Choreматic Focus Maps[1]

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Zusammenfassung

Der folgende Beitrag detailliert die Kombination von 2 bestehenden Ansätzen zur Gestaltung von Karten unter Berücksichtigung kognitiver Aspekte: *Wegfindungs-Choreme* und *Fokuskarten*. Die Theorie der Wegfindungs-Choreme entstand aus dem Leitmotiv, die Gestaltung von Karten an abstrakten mentalen Konzepten zu orientieren. Diese Vorgehensweise wird dementsprechend auch *kognitiv-konzeptueller Ansatz* genannt (Klippel, 2003) und steht in Opposition zu gängigeren Methoden der Kartengestaltung, die eher als *datengetrieben* beschrieben werden können. Der zweite Aspekt menschlicher Kognition, den dieser Aufsatz reflektiert, wird in Zipf und Richter (2002) behandelt. In ihrer Arbeit führen sie Fokuskarten ein. Fokuskarten stellen bestimmte Teile einer Karte, die zur Lösung eines Problems wichtig sind, mit geeigneten graphischen Mitteln in den Vordergrund. Verschiedene Grade der Generalisierung und der Effekt verblassender Farben werden dazu verwendet, die Aufmerksamkeit des Nutzers auf die für die Aufgabe relevanten Bereiche der Karte zu lenken. Die Kombination dieser Ansätze reflektiert kognitive Prinzipien der Informationsverarbeitung: der Fokus auf relevante Informationen und die prototypische Repräsentation funktional relevanter Aspekte.

Abstract

This contribution details the combination of two existing approaches on providing graphical route information in a cognitively adequate way: *Wayfinding choremes* and *focus maps*. The theory of wayfinding choremes originated from the leitmotif to reflect abstract mental concepts in map-like representations. It is therefore termed the *cognitive conceptual approach* to map design (Klippel, 2003) and stands in opposition to more frequently used *data driven approaches*. The second aspect of human cognition reflected in this paper is detailed in Zipf and Richter (2002). They introduced the concept of focus maps. A focus map is designed such that users' attention is drawn towards the region of interest. Different degrees of generalization and an effect of fading colors are used to funnel users' attention. The region of interest is displayed in full detail while the rest of the map is shown such that it is easily recognized as less important. The combination of these approaches reflects cognitive principles of information processing: the focus on pertinent information and the prototypical representation of functional relevant parts of a decision point.

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Introduction

Every map reflects a conceptualizing activity put forth by a map maker or a group of map makers. The map maker, nowadays aided by all sorts of technical equipment or even ‘himself’ an artificial agent, has to make sense of the information available. Yet, the degree to which maps reflect mental conceptualizations varies. A topographic map or an automatically generated internet route map are not meant to reflect the imprecision of the world in our heads; rather they are meant to provide an exact depiction of the information that is available about the real world. In contrast, sketch maps are reflections of knowledge in our heads rather than precise depictions of the information about the environment. In between these classes of representations lies a whole spectrum of different kinds of maps, some more veridical, some more abstract. One important kind of maps are schematic maps, which are crafted as maps but intentionally distort spatial knowledge—just like sketch maps or like human knowledge is. The attractiveness of these maps—and the interest of cognitive science in them—is twofold: without any question schematic maps are perceptually easier to comprehend as they contain less visual clutter (e.g., Philips & Noyes, 1982) and focus more on a specific task at hand. Therefore, they are also referred to as task-specific maps (Freksa, 1999). Second, and more relevant for the article at hand, they are reflections of human mental concepts. This shows as we find similar knowledge representation characteristics in schematic maps and in naïve human spatial knowledge. A match between internal and external representations should therefore be easier with positive effects on the map reading process, especially by those map users not trained in the interaction with maps. There are detailed explanations why it is important to define appropriate schematizations and what the positive effects of schematic representations are (see, e.g., Clark, 1989; Tversky, 2003; Klippel, 2003).

