Loci Communes 2022, vol. 1 (2), pp. 1–18
ISSN 2720-6122
https://doi.org/10.31261/LC.2022.02.03



# Cities and Human Experience – the Touchpoints of Space Perception and Wayfinding Systems in the Communication Design Perspective

Kamil Olender

University of Wroclaw, Poland
https://orcid.org/0000-0001-9322-0915

Abstract

This paper introduces the topic of wayfinding systems and the related concepts of touchpoints between spatial user experience design and empirical research. It discusses the operationalisation of the concept in the light of various scientific fields and provides the outline of the individual necessary steps crucial to design a signage system that would be the closest and most accurate in the context of spatial cognition, as well as the indication of the most frequently discussed guidelines for designers in both scientific and professional literature.

Keywords

city, wayfinding, human-centred design, communication design, spatial cognition

LOCI COMMUNES
International Journal of Studies on Spaces in Arts and Humanities, Anthropology and Architecture

## Space and Perception - a Review of Selected Studies

Although the issue of navigational systems is closer to industry practices, it is also the subject of scientific research, especially in cartography, neuroscience, and cognitive linguistics. Cartography preoccupies itself with the design of positioning systems (e.g., GPS) and spatial maps. Neuroscience, on the other hand, deals with perception and processes in the human brain and the localisation of the brain areas responsible for them. Linguistics investigates the relationship of space to language and communication, for example, by analysing the linguistic representations of the world and conceptual categorisation. Currently, interdisciplinary analyses that research navigational systems more holistically are increasingly valued (Bond, 2020).

The close relationship between human perception of the world and language was already observed by Edward Sapir and Benjamin Lee Whorf, creators of the concept of linguistic relativism. Their best-known hypothesis, based on comparative studies of European languages (defined by researchers as temporal languages) and Indian languages (e.g., the language of Hopi Indians), are the two main assumptions: linguistic determinism and linguistic relativism concerning the concepts of time, space and matter. Linguistic determinism conceptualised language (understood as a system of signs created by society) as acquired in the process of socialisation which shapes the way we think and perceive the world. Linguistic relativism was an extension and supplementation of the first one – which led to the conclusion that language systems, differentiated in many respects, are the reason for the differences in the perception of the world between the users of different languages (Jedynak, 2007). The Sapir-Whorf hypothesis divided the linguists, leading to many controversies and conflicting opinions on whether it is indeed a language that influences the way of thinking. The main counter-argument indicates the possibility of translating texts into different languages despite differences in the structure of world perception.

Regardless of the dispute described above, Sapir and Whorf also discussed the perception and reflection of space in language. The main difference between the European and Indian languages was the use of spatial metaphors. The European languages involved spatial metaphors, whereas, in Indian languages, this feature was replaced by expressions referring collectively to intensity, tendency, duration and succession (Whorf, 1982). However, in contrast to the time domain (Kövecses, 2011), the researchers did not find significant differences in the conceptualisation of the spatial domain in the languages they studied, which was related to excluding proxemic issues from the assumptions of linguistic relativism (Whorf, 2002). Other researchers, like John B. Haviland (1979) and Stephen Levinson (1992), have different insights than the original Saphir-Whorf hypothesis.

Levinson analysed the language of the indigenous inhabitants of Australia, the Guugu Yimithirr tribe, and concluded that the language involved a completely different system of spatial terms than those represented in Indo-European languages. While Europeans use relative terms, that is, dependent on their location (e.g., in front of, behind, to the left of, opposite), the representatives of the Guugu Yimithirr tribe under study used a geocentric, absolute system of spatial references (e.g., in the north from, in the east of) (Levinson, 1996, p. 181). Following this and subsequent studies conducted on more than 20 languages, Levinson distinguished three different interpretative frames defining the relations of observed objects:

1. Relative frame – describes the world from the observer's perspective. for example, phrases such as: in the front, left, on the right-handed side, behind and so on. This frame dominates most European languages.

