International Cartographic Association
Association Cartographique Internationale

North in the head: spatial reference frame and map orientation

Zsolt Győző Török [a,*]

[a] *Institute of Cartography and Geoinformatics, ELTE Eötvös Loránd University Zsolt Győző Török – zoltorok@map.elte.hu*

* Corresponding author

Keywords: navigation, map orientation, reference frame, spatial cognition

Abstract:

Effective map use in the field is based on orientation in two spaces: in a physical or *geographical* space and in a representational, *graphic* space. When using a map the wayfinding process includes the identification of the user's geographical position in the field (starting point), the identification of the target and planning the route's connecting the two points. However, the initial *direction* of the user is very rarely the orientation of the map, so the problem of navigation with maps is the translation of the representational space into the user's actual situation. In other words, the projected or actual movement path during navigation must be transformed from one *reference frame* to the other. Spatial reference frame is a key issue in cartography and geovisualization. The transformation of the human subjects' body-centred, *egocentric* reference system into an object-centred, *allocentric* reference system is a complex task. Maps are cognitive tools, traditionally representing large configurational spaces in visual, graphic form (Török 2019). They offer computational advantage over internal, human memory representation, organized into smaller spatial units. Apart from personal experience, learning from maps is a common practice (Meilinger et al. 2015). Supported by ubiquitous map services, prior to visiting unfamiliar places people consult maps to familiarize themselves, and this spatial learning results in memory structures with map-oriented reference frames. In modern societies the massive use of cartographic visualization in spatial thinking underlines the importance of modern cognitive cartographic research, resulting in new insights and consequences well beyond topographic map use (Zentai et al. 2006). Learning from maps influence the structure of the cognitive map. Increasing map use in modern information societies has strong effects on all spatial aspects of the human mind. Recent geo-visualizations, most importantly mobile navigational applications display maps with dynamic, head-up orientation and support the user by turn-by-turn voice navigation. Unfortunately, this practice does *not* support survey knowledge acquisition, cognitive map building and spatial memory training. The negative effect is decreasing navigational, or more generally spatial, ability of users of GPS navigational services. While the change of reference frame demands higher memory load for the human brain, the cost is compensated by the maintenance and development of human cognitive abilities.

The North-is-up reference frame on cartographic maps is actually a rather modern cultural convention. However, we can trace its origin back to the astronomical-geometrical worldview of ancient Greek cosmology. The priority of north was adopted by Hellenic geography and became a classic tradition after the rediscovery of the 2nd c. work, a manual on making a map of the world by *Ptolemy*. He described the construction of the map in a geometric reference frame, in a *north-oriented* geographical coordinate system. Map making based on this new concept of geometric space had substantial influence on human spatial thinking from the Renaissance period on. Modern cartography is an Enlightenment project, and from the 19th century maps became common objects in European societies. In the 20th century cartographers and generations of map users were trained in geography with north-oriented maps, atlases – even globes were displayed with north on top. The representational history of cities in European cartography a case where cognitive cartographic issues strongly influenced cartographic practice and the importance of different reference frames is demonstrative. The modern city view as a new genre appears in the late 15th century and cities views were already popular at the time the *Nuremberg Chronicle* was printed with numerous illustrations (1493). However, how it is perhaps best exemplified by Sebastian Münster's German *Cosmography* (from 1544) while *maps* were oriented north or south, the cities were given *in perspective*. In the Chronicle Buda, the capital of the Kingdom of Hungary, is represented from the east, while Münster included another woodcut, a view of the city from the south. After the long period of the Turkish occupation new representations of the former Hungarian capital were constructed by military engineers in connection with the siege of Buda (1686), representing the campaign's target from military point of view. The cities Buda and Pest, stretching along the Danube, even in the 19th century they were represented with the river as a horizontal axis in landscape format views and maps. The significant change of the orientation of the city maps is the late 19th century, more specifically the period when topographic maps of the third military survey of the Austro-Hungarian Monarchy became available. From this time on the historic material demonstrates that maps of Budapest (from 1872) are almost exclusively north-oriented. As a result of this process, generations learned geography from north oriented maps and school atlases.

