THE CONTRIBUTION OF SPACE SYNTAX TO A COMPREHENSIVE THEORY OF ENVIRONMENTAL PSYCHOLOGY

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Abstract

The study of the interrelationships of human mind and behavior with the physical environment may be referred to as "environmental psychology" (or "behavioral geography," "the psychology of space and place," etc.). In my talk, I review elements of a comprehensive theory of environmental psychology. The theoretical framework of space syntax holds promise as an important contributor to this comprehensive theory, especially when combined with the analysis of isovists. It provides a rich and diverse set of quantitative indices for characterizing places in many ways that are potentially relevant to a variety of psychological responses, including choosing routes while locomoting, orientation and disorientation, spatial knowledge acquisition, perceived spaciousness, privacy and social interaction, stress and fear, and aesthetic judgments. Space syntax also falls short in contributing to a comprehensive theory. It flirts with causal ambiguity in some cases, underplays the significance of metric spatial properties (including distance and direction), says nothing about individual and group differences in people's responses to layouts, overlooks the relevance of the overall shape or "gestalt" of layout, largely discounts the role of the superficial appearance of the environment, and assigns no special significance to the vertical or 3D qualities of places. I illustrate these claims with examples from research by my colleagues and me, and suggest ways to improve space syntax's contribution to a comprehensive theory of environmental psychology.

Psychology and the Environment

Human psychology emerges from the interaction of a brain and nervous system in a body within a social and physical world. To explain psychological acts—behaviors, thoughts, emotions—one must look not only inward at the mind but also outward at the world. That is, psychology depends in part on characteristics of the built and natural environments in which people live. The study of the role of the environment in human psychology goes by a variety of names. For the purpose of this essay, I refer to this study of mind-behavior-world by the general term "environmental psychology"; I might just as well use terms like "behavioral geography," "cognitive geography," or "the psychology of space and place." Of course, the interrelationship of psychology and environment is bi-directional: Psychology influences environments, and environments influence psychology. In this paper, I focus on describing and explaining how environments, particularly their physical properties, influence human psychology.

How do physical environments influence human experience and behavior? Put simply, they allow, facilitate, require, impede, or prevent various mental and behavioral acts. These influences are realized via a variety of psychological mechanisms:

a) *Sensory access* – what can be seen, heard, etc.

b) *Attention* – what is looked at, listened to, etc.

c) *Memorability* – what is remembered, what is forgotten, etc.

d) *Behavioral affordance* – where one can walk, eat, etc.

e) *Affect* – mood, comfort, stress, fear, aesthetics, etc.

f) *Sociality* – pedestrian flows, noise, eye contact, social distance, etc.

These mechanisms generally operate physically, as when a wall prevents us from walking or seeing in a particular direction, or chairs placed far apart impede our ability to hold a conversation. However, they also operate according to social norms or rules of permissibility and obligation (that is, *deontically*), as when a sign tells us not to enter unless we are employees. Thus, behavioral affordances not only involve where we can walk but also where we *should* walk.

The operation of the psychological mechanisms by which environments influence human psychology partially depends on the physical characteristics of those environments. Psychology-relevant physical characteristics of environments include the differentiation of their appearance, the visual access they afford, and the complexity of their spatial layout (Gärling et al., 1986; Weisman, 1981); signage is also relevant in built (anthropogenic) environments. These characteristics are important because they directly influence particular behaviors, because they provide the raw material for people's knowledge of what is in the environment, because they affect patterns of stimulation impinging on people, and because they provide information people use to guide actions. Different information allows different wayfinding strategies, and it makes the strategies easier or harder to apply effectively. Different information tells people what to expect ahead or keeps them uncertain. In some situations, information misleads people about what to expect. Knowing or not knowing what to expect leads to emotional responses such as calmness, happiness, anxiety, or fear.