2. Intristic frame – binary and independent of the observer's position towards the discussed object. The distinctive feature of this frame is the widely accepted agreement that the described object has a clearly distinguishable front and back. It is the second most popular way of describing the proxemic position of objects in European languages.

3. Absolute frame – based on the objective direction of the world, known from cartography: east-west, north-south. This frame is used in European languages only to define the geographic context of an object's location. Nevertheless, many languages use cartography as their guiding framework (Levinson, 2003).

Another fundamental linguistic theory that relates language structures to space is the theory of linguists Mark Johnson (1987) and George Lakoff (2012). Johnson and Lakoff theorised linguistic ways of expressing proxemic relations. Researchers introduced the concept of image schema – mental patterns that connect perception with communication by referring to 27 abstract categories:

Table 1
*Image schemas by George Lakoff (2012) and Mark Johnson (1987).*

| | | |
|---|---|---|
| container | balance | compulsion |
| blockage | counterforce | restraint |
| enablement | attraction | mass – count |
| path | link | centre – periphery |
| cycle | near – far | scale |
| part – whole | merging | splitting |
| full – empty | matching | superimposition |
| iteration | contact | process |
| surface | object | collection |
| diversion | up – down | removal |
| front – back | | |

## Mental Maps

Antique philosophers have been preoccupied with human orientation, but the Enlightenment philosophers – John Locke, David Hume and George Berkeley – contributed significantly to the interest in the human location. British empiricists assumed that people's knowledge of the location is based on the perception of their senses. Modernist Immanuel Kant argued the opposite – that people use the categories of time and space, which are built into our brains independent of the currently perceived reality. This dispute was resolved only in the 1930s by the American psychologist Edward Tolman who established it based on observations of the behaviour of animals placed in a maze. Tolman found that with the gradual exploration of a given place, a cognitive plan of space is created in the brain of animals and humans, which is subsequently used during the next contact with the area (Mazurek & Vetulani, 2015).

Tolman's findings were confirmed in the 1960s with the help of increasingly popular neurobiological methods. The following years gave rise to the concept of a mental map (i.e., an imaginary map). Mental maps were defined as a cognitive representation of external reality, which contains the necessary information about the spatial organisation of the phenomena (Bond, 2020).

Kevin Lynch, an American urban planner, also referred to mental maps in his research. The author of the book *Image of the City* interviewed respondents about Boston, Jersey City and Los Angeles, and then, based

on their descriptions, he created mental maps. Lynch concluded that imaginary maps are constructed using five basic elements:

1. Paths – used for changing location, that is, streets, pavements, railroads;
2. Edges – the features that constitute a barrier, interpreted as real or perceived borders, for example, walls, buildings, shorelines, curbs;
3. Districts – areas of the city of various sizes, having certain common features, for example, districts, parks;
4. Nodes – places of intersection of various types of space, for example, squares, intersections;
5. Landmarks – places characteristic for mapping the road, for example buildings, signs, mountains, shops, urban art, and monuments (Lynch, 2011).

## Inner GPS in the Brain

The behavioural research on the cognition of space found that human knowledge of space is not a coherent whole (one mental map) but a conglomerate of independent parts from which it is difficult to create a consistent plan (Kuipers, 1982; Montello, 1993). Perceived space is schematic and has a hierarchical structure of differently organised elements.

One of the ground-breaking research about the perception of space was conducted by John O'Keefe and his students May-Britt Moser and Edward Moser, explaining the structure and operation of the neural system of spatial localisation. The scientists were awarded the 2014 Nobel Prize in Physiology or Medicine. This theory introduced the concept of spatial localisation, also often referred to as the brain's GPS (alternatively, inner GPS or positioning system in the brain). Research proved that neurons of the central nervous system are responsible for the system of exploration of the environment. Inner GPS consists of place cells located in the hippocampus, grid cells arising in the intraparietal cortex, and head wall and head direction cells (Moser et al., 2015). This internal cartographic system is responsible for the experience of navigating a new space and remembering particular routes based on precisely smaller interconnected cognitive maps, usually bounded by the area covered by vision. Learning more elements of space or relocating to other new spaces is made possible by increasing neural connections (Mazurek & Vetulani, 2015, p. 15). Enlargement of the hippocampus was also confirmed by an earlier study conducted among London cab drivers with larger hippocampi than other city residents. Their size also depended on the length of work experience (Maguire et al., 2000).