Several approaches exist that aim at specifying representation theoretic aspects of schematic maps. We will briefly acknowledge two of them, one from cognitive psychology and one from artificial intelligence. The first is the toolkit approach by Tversky and Lee (1998, 1999). In their papers they analyzed sketch map drawings to elicit elements for a graphical toolkit for route directions as well as verbalizations for a corresponding verbal route direction toolkit. They propose a correspondence between these two toolkits and an underlying common conceptual structure from which both elements in the toolkits originate, i.e. verbal and graphical route directions are two different externalizations of the same mental concepts. The elements in their toolkits have the character of prototypes (see Figure 1).

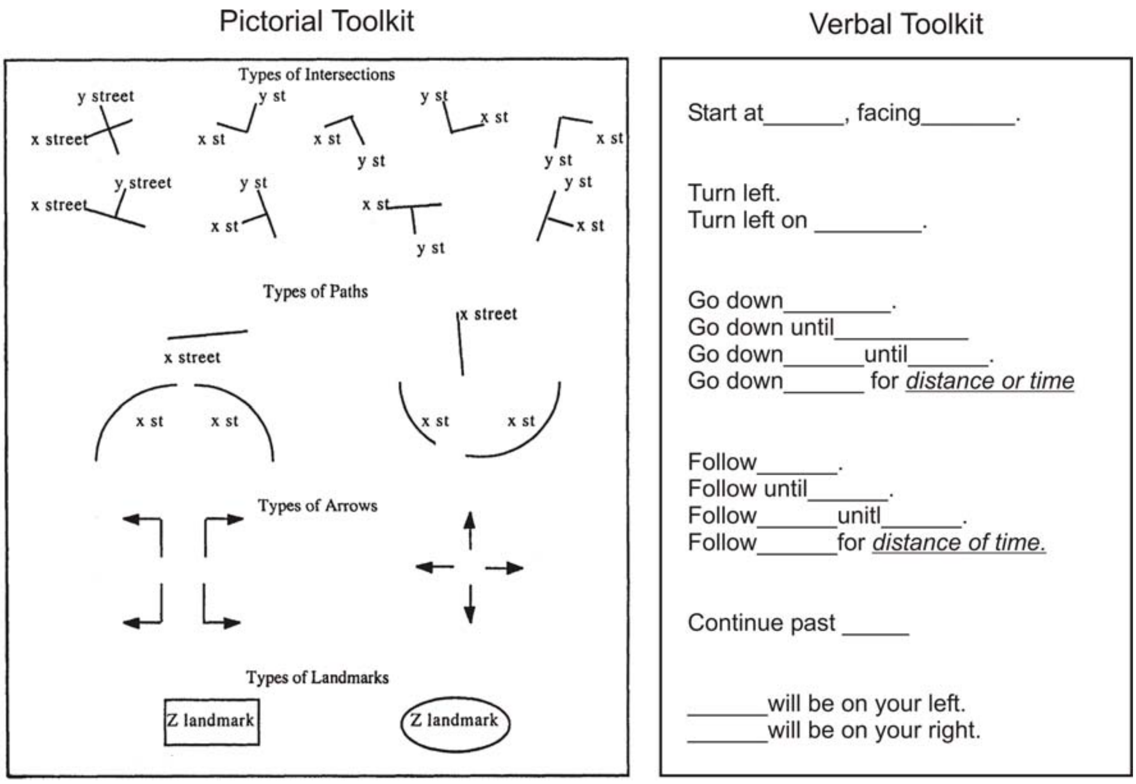

Figure 1. *Graphic and verbal direction toolkit by Tversky and Lee (1999, modified).*