Consider differentiation of appearance. Environments differ in the degree to which their parts, including landmarks they contain, are homogeneous or heterogeneous in appearance. They differ with respect to size, shape, color, architectural style, and so on. Natural environments are often more differentiated than built environments, but of course, some natural environments are much less differentiated than others. To the untrained eye, natural environments can look quite undifferentiated. Gladwin (1970) tells the fascinating story of the ocean navigators of the Pulawat Islands of Micronesia (other Pacific Island peoples have similar traditions). They pick up a great deal of useful information from the sky and water, which are richly differentiated to those trained to perceive it. This information supports technologically unaided boat trips of up to several hundred miles over open ocean. The information includes air and water color, wave and swell patterns, sun and star patterns, and recognized bird species (with their known ranges). Generally, people find differentiated environments easier to comprehend and wayfind in because the differentiated parts are more distinct and memorable—differentiation creates better landmarks (Appleyard, 1969; Lynch, 1960). At some point, however, environments may be so differentiated that they appear chaotic and would be disorienting. But it's important to remember that differentiation cannot be assessed solely as an objective physical variable. It is a subjective variable, too; what we see (what we notice) depends in part on our expectations, our interests, our training, and our state of mind. The expert navigators of Pulawat demonstrate this point; as another example, architects will generally see greater differentiation in the built environment than non–architects will.

Visual access is another relevant physical characteristic of environments. Visual access is the degree to which different places and features in an environment can be seen (for sighted people, auditory access is much less relevant). Conversely, it also concerns the locations *from* which people in a particular environment can see particular places and features, including the locations where they were previously standing, the locations to which they are headed, and the locations of various key landmarks or structural features. To what degree is the overall layout of an environment visible from a single vantage point? People have a greater sense of comprehension and can maintain their spatial orientation more easily when visual access is high. Greater visual access will decrease mystery and uncertainty. In a complex or unfamiliar environment, visual access will tend to reduce excess stress, while in a simple or familiar environment, it will tend to reduce acceptable stress to boredom. Of course, visual access of, or from, some locations will be more informative than that of, or from, other locations.

Finally, although it is difficult to define and measure it formally, layout complexity certainly has important implications for human psychology. Exactly what constitutes a "complex layout" in a psychological sense is a question for ongoing research. It might be intuitive to expect increasing size to be related to increasing complexity, but there is very little empirical evidence for this relationship. Even if it is true, it is likely to express itself in a nonlinear fashion, so that up to a certain size threshold, layouts differing in size would not differ in complexity (other things being equal). A more articulated space, broken up into more different parts, is generally more complex, though the way the different parts are organized is critical. It is clear that certain patterns of path networks are more or less psychologically complex; for example, oblique turns are more disorienting than orthogonal turns (Sadalla and Montello, 1989, and Montello, 1991). However, defining psychological complexity is difficult because humans organize information into meaningful units in a way that reduces complexity in an information-theory sense to relative simplicity in a psychological sense. A case in point is the fact that the overall shape or "gestalt" of a path layout can determine whether a particular element is disorienting. In many built environments, for example, the road network consists entirely of simple rectilinear grids or symmetric radial patterns. But a grid pattern may be disorienting if its axes do not run north–south and east–west, at least for those people who incorporate cardinal directions into their wayfinding. A curved path is more complex than a straight one, but curved paths are understood better when they fit within a radial network pattern, as long as that radial pattern is, in fact, apprehended. Layouts may be said to vary in their closeness to a "good form"; comprehending a layout is easier when the layout has an overall pattern that can be apprehended as a single simple shape, perhaps allowing easy verbal labeling. A square has better form than a rhombus; a circle has better form than a lopsided oval. People tend to understand and remember layouts as having good forms, and when the layout does not have such a form, knowledge distortion results (e.g., Tversky, 1992). Lynch (1960) mentions that the Boston Commons confused people interviewed by his research team because they tended to assume it was a square, when it is actually an irregular pentagon. It is likely that a square is simpler than a regular pentagon, which is simpler than an irregular pentagon.