## Wayfinding Systems – Operationalisation

A navigational system is – in a nutshell – a set of elements aimed at helping the user in navigating a given physical space. Another term used more often in the literature is wayfinding. The first definition in the 1960s, by American Kevin Lynch, described wayfinding as the organisation of sensory signals transmitted by the external environment (Lynch, 2011). Further theorisation led to the concept of user spatial orientation (Farr et al., 2012), which allowed the definition of wayfinding to be expanded and consequently reformulated. Wayfinding is the process of moving through space to reach an assumed destination (Casakin et al., 2000). More precisely, it is the process of identifying the current location and gaining knowledge about how to get to the desired destination faster and effortlessly (Brunye et al., 2010). The orientation systems' role will thus be to locate the user in the given space through environmental cues.

Wayfinding can be divided into three minor processes:

1. Decision making, that is, creating and developing a plan of action;
2. Executing the decision, that is, transforming the plan into a legitimate action set in time and space;
3. Processing of receiving information and perceiving it in a given environment (Arthur & Passini, 2002).

To summarise, wayfinding requires developed spatial (orientation in a given space) and cognitive (perception and processing of signals) skills. Therefore, it is crucial to properly design wayfinding systems considering the users' needs and abilities.

This paper uses the broad definition of navigational systems as a set of verbal and non-verbal elements in the form of physical and non-physical carriers. The main goal is to better orient the users while accounting for their cognitive competencies and predispositions.

## Methodology - Designing Wayfinding Systems

Martin Raubal, Max J. Egenhofer, Dieter Pfoser and Nectaria Tryfona (1997, pp. 91–99) indicate the three main steps in researching the design of navigation systems. The first step is behavioural: conducting interviews with users of the space. The point of the interviews is to collect observations about the information coming from the environment. At this stage, the group of respondents should receive a task: get from point A to point B. An example described research about the Vienna airport, where the goal of the participants in the experiment was to reach the appropriate gate for a flight to Istanbul. The participants were asked to describe what they

saw en route, particularly in terms of proxemics and directional markings. The next step is the linguistic analysis of the interviews, using the framing of image schema from Johnson and Lakoff to start the modelling. The final step is to develop the structure of the navigation system based on the emerging types of image schemas collected in the previous stages. This allows for creating individual (but ultimately collective) mental maps.

Observing a given space also helps identify potential difficulties in navigating the space, considering multiple variables. Another element of empathic observation is the categorisation of all possible user groups. This categorisation should concern not only the context of the use of the space but also all other possible functional groups of people. For instance, it is not a satisfactory conclusion to find only two basic categories at a railway station: travellers and non-travellers. Ultimately, accurate categorisation, and a thorough understanding of the target groups' needs, result in a better design.

## Space Mapping in Design

Mapping of space is not only crucial in planning traditional signage, for example, inside buildings or for urban information systems. Reference to mental maps and image schemas is also used in the design of electronic devices supporting the wayfinding process, such as personal navigation devices, navigation devices integrated with smartphones, GPS maps, portable guides, GPS watches or offline plenaries (e.g., using websites) (Tokarczyk & Frank, 2008). However, the differences in the wayfinding model between systems for pedestrians and motorists are significant. These differences concern the decision scenes, that is, places where the user has to make a selected manoeuvre (e.g., turn). Such places are usually landmarks, such as buildings, monuments, intersections. For motorists, the message about the necessity of manoeuvring must be given well in advance to execute the action safely. The pictorial diagrams from the theory of Johnson and Lakoff are therefore helpful. The most relevant categories are container, blockade, path, part-whole, link, near-far, object, centre-periphery and collection.