The second approach we will briefly present, the one from artificial intelligence, is the aspectmap approach (Berendt et al., 1998): The basic idea of this approach is to construct maps to represent specific knowledge needed for a task at hand. This knowledge, the so called *aspects*, is extracted from existing data and is represented with a cognitively motivated level of abstraction. The aspectmap approach specifies different types of (spatial) knowledge: knowledge that needs to remain unchanged, knowledge that needs to be present but can be altered, and knowledge that can be omitted in the map. Accordingly, the aspects to be depicted are ranked in a depictional precedence (Barkowsky and Freksa, 1997) and, as a consequence, some aspects may get depicted such that they cannot be read off the map literally any more. To correctly use the map, the map reader’s assumption about this depictional precedence, i.e. whether some information is depicted veridical or not, needs to match the actual precedence used. Otherwise, map reading may lead to overinterpretation, i.e. some aspect is taken for being represented veridical while it is not. Subway maps are a good example for this approach. While the direction and distance relations between stations along a line can be distorted, e.g., to fit in a qualitative eight sector direction model, and therefore cannot be read off the map literally, the ordering information between different subway lines needs to be preserved in order to keep the maps usable, and hence can be seen to be veridical.

The Wayfinding Choreme Approach

Wayfinding choremes are defined as mental conceptualizations of primitive functional wayfinding and route direction elements. Given their focus on functional aspects, i.e. the action that takes place in environmental structures, they reflect procedural knowledge, i.e. knowledge about how to interact with the world. In this sense wayfinding choremes are schemata and do not as such concern categorical knowledge about physical spatial objects (cf. e.g., Aristotle, trans. 1941; Neisser, 1976). Wayfinding choremes can be externalized, for example, graphically or verbally. The difference to the toolkit approach by Tversky and Lee (1998, 1999) and the aspectmap approach is that wayfinding choremes—especially graphical wayfinding choremes—focus on functional aspects (cf. Klippel, 2003). The approach integrates findings from cognitive psychology and artificial intelligence.

The wayfinding choreme theory got inspired by the idea of chorematic modeling, invented by the French Geographer R. Brunet (e.g., 1987). The term choreme is a composition of the root of the Greek word for space (*chor*-) and the suffix *–eme*; thereby, a relation to language is intended. Wayfinding choremes focus on wayfinding and route directions. Most pertinent for following a route is direction information at decision points on which the research efforts are therefore placed. In Klippel (2003) the empirical basis for wayfinding choremes, i.e. the mental conceptualization of functional primitives of route direction elements, is detailed. One major achievement is a clearer distinction between structural and functional elements of route information and how this distinction contributes to a better understanding of conceptualization processes. Most approaches concerned with the visualization of route information focus on structural aspects, i.e. they are concerned with the conceptualization or depiction of objects. In contrast, the wayfinding choreme theory aims at a functional characterization of route information, i.e. it focuses on actions that demarcate only parts of a physical spatial structure. The distinction is reflected in the following definitions and in Figure 2:

> **Structure –** denotes the layout of elements physically present in the spatial environment that are relevant for route directions and wayfinding. This comprises, for example, the number of branches at an intersection and the angles between those branches.
>
> **Function –** denotes the conceptualization of actions that take place in spatial environments. The functional conceptualizations demarcate parts of the environment, i.e. those parts of the structure necessary for the specification of the action to be performed.

