

Bridging the gap between useful and aesthetic maps in car navigation systems

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ABSTRACT

Thanks to the development in the field of minicomputers high resolution photo realistic maps can be shown in real time on car navigation systems. These graphics are aesthetically pleasing to the viewer. However, they also have a high impact on the user's cognitive load so the effort for their usage rises.

This paper describes an approach for the integration of complex maps in car navigation systems without harming its function. Referring to an empirical research, we can support the thesis that the function of a map and its aesthetic perception heavily depends on the user's situational cognitive load. This thesis is confirmed by the Cognitive load theory. In the following, we introduce a concept for the adaptation of a map's function and its design according to the changing situations in the automotive context.

Keywords

aesthetics, automotive, cognitive load, digital map, map design, map function

1. INTRODUCTION

Due to the technical shortcomings of minicomputers, digital maps in cars were designed in a simple graphic style yet. Thanks to the achievements in the electronic field, it is now possible to generate complex map graphics i.e. high-resolution photo realistic maps can be shown in real time during the drive [1], [2]. These maps have a high impact on the user's aesthetic perception.

In fact, these maps contain much detailed information. Because of the high visual complexity, its usage means (erfordert) a higher cognitive from the user to process the information. Besides, the cognitive load is also affected by the current situation. Considering the automotive situation, the driving task and the constantly changing external stimuli cause a high impact on the user's mind. Since these aspects affect the user's perception, driver information systems have traditionally had a simple and efficient design. With the entering of high resolution graphics in car navigation systems, the consequences for their integration in an

automotive environment have to be determined. The paper uses a user centred approach to examine the influences of a map's visual complexity in the car. On the one hand we concentrate on the correlation between the map's graphic design and its function to support the navigation task; on the other hand we analyze the impact of a map's appearance on the user's perception.

2. EXAMINING DIGITAL MAPS

2.1 State of the art

During the last years several field tests have been executed to evaluate audiovisual methods for communicating wayfinding instructions to the driver [3]. In his research Schraggen [3] compared turn-by-turn navigation systems with cartographic maps and digital maps in order to gain knowledge about their suitability for the navigation task in the automotive context. He could prove the advantage of turn-by-turn systems over map-based systems. Thus, we can suppose that simple linear navigation interfaces have a low impact on the users' cognitive load and support to match the guiding instructions with the environment.

However, if we examine Schraggen's results in more detail, we recognize specific differences depending on the particular situations. Considering situations with complex junctions, Schraggen [3] recognized that people made fewer errors with digital maps than with turn-by-turn systems. These outcomes support the assumption that people in mobile situations not solely refer to linear wayfinding instructions, but also need information about the constellation of the space in order to gain orientation. To fulfill these information needs the linearity of turn-by-turn navigation systems is inappropriate while map-based representations are suitable to communicate areal location based information. We can summarize that the suitability of a map can not only be evaluated according to its velocity of information processing, but also to its gained space knowledge. Thus, we have to distinguish between the different map functions and the user's goal, he wants to achieve.

Studies which examined the appropriate level of abstraction in maps demonstrated that highly schematic maps suffice to solve wayfinding tasks [4]. Further more Dickmann [5] showed that people need significantly more time to extract knowledge from 3d interactive maps than from plain paper maps. However, when he compared the gained space knowledge, he found that the 3d map users obtained better results. From these facts we can infer the following two aspects:

- 1) the decrease of complexity of information eases the information processing
- 2) a high level of detail and a congruent visualization of the environment supports the mental imagery of space and the memory of space knowledge.

2.2 Examining digital maps in cars

In order to gain deeper insights in the effect of map design on the user's information processing during the drive, we carried out an empirical research. Here, we compared three different map types: an abstract map, a simple graphic map and an aerial photo map. For the test drive we decided to use a road trip (including roads and motorways) as well as a city trip. The map view was aligned to the user's position and orientation. It was the user's task to navigate to an unknown destination in an unknown area with the help of the digital map. The participants were asked to evaluate the map according to their functionality and their personal aesthetic perception.