Urs-Jakob Rüetschi and Sabine Timpf (2004), in their analysis of the Zurich railway station, presented an interesting modification of some image schemas. The Swiss researchers proposed the introduction of the categories relevant to cognitive mapping: room (instead of a container), region (instead of a surface), gateway (as a specific type of conscious connection, for example, door), unconscious link (as a connection between spaces that is not obvious, for example, a waiting room located within the station

hall) and item (as a type of object). The categories allowed the researchers to map the station space with transfers and connections in line with a hierarchy within the space.

## The Features of a Proper Wayfinding System

Anna Charisse Farr, Tristan Kleinschmidt, Prasad Yarlagadda and Kerrie Mengersen from the Queensland University of Technology quote several studies on navigating different public spaces (2012). According to Australian researchers, some critical issues related to wayfinding are incorrect signs placement, height and size.

However, in the literature, there are no clear guidelines for designers. A scoping review of the literature and popular science texts on industry websites in the field of wayfinding design (both urban and private and semi-private buildings) has identified the seven most frequently occurring design remarks, which will be presented below.

### Visibility

The road signs, pictograms, signs in the buildings and so on, should be easy to find by users, which can be achieved by using appropriate colours, size of the letters, font, or pictograms. However, the most critical step is locating the signage in places where users look naturally. It is crucial, especially at the beginning of the journey, like near the entrance of the building or at so-called decision points - where users must decide which directions they should take. Therefore, the first step in designing wayfinding systems is to indicate decision points in a given space.

A designer should also think of different categories of users. Appropriate and comprehensive categorisation should be done during a so-called empathetic stage using proper research methods like observation or interviews. Initially, visually impaired and disabled users should be included in the research. Visual impairment challenges can guide designers to use the proper font, pictograms and contrast, whereas, for users using wheelchairs, the height of the signs is crucial not to be placed too high. A variety of groups of users depends on a given space or its purpose. For example, in city design, the important thing is to place maps or signage in places where people enter the city – the main bus stations, railway stations, parks and rides and so forth.

## (In)visibility

Another related feature, seemingly only contradictory to the first, is invisibility, understood in a subversive way. The key is to properly integrate the signs into the layout and the colours of the building so that the designed system is not too flashy and aesthetically incompatible. Appropriate signage should harmonise with the surroundings while at the same time being conspicuous and noticeable. That's not an easy task for designers. That is why designers should not only think within the system (understood in line with Luhmann's (2000) and Fleischer's (2007) system theory, which means thinking only from the perspective inside, not from observer's perspective, which brings the bigger picture of possible situations) but more comprehensive by considering the observer's perspective. Therefore, designers should research and predict the behaviour of users in a given space.

## Cohesion

The complexity of proxemic solutions also lies in their cross-referencing. Users look for coherent markings in the different stages of the journey to anticipate what kind of sign and type of information they should anticipate. The goal is to quickly acquire competence in the given signage while not straining the user's cognitive abilities. Frequently, designers stick cards with information in places not intended for this purpose, such as office doors or corridor walls in public spaces. Subsequently, due to the increasing amount of data, users decrease their attention or time devoted to analysing it. Total cohesion can also be achieved by placing the signage in repeatable situations, like at the crossroads or the doors to the next corridor.


Photo 1

*Świnoujście, Poland. Numbered free-standing signs indicate beach entrances. The location and appearance are consistent. © Photo by the author.*

## Versatility

The versatility feature is strongly connected with cohesion. In many organisations, new signs are not only visually incoherent but also situated in an inappropriate place due to the wrong design. The navigational system must be created so that it can be extended at a low cost. Expansion can include adding additional elements as structural or physical changes happen or when the mapped facility activities expand.

