Small Symbols With Big Effect? – A Cognitive-Affective Perspective on Map Symbolization on Small-Sized Displays

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Abstract. Maps have become ubiquitous, ever smaller, and simpler. With this, the way we engage with maps has also changed: from deliberate, cognitively effortful processing of complex maps to fast, associative, intuitive map reading of maps of daily, quick use. Smaller displays and the simplification of maps together with the ubiquitous but incidental engagement towards them re-calls for research on visual semiotics targeted to assess the impact of map design on small displays. This research, therefore, focuses on intuitive information processing of maps, in which judgments and decisions are made automatically, rapidly, and associatively. Findings from qualitative and quantitative user studies will be discussed, targeted at exploring the effects of map symbolization on small-sized displays on map users' responses of cognition and affect.

Keywords. Visual Communication, Semiotics, Psychology

1. Introduction

Throughout the past decades, empirical research in cartography has undergone two major shifts (Montello, 2002): In its beginnings, cartographic research focused on examining the effects of map elements isolatedly. While this approach accounted for results of high internal validity, it was criticized in the 1970s and 1980s for its lack of ecological validity, claiming that by isolating visual variables, the results cannot be transferred and generalized to maps due to their more complex, holistic nature (Petchenik, 1977; Montello, 2002). This critical perspective initiated a transition in research, from testing specific map elements towards analyzing the percep-

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tion of maps as a whole. Meanwhile, while current research has made a transition from low-level perceptual approaches to higher-level cognitive approaches, the technological development in the late 1990s accounted for a second transition in cartographic research and practice (Montello, 2002): The advent of new and well-accessible technologies, software, and devices, which brought new opportunities for geo-visualization (Słomska, 2018). The accessibility and availability of web and mobile services at any time, are major advantages of this development.

At the same time, the web as a new medium to display maps constrains the design to the – at times very small – physical display size. Hence, web maps nowadays require extra attention due to their particular characteristics and limitations. Well-designed web maps can be recognized as "relatively empty" (Kraak & Ormeling 2011, p.79).

While the maps used in our daily lives have become smaller and simpler, the way we engage with maps has changed as well. Regularly we encounter web maps in daily routines, such as when reading online news or when orienting or navigating in unfamiliar environments. The level of engagement in those maps, however, varies greatly. These maps will not always be cognitively processed deliberately or in detail, but at times be processed fast, automatically, effortlessly, associatively, and intuitively (Kahneman, 2002; Padilla *et al.*, 2018).

Humans constantly respond to their environments and the stimuli therein, responding differently with respect to the type and characteristics of the stimuli exposed to (Russell, 1980; Russell and Feldman Barrett, 1999). Applying this perspective to cartography indicates that the choices on how to depict and express data will affect how a map is perceived and interpreted (Monmonier, 1996). Thus, cartographic elements and their visual parameters (e.g. shape, color, hue, size, texture, and orientation) must be carefully selected to adequately represent and correspond with the particular aspect of information to be communicated (Bertin, 1974), since "changing the form of the signifier while keeping the same signified can generate different connotations" (Chandler 2007, p.143).

Cartographic semiotics provides a framework that guides the selection for the type of visual variables to use in maps, such as when to represent a particular content by shape, color, or size (Bertin, 1974). These rules, however, do not further differentiate within each type of visual variable, such as on the effects of different colors or shape symbols on the map reader's cognition, perception, or affect. In other words, while semiotics provides a shared set of signs and rules, it does not address how choices for or the composition of graphic variables may lead to different connotations, interpretations or judgments.

The current development of highly ubiquitous, simplistic maps, of rather incidental engagement calls for research on visual semiotics targeted to reassess the impact of cartographic visual variables of these *relatively empty* maps on the map user.

2. Empirical Research

The present research focuses on the empirical study of shape-symbols and their effects on intuitive cognitive judgments and affective responses evoked by associative or low-level cognitive tasks.

