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You Are Where? The Function and Frustration of You-Are-Here (YAH) Maps

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Abstract: In this article, I define you-are-here (YAH) maps and consider their fundamental characteristics from cartographic and psychological perspectives. I then review the basic phenomenon of the alignment effect, including why it happens and how it may be overcome; I also consider exceptions to the alignment effect. Finally, I briefly note some special issues with YAH maps that arise when a person uses a digital navigation system.

Keywords: you-are-here (YAH) maps, alignment effects, spatial reasoning

1. INTRODUCTION

One of the most robust and reliable demonstrations in spatial cognition (environmental, geographic, cartographic, etc., cognition) is the difficulty that results for most people when they use a misaligned you-are-here (YAH) map to wayfind—to orient themselves to the proximal and distal surrounds in order to follow a route to a destination. This difficulty is called an *alignment effect*. YAH maps are reference maps—general-purpose maps meant to show features in the environment—that are typically rather large scale (i.e., show small areas of the environment) and are placed within the surrounding area they depict. They nearly always include an arrow or some other symbol representing the location and perhaps the heading of a person viewing the map (Klippel, Freksa, & Winter [2006] use the term *complex* for YAH symbols indicating both location and heading). That is, all YAH maps are *in situ* in that they represent the area where they are placed. Because they are intended to solve wayfinding problems for a person actively engaged in applying that solution to get somewhere in real time, they must be coordinated with the surrounds when used.[1]

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Any navigation map used in situ in the manner I have described shares many of the issues discussed in this paper, although they might not technically be YAH maps. For example, a road map used while riding in a car is functioning essentially as a YAH map, insofar as the viewer usually knows his or her location and heading as depicted on the map, and is trying to reach a destination with the aid of the map; in this case, alignment effects apply as they do with standard YAH maps. With the advent of mobile digital devices, such as in-vehicle navigation systems (IVNS) (e.g., Aretz & Wickens, 1992) and GPS-enabled cell phones, the issues of misaligned YAH maps extend to portable maps that move along with the traveler and can be physically or digitally rotated repeatedly (Klippel et al., 2006), unlike a static YAH map attached to a fixed location in the environment, such as a wall. I return to this at the end.

Empirically and conceptually, YAH maps are aligned with the surrounds when the "up" direction on a vertically-displayed map (or the forward direction on a horizontally-displayed map) represents the direction a person faces in the environment—his or her heading—while viewing the map. This has been called *forward-up* or *track-up* alignment (e.g., Aretz & Wickens, 1992; Levine, 1982). YAH maps are misaligned whenever any other relationship holds between up on the map and the viewer's heading direction in the surrounding environment. That is, a YAH map can be aligned or misaligned by any angular amount varying between 1° and 359° (assuming a 1° resolution). Maximal misalignment of 180° is called *contralignment* (e.g., Levine, Marchon, & Hanley, 1984).

By varying amounts, misaligned YAH maps are typically more difficult to use than aligned maps for in situ orientation and route-following in that they require more time to determine a course direction, and those determinations are more likely to be in error. In cases when YAH maps are misaligned, they often engender a subjective sense of confusion or disorientation, and this may be accompanied by anxiety or other negative affect (Figure 1). This cost of time, error, and/or distress resulting from misalignment, relative to alignment, is the *alignment effect* (Presson & Hazelrigg, 1984; it might make more sense to call it a *misalignment effect*). Of course, not all amounts of misalignment produce an equal cost. A very minor misalignment of a couple degrees is not likely to have any cost at all, while more extensive misalignment can cost tens of seconds or more, and lead people to travel in a grossly incorrect direction to their destination. It is not completely clear what the nature of this misalignment cost function is, and its exact nature depends on the person's cognitive skills and the layout of the surrounds (discussed below). However, it appears likely that 180° may not be as disorienting as 90°, and oblique misalignments (especially between 90° left or right and 180°) may be the costliest (e.g., Hintzman, O'Dell, & Arndt, 1981; Montello, 1991). There is not likely to be much psychological difference between misalignments to the left and to the right (e.g., Sadalla & Montello, 1989), except in idiosyncratic cases