## Intuitiveness

Although the main reason for implementing orientation systems is to help the user find their way in a given space, designers often place visual aspects above functionality. This can lead to doubts and ambiguities in the process of the denotation of signs. Ambiguities within the differentiation and diversification of individual pictograms are particularly glaring. One of the most challenging symbols at the design stage is directional arrows and the ambiguities related to suggested routes straight up and diagonally (with upward diagonal arrows). Other troubling symbols belong to the toilets,

where doubts are two-fold: distinguishing men's and women's toilets and distinguishing toilets from different places, for example, the lift or the exit from the building. The situation is much more problematic when it comes to places visited by culturally diverse and multilingual audiences, like airports or hotels, where signage must be transparent for many people. This is the result of intercultural differences in the perception of symbols. For instance, shapes such as a circle and a triangle used in Poland will not always be appropriate to mark the toilets in different countries and cultures.


Photo 2

*Primosten, Croatia. The sign on the sidewalk does not match the other markings and is, therefore, counter-intuitive. © Photo by the author.*

## Essentiality

Despite the ubiquitous "cargo cult" in the design of navigational systems, it is worth sticking to the minimalist "less is more" introduced into architecture by Ludwig Mies van der Rohe. In semiotic solutions, it is not essential to present every detail but to focus on those necessary for the proper denotation of the sign. Therefore, a sound orientation system should mainly be based on space's most important directional elements, landmarks, reference points, etc. Essentiality can often be observed in examples of underground line diagrams, in which only the most important reference points such as the rivers or monuments appear, while the rest of the elements are reduced.

## Steerability

The last but not least feature is steerability – the sense of navigation. While the earlier features can be described as semiotic-functional, steerability is a primary function of the whole wayfinding system. Steerability

allows the user to locate himself, find the way directly to the destination, and easily process environmental cues after reading a particular sign (e.g., maps). (Foltz, 1998). This feature refers to the human perception of space. Therefore, designers should familiarise themselves with the latest research on neurology, cognitive and communication science. It would be advantageous to conduct their research on the designed space.

## Case Study

Using the features mentioned above of a good wayfinding system, the article presents the case study of implementing these features in the central bus station in Wroclaw (Poland). After its renovation, the station shares a building with Wroclavia, one of the biggest shopping centres in Wroclaw. The research involved a participatory observation method, with an observational form consisting of characteristics and their implementation in the orientation system. The study was conducted in May of 2022.

The bus station building is situated in the city centre, opposite the main railway station, and near major intra- and inter-city communication hubs. The bus station is located two floors below the ground. The building consists of 5 floors: 2 underground ones containing a cloakroom, a station car park and the station, and 3 floors above ground with shops, offices, and a shopping centre's car park. The combination of various functionalities made designing a proper wayfinding system quite challenging. At first glance, the structural plan allows one to create a mental hierarchy of the building's structure – the shopping centre takes up most of the space, whilst the station area appears to be side-lined. Due to the location of the mall in the city centre and the building's functionalities, there are various groups of users: shoppers, travellers, office workers, restaurant customers and residents taking walking shortcuts, and so on.

The signage system is not consistent for the building as a whole – the ones used at the station area differ from those used in the shopping centre. Signage in the commercial section has been implemented mainly in the form of blackboards suspended from the ceiling with bright, illuminated letters, signs and lettering on the walls, and free-standing signposts. There are also electronic stations with interactive maps of the facility. North-facing entrance is marked by a giant "Wroclavia" sign above the entrance, but the "bus station" sign is smaller, with a different typeface printed in white on a glass plate, which makes it less visible. The West entrance near the public transport stop and two north entrances are only marked as the shopping centre and lack any information about an entrance to the bus station.