Space Syntax as Formal Language for Spatial Layout

Spatial layout is the shape and pattern of enclosed spaces and path networks in an environment. It includes topological aspects, such as connectivity, but it also includes more sophisticated geometric aspects, such as linearity, relative distance, and curvature. Spatial layout is directly relevant to all three physical characteristics of appearance differentiation, visual access, and layout complexity. Its relevance to layout complexity is evident by definition. But it also influences differentiation; layouts with hallways of different length are more differentiated than are layouts with hallways of equal length. And layout influences visual access; straight and unimpeded hallways provide greater visual access than do hallways filled with corners.

The theoretical framework of *space syntax* (Dalton and Zimring, 2003; Hillier and Hanson, 1984; Hillier and Iida, 2005) provides a promising analytic approach to conceptualizing and quantitatively measuring the layout of built spaces, or places (it would be more accurate to call it "place syntax" or "the spatial syntax of place"). Space syntax proposes to describe rigorously how built places, particularly buildings and urban street networks, are configured—specifically, how they are articulated into discrete, interconnected pieces. This rigorous description of configuration is proposed to explain a variety of characteristics of the environmental psychology of places, such as how people will experience the place, where they will likely move within the place, and what they will come to notice and remember about it. Space syntax focuses on the topological connectivity of pieces or "subspaces" within places as being the key to explaining various mental and behavioral responses within them. Thus, the pattern of connectivity is deemed critical, while metric properties of space such as distance and direction within and between subspaces is considered largely irrelevant. Connectivity patterns are represented with various graphical and mathematical devices, including the "topological connectivity graph," which shows link connections between nodes assigned to each of a minimal set of convex pieces of the layout. Alternatively, sequences of linearly connected nodes based on potential straight-line axes or paths of movement can be assigned to nodes in a more abstract graph structure (actually, "straight" is a property of projective geometry, not topology). Any graph-theory index that can be calculated, such as the average number of nodes between subspaces, can be applied to these graph structures and related to psychological variables such as memorability.

At an early stage in the development of space syntax, Hillier and his colleagues proposed that analyses could be based on topological sequences of straight-line visibility between places, instead of just straight-line mobility. In fact, planners and architects had systematically studied visual access, typically in interior spaces, under the guise of *isovist analysis*. Likewise, geographers, surveyors, forest managers, and others had studied visibility spaces in outdoor landscapes under the rubric of *viewshed analysis* (Llobera, 2003). Isovist analysis has often been claimed to reflect the ideas of the psychologist J. J. Gibson (1950, 1979) about the importance of vistas in the visual perception of environmental layout, although neither Hardy (1967), who conceived isovist analysis, nor Tandy (1967), who named it, mentioned Gibson's work. The term "isovist" refers to the collected spatial extent of all views, or vistas, from a single location within a place. It is commonly assumed that isovists are two-dimensional and extend throughout 360° around a vantage point. Thus, a large and unobstructed open area, such as a plaza or lobby, has large isovists that are fairly symmetric around locations near its center. Narrow hallways or urban canyons have isovists that are quite variable, with long or short vistas depending on one's viewing direction. Several theorists have proposed that isovist characteristics of environments will relate to the psychological responses the environments engender, including ease of orientation, sense of privacy, stressfulness, and aesthetic judgments (e.g., Benedikt and Burnham, 1985). Many different physical properties of the isovist could be relevant to psychological responses, including total size, symmetry, maximum length, and so on. But so far, only a little work has systematically tested these properties; for example, Sadalla and Oxley (1984) found that a rectangular room appears larger from the center than a square room of the same floor area. Ishikawa et al. (1998) found that the isovist shape of a city block influenced judgments of the area of open space along the block.

Space syntax deserves credit for providing a quantitative language to characterize the spatial layout of places. There are a variety of theoretical and empirical reasons to believe that the environment is, in fact, psychologically articulated into pieces of place that are visually accessible from single locations. It is clear that humans discretize the earth surface, even at places where it is essentially continuous, without physical boundaries or delimiters. This *regionalization* is likely to be universally characteristic of human cognition about space and place across cultural groups and historical periods (Friedman and Brown, 2000; McNamara, 1986; Montello, 1995, 2003). Regions are discrete pieces of earth surface that people verbally label—name—in order to speak about layout, in stories, verbal route directions, and elsewhere (Lynch, 1960, App. A; Montello et al., 2003). The degree to which a spatial layout is articulated into regions is an important aspect of layout complexity. Space syntax excels in its consideration of spatial articulation.