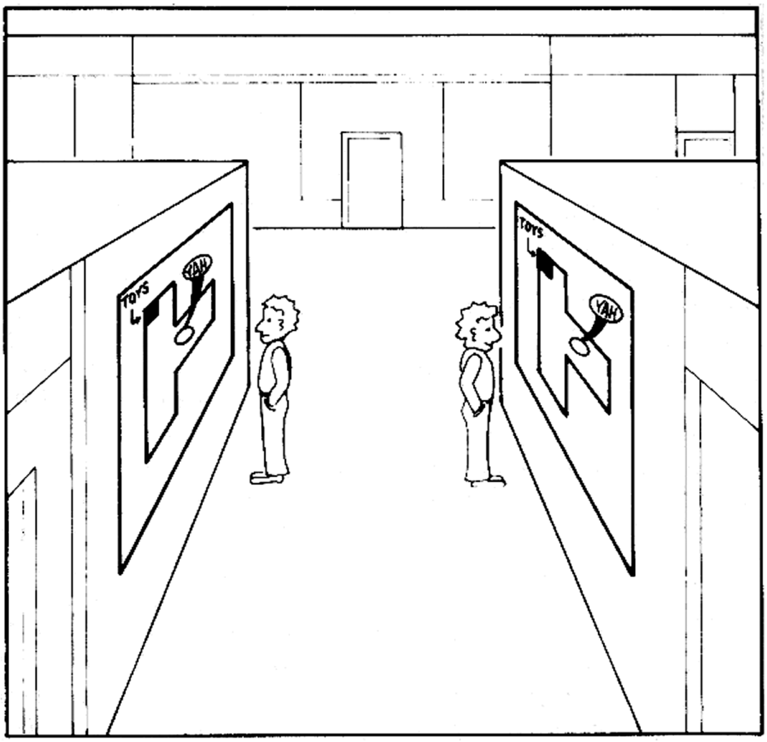

Figure 1. Misaligned YAH maps can cause problems (from Levine et al., 1984).

of people with specific asymmetric deficits, such as unilateral hemispheric neglect.[2]

YAH maps are often misaligned, some would say surprisingly often. Most readers can probably confirm this by conducting a survey in their own locality. Apparently, designers, builders, and administrators are either ignorant about alignment effects or they don't think it matters much. Whatever the reason, Levine (1982) surveyed YAH maps in New York City, finding that no more than 25% were aligned. At the Mall of America, the largest indoor mall in the United States (second in North America to the West Edmonton Mall in Alberta), I once observed a pair of shoppers struggle with their misaligned YAH map. At that time (it has since been remedied), the same map was placed on each side of a four-sided column, so that only one of the four maps was aligned. I watched as the couple studied the map, looking for a particular department store. Finally, after many more seconds than a YAH map should require, the couple turned around and marched off to their department store, apparently with confidence. Unfortunately for them, they had been standing right in front of their store, facing it the whole time, little more than 5 meters away. On my own campus of the University of California at Santa

Barbara, until recently, YAH maps constructed with ceramic tiles mounted on blue steel pillars were placed in a misaligned way in 11 out of 16 cases. Given the approximate rectilinear organization of the campus with respect to the cardinal directions, this suggests a random placement with respect to alignment.

Of course, YAH maps can be designed and/or placed in the environment in such a way that misalignment does not occur. Focusing on the placement of YAH maps reminds us that misalignment can be understood to result from an inappropriate map orientation or from an inappropriate map aspect. Map *orientation* is which direction is represented on a map as upward, downward, to the left or right (e.g., is north represented as up?). Map *aspect* is the facing direction of the map image; for example a map that is oriented so that north is up is aligned when it has a facing aspect of south in the surrounds (the viewer's heading—his or her facing aspect—would be north in this case). Misaligned maps are guaranteed whenever a single map design is placed in multiple aspects. A single map design might be placed only with a single aspect, which results in an aligned orientation if the correct aspect is chosen. Because there are some benefits to using maps that are conventionally designed, often with north at the top, this single placement would typically have a south-facing aspect (i.e., the viewer faces north when looking at the map).