Photo 3

*Wroclavia. The main west entrance near the public transport stop lacks information about being an entrance to the bus station. © Photo by the author.*


Photo 4

*Wroclavia. Signs in the shopping centre. © Photo by the author.*

The way to the station is marked throughout the gallery using suspended ceiling signs with text, an icon of a bus, and directional arrows. The directional signage does not stand out and appears second-to-last on a multi-row sign. The entrance to the station from the commercial area is marked with a "PKS" neon light, which, while being a popular abbreviation in Poland, is not necessarily straightforward for foreigners. The ticket hall contains various types of markings which differ significantly from the ones used in the shopping centre area. These include illuminated, wall-mounted departure boards, directional arrows on the floor in the form of stick-on blue lines, and wall-mounted black and white markings. Although signs in a sticker form are a good choice, they might go unnoticed, especially when the area gets crowded.


Photo 5
*Wroclavia. The north-facing entrance. © Photo by the author.*

Platforms are located at level -2, and their numbers are placed on the vertical columns next to every departure point. These markings are prominent, readable, and have appropriate contrast. "Arrivals" and "departures" directional arrows lead to the correct areas, although their noticeability might also be worse during busy times.

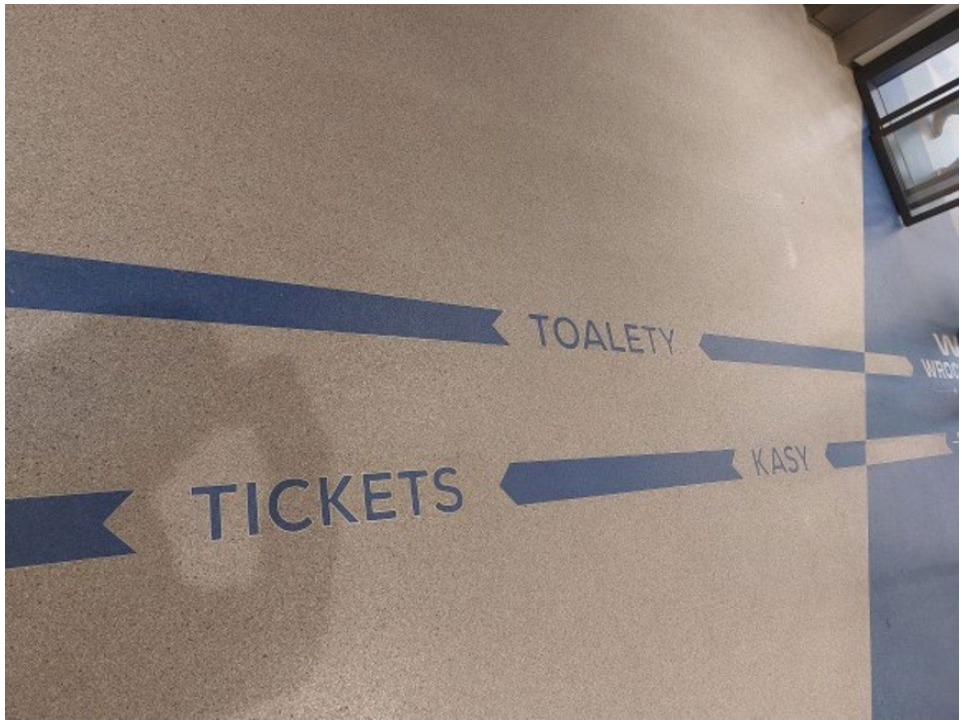


Photo 6

*Wroclavia. Directional arrows on the floor in the form of stick-on blue lines in the main hall of the bus station. © Photo by the author.*

The following table (p. 16) presents the evaluation of the theorised features. Three main points of wayfinding were considered – [E] building entrances, [W] directional arrows, and [I] markings at the station. The scale range is: excellent, appropriate, partially correct, insufficient, and poor.

In conclusion, signage used throughout the station is largely legible but appears ill-adapted to the small space. That makes some signs, for example, floor markings, unnoticeable and subject to erasure. Using both blue and black-and-white markings remains a questionable choice as they may be unintuitive. Station entrance and exterior signs are unnoticeable, and locating the entrance for travellers without a map might prove challenging.