Furthermore, a wide range of theorists, including isovist theorists like Hardy and Benedikt, the psychologists Gibson and Ittelson (1973), and the planner Appleton (1975) in his prospect-refuge theory, stress the fundamental importance of visibility spaces—*vistas*—in people's mental and behavioral interaction and engagement with the environment (roboticists such as Yeap and Jefferies [1999] do the same for artificial organisms). As we noted above, isovist theorists typically assume that the relevant space of vistas extend throughout 360° around a vantage point. Such an isovist may be termed a *full isovist*. I sometimes call it "Linda Blair space" after the young actress whose demon-possessed character in *The Exorcist* spun her head around 360°; this label highlights the fact people generally do not view the world that way. Some effort has been made to incorporate into isovist analyses a more accurate model of human visual access to vistas. Conroy (2001; now Conroy Dalton) introduced *partial isovists*, spanning a smaller visual angle such as 90°, in her dissertation work (see also Meilinger et al., 2006). I return to the issue of partial isovists below in my conclusions.

How Space Syntax Falls Short in Contributing to a Comprehensive Theory

Clearly, space syntax is promising as part of a comprehensive theory of environmental psychology, especially when combined with the analysis of isovists. It sheds light on the mind-body interactionism that leads to the world as experienced. Space syntax offers a rich and diverse set of quantitative indices for characterizing places in many ways that are potentially relevant to a variety of psychological responses, including behavioral affordances (particularly route choice while locomoting), orientation and disorientation, spatial knowledge acquisition, perceived spaciousness, privacy and social interaction, stress and fear, and aesthetic judgments.

But space syntax also falls short as a comprehensive theory of environmental psychology. A common criticism of space syntax is that it flirts with logical circularity, or at least causal ambiguity, when it is applied to existing built environments. The property of *integration*, for example, is proposed to cause variations in pedestrian flow, memorability, and the functional importance of places within a city or building. However, whether determined by the bottom-up decisions of individual business owners or the top-down decisions of planners and administrators, activities intended to draw more people are placed at locations that are typically more integrated—they are not placed randomly. The cliché witticism that the three most important factors in the value of a home or the success of a business are "location, location, location" could be rephrased in space syntax terms as "integrated, integrated, integrated." More integrated locations are likely to be more familiar to the average person, to be experienced earlier on exposure to a new place, and to be experienced more. This must at least partly follow from the fact that more integrated places are more connected to other places, as space syntax suggests. But it also occurs because the destinations that need to attract the most people are intentionally placed at more integrated locations. Thus, more integrated locations would be visited more, and more visited places would be remembered more, even if integration had no direct effect on memorability. The notion that the most connected axes in a layout will form the "skeleton" of the cognitive map could be true just because those axes are the most familiar to people. Likewise, when respondents are asked to sketch maps of layouts, it is likely they interpret this to "draw the most important features," which would generally include the most integrated paths.