Or multiple versions of the map can be designed with different directions up, so that no matter which aspect is needed for placing, an aligned version is available. However, multiple map designs may well confuse people, and the cost of production may prohibit it, so that the previous solution of placing a single design in a single, aligned aspect may be preferable. Another approach is to design horizontal YAH maps that are set in the aligned orientation; these are aligned for viewers standing on any side. This is a very good solution when it is feasible, as it also does away with the "flattening" transformation that vertical maps require (Aretz & Wickens, 1992; Liben & Downs, 1993) as well as the rotation that misalignment generally requires (see below). Finally, for many people, using signs with directional arrows, etc., may be preferred to using maps at all (see Hölscher et al., 2007).

2. WHY DO ALIGNMENT EFFECTS OCCUR?

The question of why alignment effects occur with YAH and other navigation maps is actually composed of two component questions: (1) Why is forward-up, rather than some other orientation, the aligned orientation, and (2) Why does a misaligned orientation cost time, accuracy, and/or distress? Considering the first component question, we recall that a person actively engaged in navigating to a destination uses YAH maps to determine course of travel. Given this, the person generally has to match the YAH map to his or her surrounds in an oriented manner. Shepard and Hurwitz (1984) offered that a person's forward direction in the surrounding environment, when standing or walking, is essentially "up" in his or her visual field. Thus, they argued, it is natural for people to associate forward in the surrounds with up in the visual field, including a visual field that contains a vertically displayed map. This may partially explain the observation that many languages metaphorically equate up with both north and forward (e.g., Gattis, 2001), although it does not by itself provide the entire explanation for this linguistic phenomenon. A very straightforward observation is that when using an aligned map, egocentric left on the map is left in the surrounds, and likewise for egocentric right (Harwood & Wickens, 1991). This is a spatial example of stimulus-response compatibility, which a great deal of research has explored (e.g., Kornblum, Hasbroucq, & Osman, 1990). We can probably also draw a connection to the literature on form perception and orientation (Rock, 1974). Figures have a subjective top and bottom in the visual field, the visual system's identification of which is a necessary step in decoding the shape of the figure (recognizing inverted figures is quite difficult).

In addition to the question of why forward-up is the aligned orientation, there is the question of why misalignment is costly. Our considerations above suggest that alignment is a necessary step in interpreting YAH maps, or at least a commonly applied step that facilitates interpretation. Klippel et al. (2006) explicitly discuss the trilateral relationship between person, world, and map. Misalignment leads to a mismatch between egocentric directions—directions relative to a person's location and heading—in the world and on the map. This mismatch has to be overcome. That is usually achieved by a mental manipulation (discussed next) that is cognitively challenging, or by using a cognitive strategy that does not require overcoming the mismatch but is otherwise difficult or error-prone. Given the empirically observed fact that the great majority of people find it quite difficult to deal with misaligned YAH maps, these alternative mental strategies must generally require mental effort and skill that challenges even cognitively able people.

3. STRATEGIES FOR USING MISALIGNED YAH MAPS

Logical analysis suggests a few different strategies travelers can apply to use misaligned YAH maps. All these strategies require conscious knowledge, including knowledge that a strategy must be applied and knowledge of how to apply it. The strategies involve four steps. People must (1) notice or suspect that they are viewing a misaligned map; (2) figure out how it is misaligned, that is, in which direction and by how much; (3) figure out or retrieve from memory an approach to deal with the misalignment; and (4) correctly apply the approach to deal with the misalignment. In all cases, using misaligned maps is likely to be facilitated if a person realizes to begin with that the map may be misaligned and that misalignment matters.

3.1. Steps 1 and 2: Noticing Misalignment and Figuring Out Its Nature

Steps 1 and 2, noticing misalignment and figuring out its nature, can be achieved by seeing a YAH arrow on the map and realizing that the map is probably misaligned if the arrow points in any direction but up (*probably*, because a map with an arrow not pointing upward is aligned if its aspect matches the arrow heading). During many studies and demonstrations I have conducted, I have witnessed people make such an observation about the direction of a YAH arrow, but I believe it is a rare insight for YAH map users. It requires that the map has a YAH arrow, that it is visible and distinct in design, and that it is placed correctly on the map (i.e., with the arrow heading matching the person's heading). Unfortunately, whether through design or injury to the map after production, YAH symbols are often absent, represented non-directionally as something like a dot or circle, placed with improper orientation, or placed off the side of the map in the margin or "zone of floating semiotics." Alternatively, an absolute direction symbol, such as a north arrow, could be placed anywhere on the map. To use it, people would need to know their absolute heading direction in the world and see that it does or does not match what the map indicates.