Abstracts of the International Cartographic Association, 2, 2020.
Central European Cartographic Conference and 68th German Cartography Congress – EuroCarto 2020, 21–25 September 2020, Vienna, Austria (online) | https://doi.org/10.5194/ica-abs-2-6-2020 |

After our virtual reality experiments exploring spatial learning and navigation (Török et al. 2018), in the present field experiment we tested the interaction of local and global reference frames, the sense of geographical North in a sample of young adults. We created an ecologically valid experimental setting by selecting a special location at ELTE university campus in Budapest. In an enclosed *vista space*, positioned near the river Danube and heading an easterly direction, our participants were asked first to point to North. With good visibility of the river, a major, structural landmark in the configuration of the city we were interested how the misleading direction of the Danube influenced their directional sense. While the general course of the river is north-south, at the site of the experiment the river course changes to northwest-southeast, with a deviation of 30-40° from true north. We expected that the direction of the only visible global landmark, and, of course all the local landmarks, would result in similar pointing errors. In the first test series they were asked to point/draw toward salient urban landmarks in the city, that is in *environmental space*. In the second test series they pointed towards important cities in a large, *geographical* space. Finally, they once again indicated the direction of true North in the same geographic space.

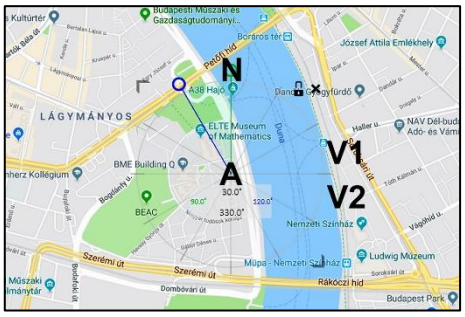

Figure 1. The location of the experiment (A) in the ELTE campus, Budapest

Our results are consistent with previous research (Frankenstein et al. 2012) that the participants had a clear sense of geographical North learned from maps, moreover, contradicting our expectations, the misleading course of the Danube and local geometry had little effect on the overall high accuracy of pointing to North. However, a few result deviated from the average and suggested high individual differences, presumably due to different spatial thinking strategies of participants. Test subjects living longer in Budapest had a much better sense of North, supporting the importance of *learned components* in this directional knowledge. Our experiment in the physical world resulted in supporting evidence that North is present in human cognitive map as the cardinal direction for orientation. The implications of the results of our experiment should be considered relevant when designing new maps and user interfaces. Another important result, our experiment suggest that local and global reference frames are not separate systems, but structured *hierarchically and integrated* in spatial orientation tasks. Although egocentric view may support direct scene recognition and object identification cartographers should construct navigational maps with geographic reference frame as well, especially in the case of extensive and complex environmental/geographical spaces, because these are still *learned first from north oriented maps*. The long tradition of paper maps, the history of cartography has a lasting effect of human understanding of the physical and virtual worlds.

Acknowledgements

This project was supported *National Research, Development and Innovation Fund of Hungary*, financed under the Thematic Excellence Programme no. ED_18-1-2019-0030 (Application-specific highly reliable IT solutions)

References

Frankenstein, Julia, B. J. Mohler, H.H. Bülthoff, T. Meilinger 2012. Is the Map in Our Head Oriented North? *Psychological Science* 2012, 23(2), 120–125.

Meilinger, T., Frankenstein, J., Watanabe, K., Bülthoff, H. H., & Hölscher, C. 2015. Reference frames in learning from maps and navigation. *Psychological Research*, 79(6), 1000–1008. doi:10.1007/s00426-014-0629-6

Török, Zsolt G., Török, Á., Tölgyesi, B., and Kiss, V. 2018. The Virtual Tourist: Cognitive Strategies and Differences in Navigation and Map Use while Exploring a virtual City. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sc*i., XLII-4, 631–637, https://doi.org/10.5194/isprs-archives-XLII-4-631-2018.

Török, Zsolt Győző – Török Ágoston 2019. Cognitive data visualization – a new field with a long history. In: Klempous, Ryszard – Jan Nikodem – Péter Zoltán Baranyi (ed.) Cognitive Infocommunications, Theory and Applications. Topics in Intelligent Engineering and Informatics 13, Springer, Berlin, 49–79.

Zentai, L.- Györffy J.- Török Zs. (eds.) 2006. Térkép-tudomány. Map-Science. Karten-Wissenschaft. *Studia Cartologica* 13.