Either explicitly, by theoretical claim, or implicitly, by omission of emphasis, space syntax underplays the role of particular physical characteristics of environments that are, in fact, relevant to human psychology. Space syntax explicitly discounts the significance of metric spatial properties of layouts, including distance and direction. "[C]ognitive space...is not a metric space, but topological." (Penn, 2003, p. 30). But a variety of conceptual and empirical considerations suggest that people are sensitive to metric properties of spatial layout. Conceptually, advanced wayfinding tasks such as detouring and creative navigation require at least approximate metric knowledge; one cannot complete the third leg of most path triangles without some knowledge of metric distance and direction. Choosing optimal routes often requires some metric knowledge (even when that distance knowledge is actually travel time knowledge, it is still metric knowledge). And spatial planning, such as deciding whether particular trips can be completed in a timely manner, requires some metric knowledge. Empirically, several studies suggest that people can and do respond to metric properties of distance and direction. For example, Montello and Pick (1993) studied the acquisition of spatial layout knowledge (the *microgenesis* of spatial knowledge) in a multi-level public building. Our intent was to generate empirical support for the theory that spatial microgenesis follows a sequence of three stages of landmark, route, and survey knowledge, a theory I called the *dominant framework* for spatial microgenesis in Montello (1998). Participants learned two routes, one above the other, in and around a large hospital complex by being walked individually along each route twice, memorizing the names and appearances of four landmarks on each route (the routes are shown in Figure 1a). After one of the routes was learned (either the bottom or top first), participants were taken to the start location of the other route through a circuitous hallway and staircase across the street. Then the other route was learned. After learning both, the vertical relationship of the two routes was explained to participants; as Figure 1b shows, the two routes were actually more-or-less congruent. During a testing phase, participants walked one of the routes one more time, stopping at the target landmarks to point to all of the other landmarks (all nonvisible from each other) with a circular dial. Participants also drew a sketch map reflecting their understanding of the two routes. The performance of some of the participants was very hard to reconcile with the notion that early stages of layout learning produce only nonspatial landmark and topological route knowledge, as suggested by the dominant framework. The sketch map of one participant, a female graduate student, is shown in Figure 1c. Although she had only recently arrived at the campus, and had never visited the hospital complex, her impressively detailed and accurate sketch map was echoed in her fine performance in pointing to the landmarks: Her mean error pointing within a route was only 14°; between routes it was only 23°.

Besides suggesting the special psychological status of vertically arranged layouts, these results indicate that people are in fact sensitive to metric properties in the environment, but that this sensitivity varies greatly across individuals. Sensitivity to metric properties that varies across individuals is even more apparent in another study of spatial knowledge acquisition, by Ishikawa and Montello (2006). They took participants, individually, on car rides through a complex and unfamiliar neighborhood with many obscuring hills, curved roads, and poor or nonexistent signage. These rides occurred once a week for ten weeks. After each ride, participants listed the landmarks, pointed between them, and estimated route and straight-line distances. Every other week, they sketched maps. Figure 2 shows results for three participants, one who performed very well (P1), one who performed very poorly (P17), and one who performed at an intermediate level (P20), improving over the ten weeks. A subset of sketch maps is shown in Figure 3, including the maps for participants P1 and P17. Clearly, P1 is very sensitive to metric distance and direction knowledge, and acquires a great deal of accurate metric knowledge over time (actually, rather quickly).

So individual differences are critically important to understanding environmental psychology, but space syntax is largely mute with respect to this. Individuals can also be aggregated into various subgroups, based on age, gender, socio-economic status, and so on. We can then consider average group differences in various aspects of environmental psychology. For example, research suggests that the two sexes apprehend spatial layout differently, on average (Lawton et al., 1996; Montello et al., 1999).

Space syntax says little or nothing about properties of layout other than connectivity. Above, we discussed the property of the overall shape or “gestalt” of a path layout, as a component of layout complexity. Rooms, plazas, and convex subspaces have shape, and this shape influences a variety of perceptual and emotional responses; the shape of surrounding visible space apparently plays a key role in orientation and spatial learning, as well (Hermer and Spelke, 1996). The shape or pattern of path layouts is also important. As we reviewed above, the angular size of turns influences orientation and disorientation. When overall path layouts have a “good” form, they can be much easier to comprehend by people. And when they have poor form, they can be very hard to comprehend. A case in point: *unicursal* mazes have path segments that twist and turn in space, but do not branch—they actually have no choice-points that require a person to pick which way to go, at the risk of getting lost. That is, they have a topological structure of great simplicity that should not be psychologically challenging or stimulating. Nonetheless, they are quite disorienting, and they promote mental states that seem “altered” from our normal waking mental state. Anyone can experience this when walking along one of these mazes or labyrinths, and its verified by their widespread use over the ages in religious and spiritual mazes.