Instead of interpreting a directional symbol like an arrow, a person could apply an approach called "feature matching." To feature match, a person recognizes that a feature on the map, such as a building, represents a feature that can be perceived in the surrounds (or the person can recognize that a feature in the surrounds is represented by a feature perceived on the map). Once this matching occurs, a person can figure out the relative orientations of the map and the surrounds, aligning them via one of the strategies reviewed below. This will not be possible with completely symmetric features, like cylindrical or rectangular columns (e.g., Levine, 1982). Solving the problem of identifying a unique location *and* heading on a two-dimensional surface involves three degrees of freedom (Pick, Montello, & Somerville, 1988). The problem can be solved by identifying two distinct symmetric features in both the world and the surrounds (a person can perceive both egocentric distance and direction for each feature), or by identifying one feature that is suitably differentiated in shape or some other aspect of appearance that is depicted on the map (color, pattern, etc.). I have noticed that a small minority of people use feature matching spontaneously, and it is likely quite challenging to use. Finally, another approach is a verbal statement on the map, like "warning, this map is misaligned with the surrounds; you should imagine you are facing behind you as you view it." I have never heard of this approach being used.

One might be inclined to think that once Steps 1 and 2 are carried out properly, misaligned maps will no longer be a problem. This is clearly false. You can readily confirm this by watching people attempt to reconcile a YAH map they know is misaligned. As a case in point, Levine et al. (1984) found that alignment effects occurred even when the importance of the direction of the arrow was stressed.

3.2. Steps 3 and 4: Figuring Out an Approach to Deal With Misalignment and Correctly Applying It

Carrying out Steps 3 and 4, figuring out an approach to deal with misalignment and correctly applying the approach, can be done in any of several ways:

3.2.1. Imagined Map Transformation. You can imagine rotating or shifting the map, typically around the axis connecting your eyes to your point location on the map, until the direction on the map imagined to be up corresponds to your actual heading (viewing direction) in the surrounds. This is the approach most analogous to image rotation (see Pazzaglia & De Beni, 2006). In contrast to rotation, I use the word "shifting" to suggest the distinction between continuous angular reorientation and discrete shifts of reorientation carried out without moving through intermediate orientations. Both are possible to imagine.

3.2.2. Imagined Heading Transformation. You can imagine rotating or shifting your own heading perspective, typically around the vertical axis running through your body from head to toe, until your viewing direction imagined to be forward corresponds to the actual direction represented as up on the map. Note that you must imagine "bringing along" the map with you—transforming its aspect—as you imagine turning or shifting.

3.2.3. Actual Map Transformation. If the YAH map is detachable, you can actually rotate it until the direction on the map that is actually up corresponds to your actual heading in the surrounds. Of course, actual shifting without moving through intermediate orientations is not possible.

3.2.4. Actual Heading Transformation. You can actually rotate your body (again, no shifting allowed) until your heading in the surrounds corresponds to the actual direction represented as up on the map. This requires that you actually transform the aspect of the map with you as you turn, without modifying the map's orientation. Alternatively, if you memorize the spatial relations on the map, then you can carry out this transformation without changing the map's aspect, which makes this possible to carry out with fixed maps. Because of the memory demand this requires, many people would probably find this challenging.[3]

In theory, one could align the map and surrounds by imagining rotation or shifting of the *surrounds*, not just the map or one's body. In a virtual environment (e.g., May, Péruch, & Savoyant, 1995), one could even carry out actual rotation or shifting of the surrounds. However, imaginally transforming the surrounds is not functional to a map user who then has to head into those surrounds as they are actually oriented relative to his or her heading.