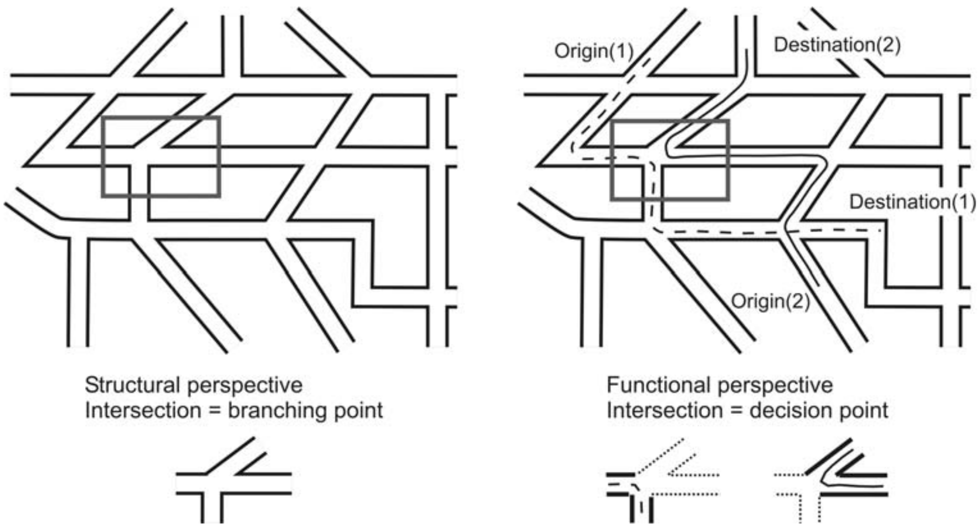

Figure 2. *Distinguishing between structural and functional aspects of route information.*

An important goal of the wayfinding choreme theory is the combination of prototypical functional and veridical information. The action that is required at a decision point is communicated by a prototypical graphical instantiation. This prototypical action representation is then embedded in a veridical spatial situation.

These theoretical remarks will be explained in the following according to their graphical implications. Figure 3 shows the results for prototypical turning directions at decision points explicated in Klippel (2003). Participants adhere to the prototypicality of the turning actions, i.e. the functional aspects of decision points. It is important to note that they do not adhere to the prototypicality of the structure of the intersections. A seven direction model for turning actions has been confirmed by these experiments and is taken as a basis for the graphical representation of turning actions at decision points. The seven resulting wayfinding choremes are employed to schematically depict route information.