The biggest shortcoming is the lack of directional signage from the public transport-facing entrance. It would appear that during the building's recent renovation efforts, the commercial area was prioritised, whilst the bus station became less noticeable.

Table 2

*The summary of the observation of Wroclaw's main bus station. © Kamil Olender.*

| Feature | Main result | Comment |
|---|---|---|
| Visibility | E: poor<br>W: partially correct<br>I: appropriate | Only one entrance is marked, but the sign is quite small.<br>Signage in the shopping mall does not stand out.<br>The signage is quite visible. |
| (In)visibility | E: insufficient<br>W: excellent<br>I: appropriate | Concerns only the northern entrance because of background usage. Visually coherent with the wayfinding system of the shopping centre.<br>Despite different colour scheme and styles of signs, is visually coherent with the design of the area |
| Cohesion | E: appropriate<br>W: excellent<br>I: partially correct | Not always coherent.<br>Fully coherent.<br>Lack of cohesion between blue and white markings. |
| Versatility | E: partially correct<br>W: appropriate<br>I: appropriate | Requires funding but allows for an extension.<br>Can be easily extended.<br>Can be easily extended |
| Intuitivness | E: partially correct<br>W: appropriate<br>I: appropriate | No foreign languages, abbreviations used might not be understandable.<br>Mainly well positioned.<br>Mainly well positioned. |
| Essentiality | E: appropriate<br>W: appropriate<br>I: partially correct | Mainly well-illustrated with words and simple icons<br>Mainly well-illustrated with words and simple icons.<br>Utilises visual markings instead of text. |
| Steerability | E: poor<br>W: partially correct<br>I: appropriate | Almost no signage or maps outside the building.<br>Not always visible. Not many information points.<br>Steerable during not busy times. |

## Summary

The article presents an overview of the most important theoretical, research and design knowledge about developing signage systems for different spaces. The observational method and the seven principles for designers acting in accordance with the communication design methodology do not exhaust the subject. However, the paper summarises the most frequently discussed design principles in the scientific literature and industry texts. In line with the communication design theory (Fleischer, 2007), the design stages, such as strategic planning and the creative process, should be preceded and followed by the research phase. The first step should involve an analysis of both the space and the audience that will ultimately use the signage system. Then, the designed signage should be tested by the users.

This article aims to present the complexity of the wayfinding subject and draw attention to the proper analysis of the existing situation and the current state of knowledge to achieve human-centred design solutions. This insight also extends the case of the differentiation of orientation systems for commercial and public spaces.

## References

Arthur, P. & Passini, R. (2002). *Wayfinding: people, signs and architecture*. Oakville: Focus Strategic Communications.

Bond, M. (2020). *Wayfinding: The Art and Science of How We Find and Lose Our Way.* London: Pan Macmillan.

Brunye, T. T., Mahoney, C. R., & Taylor, H. A. (2010). Moving through imagined space: mentally simulating locomotion during spatial description reading. *Acta Psychologica, 1*, 110–124. https://doi.org/10.1016/j.actpsy.2010.01.003

Casakin, H., Barkowsky, T., Klippel, A., & Freksa, C. (2000). Schematic maps as wayfinding aids. *Lecture Notes in Computer Science*, 1849, 54–71.

Farr, A., Kleinschmidt, T., Yarlagadda, P., & Mengersen, K. (2012). Wayfinding: A simple concept, a complex proces. *Transport Reviews*, *6*, 715–743. https://doi.org/10.1080/01441647.2012.712555

Fleischer, M. (2007). *Ogólna teoria komunikacji*. Wrocław: Wydawnictwo Uniwersytetu Wrocławskiego.

Foltz, M. A. (1998). *Designing Navigable Information Spaces*. http://www.ai.mit.edu/projects/infoarch/publications/mfoltz-thesis/thesis.html

Haviland, J. B. (1979). How to talk to your brother-in-law in Guugu Yimidhirr. In T. Shopen (ed.), *Languages and Their Speakers*. Cambridge, Mass: Winthrop.