4. EXCEPTIONS TO THE ALIGNMENT EFFECT

Alignment effects are very robust with YAH maps, arising from the need to coordinate information about a traveler's location and heading with map information, and also with information perceived from the local surrounds. However, when people do not need to coordinate themselves, the map, and the local surrounds, such as with nonnavigation maps, the map's orientation is largely a matter of convention. Western Medieval T-O maps were conventionally oriented with east toward the top; "orienting" a map, and by extension, ourselves, is a term derived from the practice of placing the Orient—the East—toward the top (e.g., see *The History of Cartography* series published by the University of Chicago Press). Many larger-scale maps—those showing small land areas such as buildings or campuses—are designed with something other than north toward the top. And many of us have seen the Aussie world map, which places south at the top and gives Australia and New Zealand the distinct appearance of "being on top."

Even with YAH maps, however, alignment effects are not universally found. A relatively small minority of map viewers can use misaligned maps with little cost in time or accuracy, and little sense of disorientation. There is some evidence that practice with misaligned maps improves performance with them (MacEachren, 1992). Many people who are very familiar with the environment in question do not get particularly bothered by misaligned YAH maps, but of course, such people either have no need for the map or need it for only restricted wayfinding purposes. The layout of the environment matters, too (Werner & Schindler, 2004). Misaligned YAH maps are easier to cope with in rectilinear environments for which misalignment would typically be limited to 90° chunks or "quadrants" of egocentric surrounding space (Montello, 1991). Strategies like feature matching certainly work better in environments that are more differentiated in appearance (e.g., Klippel et al., 2006).

However, not even all navigation tasks conducted in situ necessarily benefit most from forward-up alignment. Some people in some circumstances prefer a fixed alignment, such as north-up, to a forward-up alignment (Gramann, Müller, Eick, and Schönebeck [2005] provide evidence of two types of orienters in virtual environments, "turners" and "nonturners"). I noted above that multiple map orientations (i.e., with different surrounding directions represented as up) might confuse map users. Harwood and Wickens (1991) examined the performance and preference of helicopter pilots using dynamic electronic map displays in a flight simulator. Tasks such as route planning (not just route following) benefited from fixed alignment maps, such as north-up. Harwood and Wickens suggest that forward-up dynamic navigation maps work best when the traveler has to coordinate his or her egocentric frame of reference to the map information in order to determine the proper heading to reach some destination. This route following is probably the typical task for which a standard YAH map is used. But when the traveler needs to acquire and maintain knowledge of other locations and headings besides his or her own—such as when the spatial relationships among external locations in a geo-referenced frame of reference is important—a fixed alignment dynamic map works better.

Although the usual concern researchers and designers have with misaligned YAH maps is their role in disorienting travelers, at least some people also acquire knowledge about an environment while using YAH maps. It seems that multiple map orientations, including those presented via dynamically updated systems such as digital navigation systems, may interfere with learning environmental layout—with the development of the cognitive map (Aretz, 1991; Tlauka & Nairn, 2004). This is an important issue and deserves more research.

The existence of dynamic navigation displays leads us to think somewhat differently about issues of map placement and alignment. Dynamic displays move along a route with the traveler, and they are able to rotate automatically as the traveler turns to maintain forward-up alignment. Moving along a route is similar to a person (the "navigator") in an automobile manually turning a paper map as the car turns. But this analogy is misleading for at least two reasons. First, when a paper map turns, it turns in entirety. When an image on a mobile device turns, the frame around the image provided by the physical device does not turn. This may impede updating, although no research has directly examined this possibility. Probably more important, automatic map reorientation on dynamic displays occurs without the intent—or, possibly, attention—of the traveler. But dynamically maintaining one's sense of geo-referenced heading (updating one's "azimuthal frame" or heading relative to a fixed Earth surface), beyond minimal changes, requires attention. This is probably why pilots often prefer fixed-alignment maps in their cockpits.

REFERENCES

Aretz, A. J. (1991). The design of electronic map displays. *Human Factors, 33*, 85–101.

Aretz, A. J., & Wickens, C. D. (1992). The mental rotation of map displays. *Human Performance, 5*, 303–328.

Gattis, M. (Ed.) (2001). *Spatial schemas and abstract thought*. Cambridge, MA: The MIT Press.

Gramann, K., Müller, H. J., Eick, E. M., & Schönebeck, B. (2005). Evidence of separable spatial representations in a virtual navigation task. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 1199–1223.