The analysis of the results provides significant differences between the road trip and the city trip. Concerning the road trip people liked the aerial photo map most; the abstract map got the fewest positive rating. Regarding the map's support for the navigation task the aerial photo map was rated best. The simple graphic map was rated second best. The abstract map got the fewest positive rating. Concerning the city trip the estimation changed. Now the simple graphic map got the best results according to its functionality and its aesthetic perception. The opinions about the aerial photo map were conflicting. Similarly to the road trip the abstract map got the fewest rating in functionality and aesthetic perception.

Comparing the road trip and the city trip major differences can be observed. In situations of low cognitive impact people preferred the usage of complex maps and conceived them as being most aesthetic. However, in situations of high cognitive load complex maps presented a big workload for the users. Here simple graphic maps were preferred. These results nourish the assumption that the particular situation exerts high influence on the perception of map graphics. The weak evaluation of the abstract map raises the impression that little information irritates the user and evokes an uneasy feeling, even if the content is irrelevant for the current task. This becomes especially obvious in situations of low cognitive load. We can conclude that the user's demand on a map differ according to the cognitive situation and his information needs. In order to ensure the users information processing, the map design has to be adapted in its content and its graphic representation.

These insights can be underpinned by the Cognitive load theory. According to Sweller [8] the human cognitive load is additive i.e. summing up all the existing external and internal stimuli results in the human cognitive load for a particular situation. Thereby humans feel most comfortable when the cognitive load fits to their abilities. If the cognitive load is too high, humans feel overburdened, stressed and get tired. On the other hand if it is too low, humans get bored and lethargic. Both cases have a negative impact on the perception of aesthetics. Thus, for the design of digital maps for the automotive context it is not necessarily important to make them simple rather to adapt the map design to the particular cognitive situation. In doing so two aspects have to be taken into account:

- the function of a map must be adapted to the changing situation
- the graphic design of a map must be adapted to the map's function and the cognitive load of the situation

Thus, it seems, if there exist a high cognitive load, a graphic is suitable, which concentrates on the navigation task and only contains few, reduced information. By contrast, in situations of low cognitive load, the graphic should be more complex and serve the users demands on further information on the surrounding. Consequently, we search for options to vary the map design in order to serve its functionality and at the same time to adapt its visual complexity to the particular cognitive situation.

3. ADAPTATION OF COMPLEXITY

In order to vary the visual complexity of a map, we have to determine the corresponding components.

3.1 Complexity and Graphical Means

The classical cartographic graphic system consists of three basic elements: point, line and plane. If we vary the graphical elements by means of the visual variables, their visual complexity changes. A well established approach for classifying graphic variables in maps was introduced by Bertin [9]. He distinguishes the following seven graphic variables: texture, color value, color hue, size, shape, alignment and position. This document refers to Bertin's classification while it includes the variables of value and hue to the variable color. Thus six graphic variables are used here:

- texture: variation in structures and patterns
- color: variation in value, hue and opacity
- size: variation in the expansion of height, width and simulated depth
- shape: regularity of angles and amount of planes
- alignment: variation in the angle of alignment
- position: variation of the x- and y- coordinates

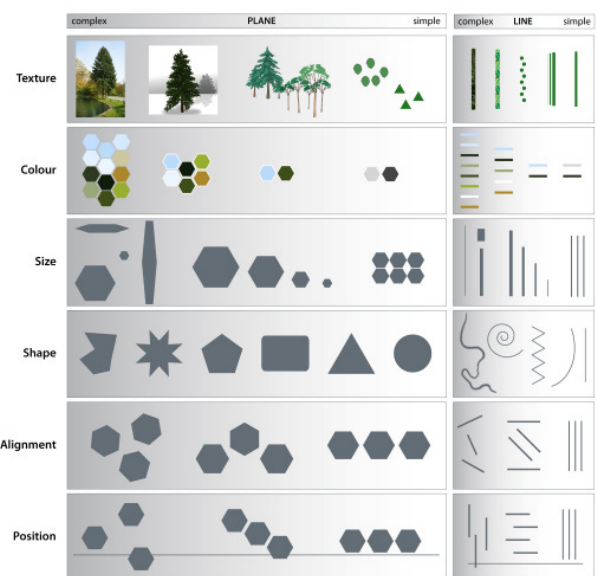


Figure 1: Stages of complexity for the basic graphic variables

If the level of detail for the single elements increases, the complexity rises. In figure 1, the different stages of complexity for the graphical basic elements plane and line are illustrated.