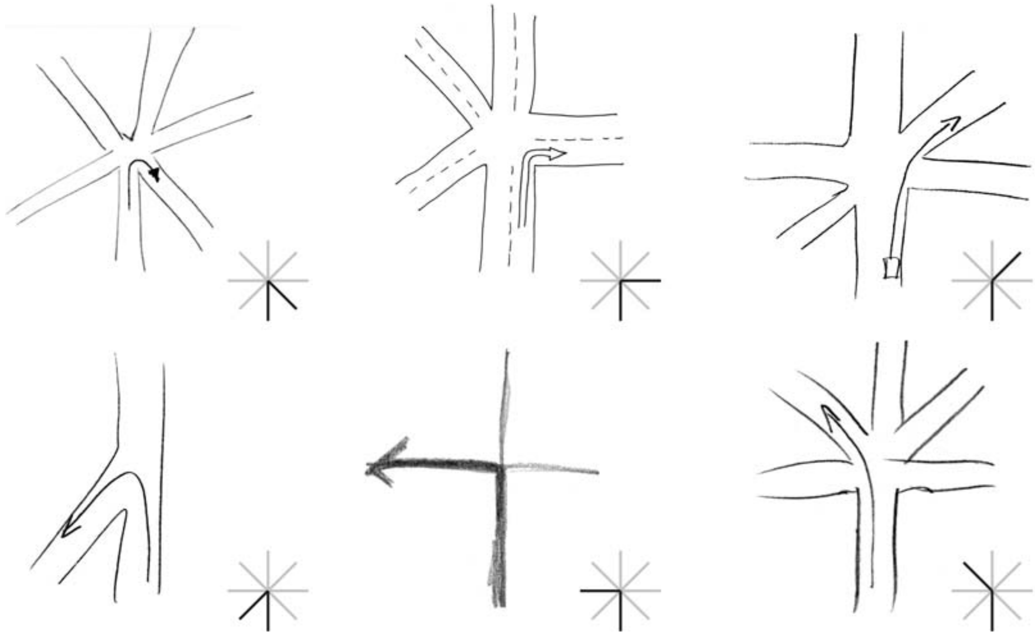

Figure 3. *The behavioral basis of wayfinding choremes (Klippel, 2003).*

Given the set of wayfinding choremes for the functional parts of decision points, we will now turn to the remaining information at a decision point. The considerations of a wayfinding chorematic depiction are twofold: First, the action that has to be performed at a decision point has to be communicated clearly. This is done by graphic wayfinding choremes. Second, over-schematization can lead to wrong inferences. Therefore, an alternative strategy is chosen: a combination of veridical information, for recognition and pattern matching, and prototypical information, for the communication of the required action. Figure 4 explicates an example of a decision point. At this decision point the functional relevant parts are replaced by a wayfinding choreme (see Figure 3), whereas the remaining branches are kept veridical, i.e. their angular information is left unchanged.

Figure 4. *Combining prototypical information (wayfinding choremes) and veridical information at decision points.*

Different to existing solutions and navigation systems, a wayfinding choreme based navigation assistance system focuses on the functional information for which prototypical graphical concepts can be determined. The conceptualization of an action that takes place at a decision point demarcates branches that are emphasized; branches that are not functionally involved are deemphasized, however, kept veridical to ensure that the corresponding intersection can be easily identified.

Focus maps

Focus maps as presented in Zipf and Richter (2002) are designed such that a user's attention is drawn towards the map part of interest. Clearly, this map part, the region of interest, depends on the task at hand; in case of wayfinding it is the area along the route to be taken. By focusing on this region, the user's mental processing of the map information is guided to the area of relevant information. The remaining parts of the depicted environment are shown in the map but are recognizable as irrelevant. They can still be used, for example, to orient oneself with respect to an area well known but not in focus. Hence, with focus maps a user's interpretation process gets inadvertently focused on the region of interest, which eases the map reading process as the amount of information to be processed is reduced.

The focusing effect is achieved by employing two techniques: a generalization to different degrees and fading colors. Map features in the region of interest are displayed veridical; generalization of these features is kept to a minimum. With increasing distance to this region, map features' degree of generalization increases, i.e. map features that are far off from the region of interest are simplified to a high degree. This is the first step in order to create a funnel towards the region of interest. The second step lies in the use of colors. Since in map making color is often used to denote a feature's class membership, it is not feasible to use totally different colors inside and outside the region of interest. But it is possible to use different shades of the same color category; bright and shiny colors for features inside the region of interest, dimmed and grayish ones for features outside of it. Again, with increasing distance the colors increasingly fade out. The combination of these two effects, increasing degree of generalization and fading out of colors, results in a kind of funnel that focuses a user's attention on the map part of interest.

Figure 5 shows two focus maps of the city area of Heidelberg, Germany (Zipf and Richter, 2002). These maps display a static situation, i.e. they do not show a route. They are divided into several concentric areas; decreasing focus is not implemented as a continuous effect. The innermost area is in focus, this is the region of interest. In these examples it is in the center of the map. Outgoing from there, with each new area the amount of detail decreases and the colors used get dimmer and lighter: the depicted buildings at the edge of the map are almost white with a simplified geometry while the inner ones have a clearly darker color and much more detail.