Finally, the superficial appearance of the environment is nearly completely ignored by space syntax, including surface colors, textures, and patterns. Yet, environmental differentiation is an important predictor of how people mentally organize the environment and maintain orientation. This includes signage; the location, completeness, clarity, and legibility of signs all influence orientation and knowledge acquisition (e.g., Arthur and Passini, 1992). More generally relevant, however, is the nature of visually perceived landmarks in the environment, objects or patterns that can be distinguished from the surrounds, remembered, and used to learn the layout of the environment, maintain orientation, and communicate about the layout to other people (Denis et al., 2007; Presson, 1988; Steck and Mallot, 2000).

Conclusion: Increasing Space Syntax’s Contribution to a Comprehensive Theory of Environmental Psychology

In the future, I expect space syntax will contribute more to a comprehensive theory of environmental psychology. Research will systematically evaluate the role of different measures of pathway connectivity and visibility so that the relevant causal factors can be identified (e.g., Dara-Abrams, 2006). Space syntax provides many alternatives for analysis, and in some cases, logical considerations do point to the application of one measure or another for particular purposes. But, in general, space syntax still does not provide enough of a principled basis for selecting among the alternatives, whether the principles are theoretically or empirically derived. Should (axial) lines through open spaces be based on pedestrian access or visibility? Should we calculate depth, connectivity, integration, or the ratio of nodes to edges? Which is more appropriate for a particular purpose, the convex map or the axial map? When analyzing isovists, should we look at isovist area, convexity, compactness, maximum diameter, minimum diameter, circumference, drift, or some correlations among these measures?

Problems of causal circularity or ambiguity when applying space syntax to extant places will be disentangled with research on created environments, real or virtual. Manipulating actual built environments is possible, but quite difficult and expensive (except for modest environments built inside large rooms), so the possibility of studying space syntax and other aspects of environmental psychology with virtual environments has great appeal and has attracted quite a bit of attention. Some research on space syntax with virtual environments has already been done (e.g., Meilinger et al., 2006), but much more is called for.

The concept and implementation of partial isovists, discussed above, can be improved in the future. We can structure them in a more principled way by considering the properties of the visual field; a static visual field extends nearly 180° to the right and left of one’s line of sight, and the high-resolution fovea, the central portion where we focus for detailed vision, makes up a small fraction of this. We could also structure partial isovists on the basis of systematic observations of people's viewing behavior in particular environments, which would allow us to tailor the isovists to particular places that elicit different viewing behavior. We could build a very sophisticated model of isovists that structures them variably across their extents, weighting them in different directions to capture differences in where people actually look and what information is available in different areas of the visual field. Similarly, *probabilistic isovists* (or viewsheds) could incorporate different probabilities of seeing in particular places in the surrounds as a function of distance or the presence of barriers differing in opacity.

The appropriate role of metric properties of spatial layout will eventually be clarified and incorporated into space syntax. Although some space syntax researchers have considered metric properties, its importance is still undervalued in that literature. Metric properties logically matter to environmental psychology, and research supports that a comprehensive theory would need to include it. However, although topology and other nonmetric properties are insufficient by themselves, it may be that metric properties need only be incorporated approximately or vaguely (so-called *qualitative metrics*—see Montello and Frank, 1996).

In the future, space syntax will be expanded to include aspects of the third dimension in places, including the effects of vertically extended visual spaces on aesthetics and other responses, and the effects of vertical relationships in multi-level structures on orientation and spatial learning. There is little or no mention of absolute size in space syntax, whether the size of single rooms or convex subspaces, or the overall size of places like buildings or cities. In the end, size may have less influence than one might expect, but it is quite unlikely to be totally irrelevant, and it is an empirical question that deserves research. Finally, there is little reason why space syntax should have no relevance to natural places, like wilderness areas. Viewshed analysis has long been applied to such places, and future research will apply versions of space syntax to them as well.

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Figure 1:

Study on the microgenesis of spatial layout knowledge by Montello and Pick (1993). The figures in (a) show the bottom and top experimental routes in and around two floors of a hospital complex. The actual vertical overlap of the two routes is shown in (b). The sketch map of one participant, a female graduate student, is shown in (c).