Jedynak, A. (2007). *Doświadczenie i język*. Warszawa: Wydawnictwo Naukowe Semper.

Johnson, M. (1987). *The body in the mind. The bodily basis of meaning, imagination, and reason*. Chicago: University of Chicago Press.

Kövecses, Z. (2011). *Język, umysł, kultura. Praktyczne wprowadzenie* (A. Kowalcze-Pawlik & M. Buchta, Trans.). Kraków: Universitas.

Kuipers, B. (1982). The "map in the head" metaphor. *Environment and Behaviour, 2*, 202–220. https://doi.org/10.1177/0013916584142005

Lakoff, G. (2012). *Kobiety, ogień i rzeczy niebezpieczne. Co kategorie mówią nam o umyśle (*M. Buchta, A. Kotarba & A. Skucińska, Trans.*)*. Kraków: Universitetas.

Levinson, S. C. (1992). *Language and cognition: the cognitive consequences of spatial description of Guugu Yimithirr*. Working Paper. Nijmegen: Cognitive Anthropology Research Group, 13.

Levinson, S. C. (1996). Relativity in spatial conception and description. In J. Gumperz, & S. C. Levinson (Eds.), *Rethinking linguistic relativity*. Cambridge: Cambridge University Press.

Levinson, S. C. (2003). *Space in language and cognition. Explorations in cognitive diversity*. Cambrige: Cambridge University Press.

Luhmann, N. (2000). *The Reality of the Mass Media*. Stanford: Stanford University Press.

Lynch, K. (1990). *The image of The City*. Cambridge, Massachusetts, and London: The MIT Press.

Maguire, E., Gadian, D., Johnsrude, I., Good, C., Ashburner, J., Frąckowiak, R., & Frith, C. D. (2000). Navigation-related structural change in hippocampi of taxi drivers, *Proceeding of the National Academy of Sciences of the United States of America*, *97*(8), 4398–4403. https://doi.org/10.1073/pnas.070039597

Mazurek, M. & Vetulani, J. (2015). *Bez ograniczeń. Jak rządzi nami mózg*. Warszawa: PWN.

Montello, D. R. (1993). Scale and multiple psychologies of space. In U. Frank, & I. Campari (Eds.), *Spatial information theory: theoretical basis for GIS*. Berlin–New York: Spinger-Verlag.

Moser, M., Rowland, D., & Moser, E. (2015). Place cells, grid cells and memory. *Cold Spring Harbor Perspectives in Biology, 5*. doi: 10.1101/cshperspect.a021808

Raubal, M., Egenhofer, M. J., Pfoser, D., & Tryfona, N. (1997). Structuring space with image schema: wayfinding in airports as a case study. In S. C. Hirtle, & A. U. Frank (Eds.), *Spatial information theory a theoretical basis for GIS*. Berlin: Springer.

Rüetschi, U.-J. & Timpf, S. (2004). Schematic geometry of public transport spaces for wayfinding. In M. Raubal, A. Sliwinski, & W. Kuhn (Eds.), *Geoinformation und Mobilitat*. Münster: IfGI.

Tokarczyk, P. & Frank, A. U. (2008). Systemy nawigacji dla pieszych: automatyzacja pozyskiwania danych. *Archiwum Fotogrametrii, Kartografii i Teledetekcji*, *18*, 613–623.

Whorf, B. L. (1982). *Język, myśl i rzeczywistość* (T. Hołówka, Trans.). Warszawa: Państwowy Instytut Wydawniczy.

Whorf, B. L. (2002). J*ęzyk, umysł i rzeczywistość* (T. Hołówka, Trans.). Warszawa: KR.

Authors' note

Correspondence concerning this article is to be addressed to Kamil Olender,
email: kamil.olender@uwr.edu.pl