Besides the graphical variables the complexity of a graphic also depends on its way of projection. If we understand maps as an abstract model of reality, every map is based on a real circumstance, which it charts. The more the reality corresponds to the chart, the easier is it to match the information to reality – thus the cognitive load decreases. To determine the congruency of a map three parameters have to be taken into account (see also figure 2):

- Alignment: it describes the congruency between the map and the position of the user. The more the divergence increases the more the complexity grows. The biggest complexity is received by 180° [10].
- Perspective: it defines the angle of view a map projection takes in.
- Scale: it defines the ratio between the charted size and the real size of an object.

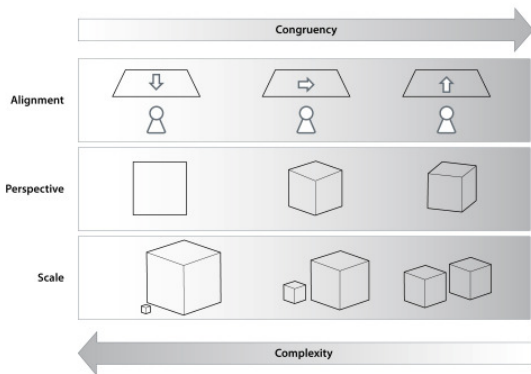


Figure 2: Stages of complexity for the way of projection

Hence, the most complex maps have a low congruency and its graphical variables have a high level of detail. The lowest complex maps have a high congruency and its graphical variables have a minimal level of detail. Furthermore, maps can have a high congruency and a low level of detail or a low congruency and a low level of detail. On the basis of these both parameters - graphical variables and way of projection - we can classify maps according to their complexity. Thus we can define four extremes:

- a) simple – less congruent
- b) simple – congruent
- c) complex – congruent
- d) complex – less congruent

For a better understanding we have drawn a matrix with four examples to illustrate the different extremes. Thereby the borders between the single sections are not dense but represent fluent transitions (see figure 3).

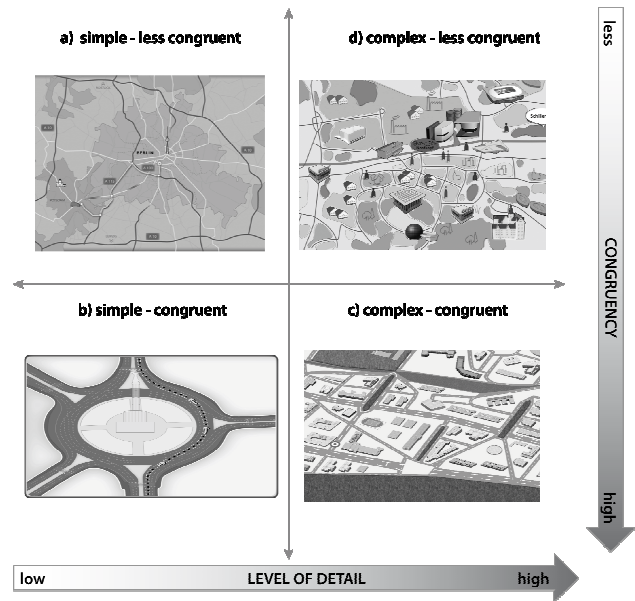


Figure 3: Matrix of maps' complexity referring to the graphical variables and the way of projection

