition has been researched cross-culturally to the degree that language has been.

Spatial Language. A comprehensive discussion of cultural differences in cognition must consider the relationship of language and thought. Presumably, language is one of the most important vehicles of the socialization processes described in the SSSM. Different cultures obviously speak different languages. Furthermore, the history of the behavioral and social sciences contains many claims that thought is "internal language", or at least that thought fundamentally depends on language. J. B. Watson, for instance, proposed that thought was "covert vocalization". More specific to our present concern with spatial cognition, Littlejohn (1963) claimed about the Temne of Africa that "since they have no word for space in general, it is unlikely that they have a concept of it".

The most influential statement about the influence of language on thought is the so-called *Whorfian Hypothesis* (French, cited by Segall et al. [1966], called it the "Humboldt-Boas-Cassirer-Sapir-Whorf-Lee Hypothesis"). This is the claim that a cultural group's language determines the way its members perceive and think about the world. Weaker forms of *linguistic relativity* suggest only that linguistic differences cause some differences in thought. Linguistic relativity has a rocky intellectual history. Segall et al. (1966) stated that in "100 years of study there has been disagreement as to whether genuine differences in perception [as a function of language] were ever demonstrated" (p. 38). Many writers consider particularly damaging the research by Heider (1972 -- now Rosch) showing that cultures with very few color terms nonetheless perceive the structure of unnamed color categories much as cultures like our's do that have more color terms. Recently, Pinker (1994) unequivocally criticized the Whorfian hypothesis. In his words, "there is no scientific evidence that languages dramatically shape their speaker's ways of thinking" (p. 58). Pinker offers an alternative interpretation of the well-known Kay and Kempton (1984) study with color chips, a study that has more recently been offered as support for a limited Whorfian view.

It is now generally recognized that a strong Whorfian view is untenable. However, Pinker's vigorous claims notwithstanding, it must also be recognized that legitimate questions dealing with the influence of language on thought persist. The validity of some form of linguistic relativism is an ongoing research issue (Mark, 1993; Pederson, in press). In particular, Lakoff (1987) offered an exceptionally detailed, erudite, and subtle discussion in support of some form of Whorfianism.

Turning to the specific topic of this essay, there is no question that spatial information is expressed differently in some languages than in others. Questions about the implications of linguistic differences for aspects of spatial cognition have long been part of the debate over linguistic relativism (see Lakoff, 1987). Recent work continues to attempt to answer these questions (Haviland & Levinson, 1994; Weissenborn & Klein, 1982). How substantial and fundamental are implications of spatial linguistic differences for general cognitive differences?

Although a resolution of the issue is beyond the scope of this essay, there is one phenomenon that I want to consider further. That is research on linguistic differences in the spatial frames-of-reference used in locative expressions. It is well documented (Brown & Levinson, 1993; Haviland & Levinson, 1994; Pederson, 1993) that some cultural groups almost exclusively use absolute frames such as cardinal directions to express location, even at small scales of "figural" or "manipulable" space. This is in stark contrast to cultures like our own that almost exclusively use an egocentric frame (left, right) to express location in small-scale space.

The implications of this provocative difference for the linguistic relativism debate is a little uncertain because both groups can and do shift between both systems (Pederson, 1993). However, I believe it suggests an important point about cultural differences in spatial cognition: Cultural groups are likely to vary in their spatial cognitive processes or structures when no clear "best" solution exists for a problem involving spatial information. As Pederson (1993) discusses, "Each system has its advantages and disadvantages in various communicative contexts" (p. 296). We are all familiar with the ambiguity of using an egocentric frame in communication -- whose left do you mean? And, as Pederson notes, knowing the orientation of the cardinal directions at all times is no trivial or automatic task. In other words, the problem of locative expression in face-to-face communication has no clearly superior best solution. Either you deal with the problem of establishing the deictic frame in communication or with the problem of establishing the orientation of the cardinal directions at a given spot. As a general principle, therefore, we might expect more cultural (and individual) variability with more ambiguous problems. So another way to state the theme of this essay might be: Cultural variation in spatial cognition is relatively minor insofar as most spatial problems do not have a variety of nearly equally effective and efficient solutions.

Pictorial Perception. Clearly people from some traditional cultures have minimal or restricted prior experience with the conventions of pictorial representation (drawings, photos, TV images, etc.), though it is unlikely that any human group does not practice some iconic pictorial representation. As I reviewed above, probably the strongest finding in the cross-cultural literature on perception is that people from some traditional cultures have difficulty interpreting the depiction of 3-dimensional scenery in 2-dimensional media. For people in all cultures, facility at this depends on training and/or practice. The ease with which this skill can be acquired is still contested, as in the case of learning to interpret cartographic "pictures" (Blaut, 1991; Liben & Downs, 1989).

Home Ranges and Activity Spaces. Different cultures practice different forms of economic activity -- they sustain themselves in different ways. This entails, among other things, different temporal and spatial patterns of activity. And within these average cultural group differences, one can also identify variations in patterns of sex-related, age, SES, and other differences; the natures of these variations constitute ongoing research questions (Munroe et al., 1985; Rapoport, 1976). Although, strictly speaking, home ranges and activity spaces constitute examples of behavior rather than cognition, I discuss them here because they are often considered as causes of spatial cognition (e.g., wider travel patterns produce better navigational skills), effects of spatial cognition (e.g., activity space is a subset of "awareness space"), or both.