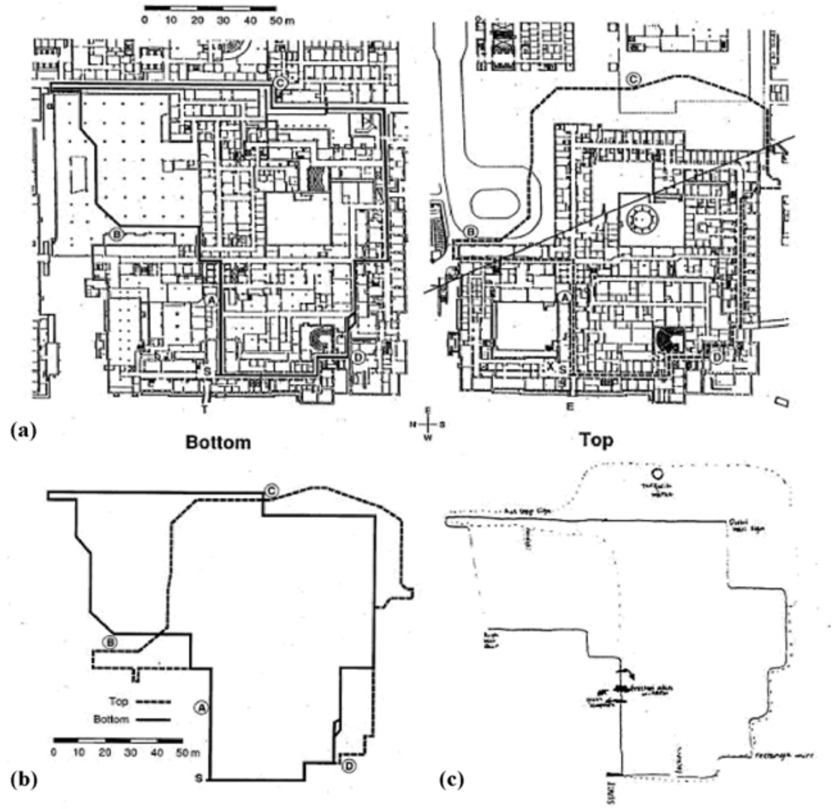

Figure 2:

Pointing error, distance correlations, and sketch map accuracy (bidimensional correlations) by three participants in the study of spatial microgenesis by Ishikawa and Montello (2006)

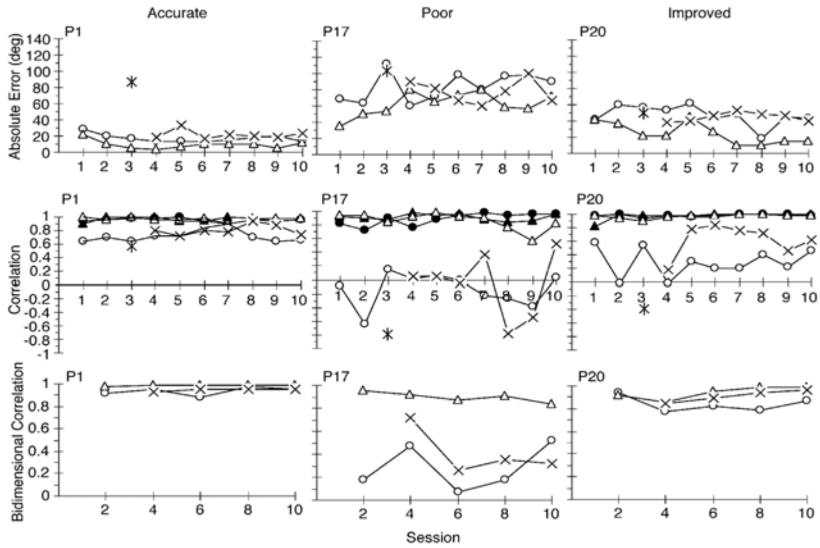

Figure 3:

Sketch maps of varying quality by participants in the study of spatial microgenesis by Ishikawa and Montello (2006). Average bidimensional correlations of the sketch maps with the actual layout are shown in parentheses