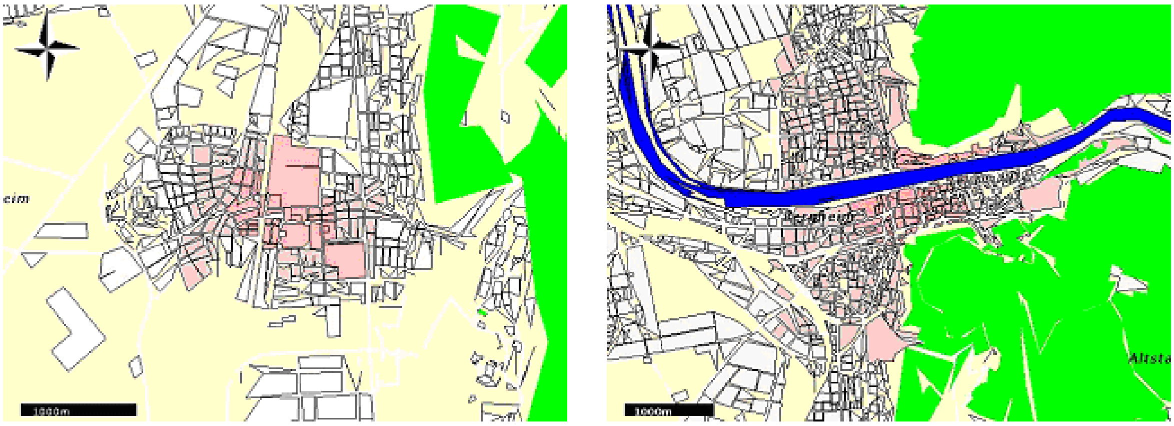

Figure 5. *Examples of focus maps (from Zipf and Richter, 2002).*

Chorematic focus maps

The two presented approaches to map design can be combined, resulting in *chorematic focus maps*. From a representation theoretic point of view these maps are well suited as wayfinding assistance. Their design process comprises four steps: first, calculating the route to be taken, i.e. a connection between origin and destination. This determines the area that needs to be depicted on the map. Second, selecting aspects relevant for the task given. These aspects are used to construct a focus map in the third step. In a last step, functional relevant parts of the selected route, i.e. the branches of a decision point that will be used by a wayfinder, are replaced by the corresponding graphical wayfinding choreme (see Figure 3 and Figure 4).

Wayfinding choremes and focus maps complement each other ideally. Both approaches draw their motivation from cognitive principles of information processing. And even though one approach, wayfinding choremes, is cognitive-conceptual and highlights the relevant information by employing conceptual prototypes and the other, focus maps, is data driven and keeps the relevant information veridical but deemphasizes other information, their combination eases information processing significantly: On the one hand, with focus maps a user's attention is drawn towards the map's region of interest. This focuses the mental process, map reading, on the location of the relevant information, its *where part* so to speak. Graphical wayfinding choremes on the other hand emphasize the functional relevant parts of decision points. Additionally, further information remains veridical. By this procedure, the route and the corresponding actions to take stick out in the map and are easy to process. Wayfinding choremes emphasize the, so to speak, *what part* of the information. In combination, we have designed a map that allows a user to concentrate *on* the relevant information *in* the relevant part of the map; thus, the cognitive effort to process the information is drastically reduced, and map reading should become easier.

Future Research Directions

In its basic variant, focus maps display the region of interest in total, i.e. the complete route—or at least a significant part of it—is presented at once to the user who then needs to cope with all of it. In an electronic navigation system the approach can be extended to just presenting the next decision due, i.e. the next decision point to further ease chorematic focus maps' usage. In this case the region of interest is around a single decision point, which is shown in full detail with the functional relevant parts substituted by a wayfinding choreme. Thus, the focus shifts after each decision point from the decision point just passed to the next and the user's attention is drawn on the decision to come which further emphasizes a concentration on the presently relevant information.

As discussed, however, by several authors (e.g., Denis, 1997; Klippel, Tappe, and Habel, 2003), several decisions are often grouped into a single concept, for example 'turn left at the third intersection'. This new concept involves at three subsequent decision points two straight movements followed by a left turn. These *higher order route direction elements* (HORDE) (Klippel, 2003) reflect an omnipresent characteristic in spatial cognition, i.e. the grouping of basic elements into chunks (e.g., Miller, 1956; Allen & Kirasic, 1985). Wayfinding choremes allow for a straightforward specification of HORDE on a conceptual level by employing a grammatical notation, the *wayfinding choremes route grammar* (WCRG). Yet, graphically, HORDE need special treatment: either several decision points need to be focused on at once, or a decision point further ahead, one that, for example, requires the turn, needs to be in focus. A detailed examination of HORDE and possibilities to adequately depict them are ongoing research.

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