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DISCUSSION

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Daniel R. Montello[1]

Abstract In this discussion essay, I contend that the role of landmarks is exaggerated in basic and applied spatial cognition research. Specifically, I discuss empirical and theoretical arguments consistent with two claims. First, the word landmark is a label for several different concepts, although its precise reference in a particular context is rarely specified carefully. Further, whether specified or not, researchers never use the term landmark to mean everything that the concept can legitimately mean. Thus, when researchers assert something about the role of landmarks in spatial cognitive activities, they exaggerate their particular meaning at the expense of a broader ontology. Second, I claim that even when landmarks are clearly and precisely defined, their role in specifying location is misunderstood and less fundamental than proposed. In exaggerating landmarks, other important components of spatial knowledge, memory, and reasoning are undervalued. Taken together, these two claims support my contention that landmarks are exaggerated in spatial cognition.

1 Introduction: The Landmark Concept in Spatial Cognition and Behavior

The concept of landmark is among the most venerable and broadly applied in the study of spatial and geographic

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cognition; perhaps only the concept of cognitive map itself is more so. It is my contention in this discussion essay, however, that the concept of landmark is polysemous, misunderstood, and overextended to such an extent that the way it has widely been used has been an overemphasis—an exaggeration—in much of the literature of spatial cognition. Some theories accord it too much centrality, considering that they somewhat misconceive how landmarks actually function in navigation and spatial learning, and considering that they employ only one interpretation of the concept when in fact there are several legitimate interpretations (and all uses of the concept in the literature certainly do not converge on just one of these interpretations). If this can be said of theoretical treatments of the landmark concept [1, 8, 13, 19, 27, 28, 36], it is also clearly true of efforts to automate the identification of landmarks and their inclusion in digital navigation systems [5, 10, 11, 21, 32, 33].

The idea of landmark is a common lay concept (actually a set of related concepts) and probably has been for millennia. At least as far back as Trowbridge [39], one can find a scientific discussion of the role of landmarks in human spatial cognition. In his paper, Trowbridge emphasized the home as a "reference point" for the formation of "imaginary maps" (incidentally, the latter term predates by decades the introduction of "cognitive maps" by Tolman [38]). But probably Lynch [26] deserves most credit for stimulating scientific interest in the concept of landmarks by researchers of environmental cognition. Lynch introduced five "elements of urban images", types of physical features in the environment that play prominent and widespread roles in people's beliefs about the physical appearance and structure of a given city. They are the features people recall when you ask them to describe a city, features people use to give verbal route directions, and features that

give a city visual organization and distinctive appearance. Lynch labeled these elements: landmarks, nodes, paths, edges, and districts. Perhaps the problem of landmark exaggeration starts with these well-known concepts. I make this claim because one can appreciate that all five of Lynch's elements are actually types of landmarks. Any of them can be sensorily (typically visually) distinctive, recalled or recognized, used to guide wayfinding, support geographic orientation, help organize environmental knowledge, serve to organize episodic memories of personal experiences, and so on. What Lynch calls "landmark" is simply one form of landmark, namely landmarks as punctual or pointlike (zero-dimensional) structures. In fact, nodes too are pointlike and do often function as landmarks in environmental cognition ("I sold my soul at the crossroads"). Likewise, we can readily appreciate that paths and edges are one-dimensional landmarks ("walk until you see the river"), and districts are two-dimensional landmarks ("I'll meet you downtown tonight").

2 "Landmark" is Extremely Polysemous

A persistent conundrum for theoretical and conceptual discussions of landmarks is its polysemous nature—it means more than one thing. Presson and Montello [31] discussed no fewer than six fairly distinct definitions of landmark. What they called the "minimal definition" is that landmarks are simply distinct objects or features in the environment that can be noticed and remembered. Thus, in a given wayfinding experiment, there would be nothing especially bizarre about a person using something as prosaic as a trash can or a chip in the curb as a landmark. But it would be odd to think we need navigation systems to automatically identify landmarks like these. Presson and Montello discussed two distinct but related "non-relational definitions" of landmarks. The first is a feature that has a special symbolic significance for a place or region, essentially standing for it. In this sense, the Eiffel Tower is a landmark for Paris and Christ the Redeemer for Rio de Janeiro. The second non-relational sense is a landmark that is large and visually prominent, thus visible from far away. Although many examples of this definition are also symbolically representative (Il Duomo in Florence), the two non-relational ideas are distinct—a very tall tower crane in my city is currently serving as a landmark only in the second non-relational sense. Finally, Presson and Montello also discussed three distinct "relational definitions" of landmarks. In the first sense, something is a landmark because it serves as a cue for another feature, place, or action. A common example is in the instruction "turn right at the gas station". Second, landmarks are landmarks because they play the important role of a key that links locations and headings in the world

with locations and headings represented on a cartographic or cognitive map. This intriguing notion highlights how landmarks typically do not function merely as visual "beacons" or targets that you locomote toward. They allow you to match a place and direction in the surrounding perceived environment as being a particular place and direction on the map, thus allowing you to spatially coordinate the two "spaces" (equivalently, this can be phrased so that orientation on the map is coordinated with orientation in the surrounds). Finally, Presson and Montello discussed what might be seen as the most cognitively sophisticated meaning of landmarks, that they function as "reference points" or "anchor points" around which to organize one's spatial knowledge [9, 34]. In this sense, they are like vertebrae around which the spatial knowledge skeleton is constructed [25].