Harwood, K., & Wickens, C. D. (1991). Frames of reference for helicopter electronic maps: The relevance of spatial cognition and componential analysis. *The International Journal of Aviation Psychology, 1*, 5–23.

Hintzman, D. L., O'Dell, C. S., & Arndt, D. R. (1981). Orientation in cognitive maps. *Cognitive Psychology, 13*, 149–206.

Hölscher, C., Büchner, S., Brösamle, M., Meilinger, T., & Strube, G. (2007). Signs and maps—Cognitive economy in the use of external aids for indoor navigation. In D. S. McNamara & J. G. Trafton (Eds.), *Proceedings of the 29th Annual Cognitive Science Society* (pp. 377–382). Austin, TX: Cognitive Science Society.

Klippel, A., Freksa, C., & Winter, S. (2006). You-are-here maps in emergencies: The danger of getting lost. *Journal of Spatial Science, 51*, 117–131.

Kornblum, S., Hasbroucq, T., & Osman, A. (1990). Dimensional overlap: Cognitive basis for stimulus-response compatibility—A model and taxonomy. *Psychological Review, 97*, 253–270.

Levine, M. (1982). You-are-here maps: Psychological considerations. *Environment and Behavior, 14*, 221–237.

Levine, M., Marchon, I., & Hanley, G. L. (1984). The placement and misplacement of you-are-here maps. *Environment and Behavior, 16*, 139–157.

Liben, L. S., & Downs, R. M. (1993). Understanding person-space-map relations: Cartographic and developmental perspectives. *Developmental Psychology, 29*, 739–752.

MacEachren, A. M. (1992). Learning spatial information from maps: Can orientation-specificity be overcome? *The Professional Geographer, 44*, 431–443.

May, M., Péruch, P., & Savoyant, A. (1995). Navigating in a virtual environment with map acquired knowledge: Encoding and alignment effects. *Ecological Psychology, 7*, 21–36.

Montello, D. R. (1991). Spatial orientation and the angularity of urban routes: A field study. *Environment and Behavior, 23*, 47–69.

Montello, D. R., Waller, D., Hegarty, M., & Richardson, A. E. (2004). Spatial memory of real environments, virtual environments, and maps. In G. L. Allen (Ed.), *Human spatial memory: Remembering where* (pp. 251–285). Mahwah, NJ: Lawrence Erlbaum Associates.

Pazzaglia, F., & De Beni, R. (2006). Are people with high and low mental rotation abilities differently susceptible to the alignment effect? *Perception, 35*, 369–383.

Pick, H. L., Montello, D. R., & Somerville, S. C. (1988). Landmarks and the coordination and integration of spatial information. *British Journal of Developmental Psychology, 6*, 372–375.

Presson, C. C., & Hazelrigg, M. (1984). Building spatial representations through primary and secondary learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*, 716–722.

Rock, I. (1974). *Orientation and form*. New York: Academic Press.

Sadalla, E. K., & Montello, D. R. (1989). Remembering changes in direction. *Environment and Behavior, 21*, 346–363.

Shepard, R. N., & Hurwitz, S. (1984). Upward direction, mental rotation, and discrimination of left and right turns in maps. *Cognition, 18*, 161–193.

Tlauka, M., & Nairn, M. J. (2004). Encoding of multiple map orientations. *Spatial Cognition and Computation, 4*, 359–372.

Waller, D., Montello, D. R., Richardson, A. E., & Hegarty, M. (2002). Orientation specificity and spatial updating of memories for layouts. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*, 1051–1063.

Werner, S., & Schindler, L. E. (2004). The role of spatial reference frames in architecture: Misalignment impairs way-finding performance. *Environment and Behavior, 36*, 461–482.

NOTES

1. The need for YAH maps to be placed in the area they represent and used for active navigation in that surrounding area is not strictly true. I would also include *imagined* situations, as when a person imagines the placement of the YAH map and imagines traveling in a distant area. However, the typical use of YAH maps, by far, must surely involve actual places through which a person is actually traveling.
2. I do not know of any research on YAH maps with people that have unilateral hemispheric neglect.
3. However, in their third experiment, Waller, Montello, Richardson, and Hegarty (2002) found that many respondents could carry out just this task when they were asked to imagine a simple floor array rotating with them as they actually turned their bodies.