As I listed above, I believe the regionalization of space is culturally universal, and I expect that all peoples have some concept of territorial control over various regions. Of course, the exact nature of the territories and their control varies. Not all cultures explicitly codify territorial laws or incorporate concepts of sharp boundaries or put up physical barriers, etc. (e.g., Hallowell, 1942). But nothing I have read suggests that there are cultural groups who do not, at a minimum, practice forms of personal or in-group control over access to regions: personal space around the body, hunting territories, home territories, etc.

Formal Measurement of Space. Many traditional groups studied by anthropologists (and presumably the prehistorical groups studied by archeologists) did not have formal, abstracted systems of spatial measurement and manipulation, as in geometry and surveying. In a fascinating article, Hallowell (1942) reviewed his own work with the indigenous Saulteaux of Canada, as well as the work of other anthropologists with other groups. At that time, the Saulteaux used crude spatial quantities arising out of perceptual observation and experience, quantities such as "near" and "far away" that can hardly be called measurement. And like many peoples throughout history and prehistory, to the extent that the Saulteaux did use measurement (i.e., standardized matching quantities), their standards were imprecise,

individually and situationally variable, and largely incommensurate. Examples are the expression of larger-scale distances in dynamic activity terms ("3 sleeps away") and that of smaller distances in body-part terms ("3 fingers high") (see also, Littlejohn, 1963). The lack of formal and precise measurement concepts undoubtedly reflected and influenced the way these traditional cultures could think about space. However, it is important to remember that members of technologically-developed cultures like ourselves also reason in our everyday lives in qualitative and fuzzy metric units, temporal activity units, and so on (e.g., our common use of qualitative spatial linguistic terms) (Montello & Frank, in press). As Hallowell stated, "this level of discrimination is undoubtedly a generic human trait" (p. 62).

Environmental Cues. A final important area to look for cultural differences in spatial cognition is in the environmental features or "cues" that are noticed, remembered, and verbally labeled. Hazen (1983) and Rapoport (1976) both offer this as their primary evidence/example of cultural differences in spatial cognition. These authors make much of the variety of features used for orientation by traditional Micronesians, Eskimos, Australian Aborigines, and Saharan Tuareg. But is it a profound difference that Saharan nomads utilize sand dunes, Eskimos snow drifts, and Micronesians ocean swells? It seems more reasonable to see these as superficial and unavoidable variations on the universal ability of humans to take advantage of whatever information is available in their environment to exploit, however subtle. In fact, such cross-cultural research provides evidence for the operation of universal principles of feature selection: Select reliable, perceptible, and informative cues. The celebrated *etak* method of the Micronesians, for instance, is a modest variation on the "celestial navigation system familiar to Western navigators" (Hazen, 1983, p. 4). It is ironic, therefore, that while different cultures do attend to and remember different environmental features for use in navigation and communication, cross-cultural research on the topic may be most valuable because it provides evidence for universal principles.

4 Conclusion: Implications of Cultural Differences in Spatial Cognition for GIS

The theoretical and empirical issues reviewed in this essay suggest to me that the magnitude and pervasiveness of cultural differences in spatial cognition are often exaggerated. Many important aspects of spatial cognitive structures and processes are universally shared by humans everywhere. Furthermore, many of the apparent cultural differences that exist are actually not due to culture but to other factors that vary within cultures, such as professional training and expertise, social class, and so on. Different cultures usually do speak different languages, but it is a matter of ongoing controversy as to whether such differences have substantial effects on spatial perception and thinking. And virtually all of the evidence for substantial cultural differences in spatial cognition suggests that they occur primarily between traditional and technologically-developed cultures, not between different technologically-developed cultures.

This suggests a critical point about the implications of cultural differences in spatial cognition for GIS. The GIS users and designers for whom most such issues would be a concern are not untrained nonspecialists. Nor are they likely to be untrained nonspecialists in the future, except for possibly those using the representational function of GIS (i.e., spatial visualizations). Members of the GIS research and design community constitute a specialized "subculture" requiring training even in the United States and other technologically-developed cultures. The untrained sophomore doesn't understand the nuances of cartography or spatial analysis either; they too need to be taught the distinctions between lagoons, ponds, and marshes. People from traditional groups may not use formal systems of spatial measurement and manipulation, like surveying and geometry, but neither are they using GIS. At such time that members of their culture do use GIS, they will undoubtedly have acquired such formal systems. This is true, I think, because people from all cultural groups can readily learn the spatial concepts and procedures necessary to use GIS even if their cultures did not traditionally use them.

If substantial cultural differences in spatial cognition actually existed, the GIS community should take them into account in GIS research and design. Like other technologies, GIS should not and will not be restricted to European and European-American cultures. And I recognize that there are many significant and important cultural issues surrounding GIS, as I pointed out at the beginning of this essay. However, I do not believe that the topic of cultural differences in *spatial cognition* deserves a great deal of attention in the GIS community. Probably the spatial cognitive issue most deserving of cross-cultural attention is that of feature definitions incorporated into spatial data transfer, as Mark (1993) discusses. The solution may involve the compilation of some cross-cultural dictionaries for geographic features. Alternatively, non feature-based approaches (e.g, raster) may provide an end run around this problem; resident "feature experts" could define locally appropriate features at culturally distinct data processing sites.

None of this is meant to suggest that the GIS community should ignore the cognitive abilities and characteristics of humans. On the contrary, I believe that such considerations continue to be underappreciated and underresearched. The point is that whatever the important cognitive issues are, their culturally universal aspects are much more significant than are their culturally variable aspects.

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