This is a rich and variegated notion of landmark, but it still falls short of the true richness and diversity of the term. For instance, the distinction between local and global landmarks is important (e.g., [37]). The two types can be distinguished (approximately) by the size of the area over which they can be perceived and how much motion parallax they demonstrate as one locomotes about; one or both of these properties determine the area over which a feature can serve a particular landmark function. Another aspect of landmark richness is their sensory qualities. Landmarks are nearly always considered to be visually sensed (by humans), but even people without impaired vision undoubtedly remember, associate, and orient with the help of landmarks sensed via other modalities, especially audition and olfaction.

Above, I made it clear that landmarks are not just pointlike features. But even more, they are not even necessarily discrete features at all. Entire "views" or scenes often function as landmarks—they can be recognized, they can support orientation, they are part of the content of environmental memory, etc. This is apparently a rather different notion of landmark than what has been meant by Lynch and many of the researchers who came after him, but it is not a particularly novel idea that scenes function in this way. The psychologists Gibson [17] and Ittelson [23] both wrote about the psychological centrality of environmental scenes or "vistas". Planners such as Appleyard [2] and Benedikt [4] also stressed the importance of views, whether in cities or inside rooms. Researchers studying the spatial cognition and navigation of robots [24, 40] and nonhuman animals [7, 12] have prominently featured the role of views or scenes, linked by actions, in spatial learning and wayfinding. Widely known work by other psychologists has provided evidence that human children and animals like rats orient by means of recognizing the shape (they refer to it as "geometry") of the surrounding environment, such as a room [6, 14, 20]. Of course, the shape must be somewhat

nonsymmetric to function in this way. The simplest scenario, used in several research studies, is to ask research subjects to orient themselves in rectangular rooms, the two diagonally opposite corners presenting the same scene geometry, different than the other two. Adults apparently do not rely on room shape as strongly as young children and nonhumans do, but they can still use the shape of the surrounds to orient. Although these authors contrast geometric information with superficial non-geometric "landmarks" such as colored walls or graphical symbols, one can appreciate that both mechanisms of orientation rely on recognizing specific and stable environmental structures or features. Which is to say that both are types of landmarks. Anecdotally, I enjoy demonstrating to myself the psychological power of this type of vista-shape orientation by partially blocking my vision during my daily commute on the highway so that I cannot see any of the exit signs. I can still readily figure out where my exit is by recognizing the shape of the surrounds: the curves, the slopes, the shapes of the barrier walls and hedges. This type of landmark poses a real challenge to anyone who would add them to route directions, automatically or otherwise, especially if they claim to do so in a "cognitively-adequate way".

Physical features or structure in the environment clearly play an important role in environmental cognition. In the case of landmarks, in any of its multiple senses, this feature or structure must be relatively stable in location and appearance. Portions of the physical environment function as landmarks—in any sense—only when their identity is remembered[1] (i.e., they exist in a person's or automated system's mental or external representations), and the identified feature or structure is linked to locational information. But, as I have argued, this still leaves a tremendous amount of variability in the meaning of the concept of "landmark". Yes, a given author can specify what he or she means by the term landmark (although many authors do not), which at least addresses the problem of not knowing exactly what the author is discussing. But it leaves the problem of an obscure and uncertain ontology for landmarks in our theories and information systems. One could try to proclaim the special importance of one meaning over others, but all the meanings seem to me to refer to things that are semantically useful to sentient creatures and, thus, to spatial-cognition researchers. Giving one meaning hegemonic status seems like an act of arbitrary fiat, like claiming to know exactly how tall a protuberance must be in order for it to be considered a mountain (as in the obvious folly of *The Englishman Who Went Up a Hill but Came Down a Mountain*). How can we say that landmarks are so important (e.g., to

navigation systems) when there seems to be scant prospect that we can even settle on what they are?