3.2 Maps and Functionality

On the basis of the matrix the specific characteristics of the four different areas become visible. The map example in section A distinguishes itself because of its high level of abstraction and a simple graphic style. Because of the simultaneous perception of manifold information, an overview of a complex situation can be received. Also the example in section B uses a simple graphic style to simplify the view. At the same time it attempts to gain a high congruency. Because of the reduction of the details the cognitive load decreases which supports a fast and efficient processing of knowledge. The closeness to reality and the low cognitive load encourage its usage for the navigation and the wayfinding task. The map example in section C has a high iconicity because of its high level of detail and its high congruency. Thus, it allows the user to develop a detailed image of a particular place and at the same time it enables the user to locate himself in the surrounding. Because of their distance to reality the map example in section D has the highest range of freedom in design. This allows a free and creative usage of the graphical means and qualifies it for the communication of personal points of view.

Referring to the matrix the correlation between the graphical means of a map, its way of projection and its function becomes obvious. Thus, a change in the graphic style will always affect the function of a map. With the graphic adaptation we can create maps which support the varying demands of the user. Rather looking for the *one* best map, we should offer the user different maps according to the current situation and his information need.

3.3 Consistency of a Map's Graphic

In the chapter above, we have introduced a concept for the adaptation of map design in order to fit it to the changing functions and cognitive situations. Therefore, we varied the map's graphical variables and its way of projection. In order to support the user by adapting the map rather than confusing him we have to take the consistency of a graphic into account. Thus, for

integrating these ideas into a total system the scope of variety must be limited to ensure a consistency of the whole map design.

A graphic's consistency is formed by a closed picture concept. The picture concept determines the consistency of the different elements of the picture referring to the style of visualization, the imagery code, the color concept, the choice of perspective and the graphical means [11]. Although the adaptation of a map's complexity requires changing its elements, the consistency can be kept by limiting them. For a better understanding we created a sequence of graphics to illustrate the variation of complexity without harming its consistency (figure 4).



Figure 4: Example for varying a map's complexity by keeping the picture concept

The two different map types differ in its function: while the first one is suitable for the planning task, map type two allows the user to develop a detailed image of a particular place and enables him to locate himself in the surrounding. Beside the level of detail, also the alignment, the perspective and the scale is adapted. Additionally, for each map type we varied the texture and the shape of the graphic elements, which results in three different stages of complexity. As we stick to the picture concept, the consistency of the map design remains.

CONCLUSION AND PERSPECTIVE

3.4 Conclusion

Throughout the paper we have demonstrated that an appropriate map design for the automotive context has to be adapted in its function and its graphic representation according to the user's information needs and the cognitive load of the situation.

We developed a concept which allows us to adapt the map design to different map functions and at the same time vary its visual complexity. Referring to the matrix, we defined particular map functions and clarified the correlation between function and design. Additionally, we found a solution for varying the visual complexity of a map without harming its function and its visual consistency. This allows us to integrate the new technological possibilities for displaying complex graphics in car navigation systems without harming its usage for the navigation task. Furthermore, we demonstrated the theoretical outcome with the

help of the graphic representation of two map types. Each map type is shown in three different levels of complexity, while its consistency remains. To sum up, we have made a proposal for the integration of useful and aesthetic maps in car navigation systems which extends the usage of digital maps in cars.

3.5 Perspectives

We demonstrated that the new possibilities for presenting maps in cars offer manifold opportunities to support the user during the drive as well as causing a pleasing experience. Thereby we concentrated on the graphical parameters to adapt the complexity of a map. However, it has become apparent that a change in the graphical style always affects the content of a map. In a next step we will examine the content and the usage of information in the car profoundly. The internet already shows the usage of digital maps in manifold ways. The physical place attains additional facets, which can be explored via maps. We assume that the extent of functions for digital maps in a connected world will increase. Thus, we have to explore the role of maps for the communication of information in the automotive context. In doing so we will follow the user centered approach and take the users' needs into account. Afterwards these results will be aligned with the spotted possibilities of map design. Here, the developed matrix marks a first approach. Finally we will implement the spotted solutions in prototypes to perform empirical research and improve the results.

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