To be clear, I do not mean to imply that any structure or feature of the physical environment that can play a psychological role should be considered a landmark or collection of landmarks. Environmental structure that provides textural elements that a mobile entity can use to judge the size and relative locations of other features (as in [15]) is not functioning as a landmark, because no identification of its specific identity plays a role in this activity. Environmental structure that provides the optic flow for a mobile entity to judge its own speed or direction (as in [16]) is not functioning as a landmark, again because its identity plays no role. Environmental structure that intentionally provides semantic information for a mobile entity (in this case, a human) to garner interesting or useful information about the environment (as in [3]) is not functioning as a landmark; it is signage.[2]

3 Landmarks and Location: Ambiguity and Misconstrual

The theorists I cite above (and many others) place so much emphasis on landmarks mostly because they believe that landmarks are key for understanding spatial knowledge and orientation at environmental scales (buildings, campuses, parks, cities). Specifically, according to these researchers, landmarks define locations, organize locational information, and serve to represent and communicate locations. This claim is much more problematic than many researchers seem to appreciate. For example, we often use commonplace features as landmarks in expressions like "turn right at the gas station". But there may be hundreds of gas stations in that city, even several along that specific route. What this expression actually means is: "turn right when you reach the gas station at the location where you imagine yourself to be while following along with these verbal directions". It is location that clarifies the unique identity of that particular gas station. Or consider that charming enigma of spatial-cognition researchers wherein a long-time resident gives directions to a visitor by saying something like "take the second left after the spot where old Mr. Ort used to stack his hay bales" (any sign of the hay bales being long gone). How can a non-existent feature be a landmark? That can happen only when the location of the non-existent feature defines its identity. Even features that never existed can function as landmarks. The celebrated "Etak" system of the Micronesian navigators [18] involves not only

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[1] They must be remembered as a specific token, not just a type. Not "a house" but "Leila's House" (if there are no other houses around, a house becomes a token object).

[2] Of course, the physical object that materially instantiates a sign can function as a landmark instead of a semiotic artifact—"go past the metal pole holding the red six-sided object".

reference islands that are never sensed but imaginary reference islands that do not exist and never have. The navigators know they don't exist, but create them as placeholders for locations. In all of these examples, location defines the landmark—the landmark does not define the location! That is, spatial context often allows us to distinguish a landmark, giving it the unique identity it requires to act as a landmark.

This paradox should lead us to resist assigning landmarks too much credit for determining location. What's more, overemphasizing the role of landmarks in spatial cognition leads researchers to overlook or undervalue other important components of spatial knowledge, memory, and reasoning. The other day, a knowledgeable friend in this field told me that he had sympathy for my thesis that landmarks are exaggerated, but that I should remember that people like his wife really do "navigate by landmarks". This nicely captures what I think is a widespread confusion about landmarks and spatial knowledge. The landmark concept is used in an enlarged way so it includes not only the recognized structure or feature, which constitutes the landmark, but the spatial context in which it is embedded—the spatial context that makes it a landmark beyond the simple fact that it is recognized or recalled. For example, what I [29] called Siegel and White's [35] "dominant framework" of spatial learning posits three stages of spatial knowledge that people supposedly acquire upon going to a new place: landmark, route, and survey knowledge. In this theory, however, landmark knowledge is nothing but knowing the identity of a feature or structure. A person with just landmark knowledge would recall or recognize a landmark but would not know where it is, and thus would not know where he or she was located as a result of perceiving the landmark. Thus, the dominant framework proposes there is some stage when people learn to recognize landmarks without knowing any locational information (rather untenable as a general theory of knowledge development). Any form of locational knowledge of landmarks is more than just landmark knowledge. It is knowing the spatial context of the landmark, whether its position in a sequence of landmarks, its association with left or right turns, its distance or direction from other landmarks, its location within a region, etc. Whether route knowledge, survey knowledge, or some other type of spatial knowledge, knowing the location of the landmark or what the landmark tells you about your own location is more than landmark knowledge. It is typically nonsensical to say that someone navigates or orients entirely by landmarks.

Human spatial cognition (not to mention that of robots and other animals) involves many more types of reasoning, concepts, and representations than just landmarks. Stressing landmarks so much paints a misleading picture. Some people do get by with very limited metric survey knowledge (but characterizing it as merely landmark knowledge

is misleading, as I have just argued). But other people think quantitatively about location in the world, understanding properties like distance, direction, and size approximately metrically.[3] At least some people clearly think this way [22], even if their metric understanding is somewhat distorted and has limited resolution (but metric properties are never of unlimited resolution, even in detailed reference maps, GPS databases, and so on). Creative wayfinding tasks such as shortcutting and detouring often require at least approximate metric knowledge, and people can do these things, sometimes to amazing degrees, and even in less regularly structured wilderness environments. Choosing optimal routes similarly requires some metric knowledge in many situations, even if travel time is what is optimized. Generally speaking, effective spatial planning often calls for some metric knowledge and not just "landmark knowledge". And as much as landmarks may improve verbal directions for many or even most people, as several of the researchers cited in this essay claim and several studies demonstrate, some of us actually want to be given metric information like cardinal directions and distances in the directions we receive. Ironically, perhaps the efforts to include landmarks in automated navigations systems, which is part of the effort to provide people with ready access to any and all information they ever want to know, will in the end spatially infantilize people so much that they will truly be unable to think spatially about much more than landmark identities [30].

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[3] Formally defined geometric terms like "metric" do not strictly describe human spatial knowledge, as violations of the metric axioms, etc., are easily demonstrated. I use the term informally to suggest that humans display considerably more spatial knowledge than just nonmetric properties like connectivity and sequence.

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