In qualitative and quantitative studies, visual stimuli composed of symmetric, achromatic, geometric shapes are used to study participants' intuitive judgments and affective responses towards them. The selected visual stimuli refer to commonly used graphic variables in visual communication and in thematic cartography to indicate nominal data. In this research, geometric shape stimuli (e.g., circle, triangle, square) were studied first isolatedly, i.e., without a map context, followed by increasing the task complexity by setting the stimuli in applied scenarios and cartographic contexts.

2.1. Study 1: Cognitive Relatedness of Geometric Shapes

The first empirical study aimed at identifying the cognitive relatedness of geometric shapes and to disclose processes involved in people's intuitive cognitive judgments with respect to those shapes (for details see Klettner, 2019). The study's stimulus material comprised 12 two-dimensional, achromatic, geometric shape. All shapes were displayed in black on white paper cards. Participants were first instructed to sort the paper cards according to the shapes' similarities and later to explain their decisions. The study was conducted in individual settings and all participants, tested by the same instructor. In total, 38 individuals participated in the study (mean age M = 21.50, SD = 3.00). Each participant completed the following three tasks:

1. a free-sorting task (task 1) in which participants were instructed to sort the set of 12 geometric shapes according to their similarities,
2. a retrospective verbalization task (task 2) which aimed to identify strategies applied when grouping the geometric shapes, and
3. a labeling task (task 3) in which the participants were instructed to label each group by its most prominent characteristic(s)

Based on the results from free-sorting task 1, the frequencies of co-occurring pairs of shapes were mapped into a co-occurrence matrix. The matrix was further subjected to cluster analysis and multidimensional scaling to statistically reveal the (dis)similarities and proximities between the geometric shapes. Findings from cluster analysis revealed a three-cluster configuration, while multidimensional scaling further quantified the proximities between the geometric shapes in a two-dimensional space (see *Figure 1*).

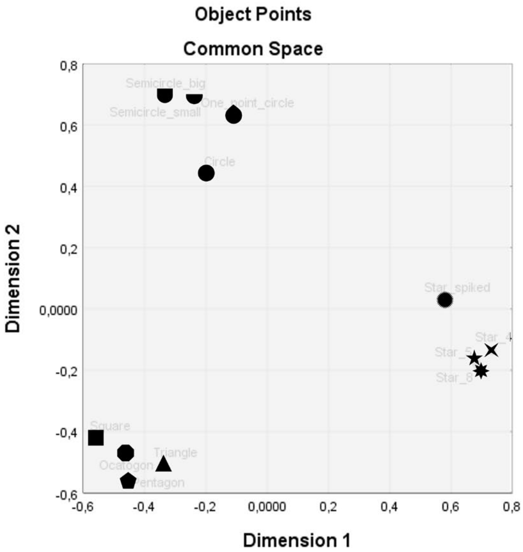

Figure 1. MDS results from free-sorting 12 geometric shape stimuli, indicating the shapes' cognitive relatedness (from Klettner, 2019).

The results from retrospective verbalization task 2 and labeling task 3 were subjected to qualitative and quantitative content analyses to identify processes involved in people's intuitive judgments with respect to the tested set of geometric shapes. Findings indicate four strategies underlying the participants' similarity judgments, that is, visual, affective, associative, and behavioral strategies.

2.2. Study 2: Affective Differentiation of Geometric Shapes

A second empirical study was conducted to further explore people's affective responses towards, again, two-dimensional, achromatic, geometric shape stimuli. The study comprised two tasks:

1. a shape evaluation task, in which geometric shapes were studied isolatedly, i.e., without cartographic context, followed by
2. a map evaluation task, in which the geometric shapes were displayed on maps

Designed as an online questionnaire, participants' were instructed to rate each shape and map stimulus by using a Semantic Differential technique (Osgood, Suci & Tannenbaum, 1967). Each shape and map stimulus was displayed successively. In total, 80 individuals participated in the study. 77 participants indicated their age (M = 22.06, SD = 3.80). A between-subject design was applied which allowed to minimize the number of stimuli ratings for each participant and to preclude participants from rating the same shapes twice in both shape and map evaluation tasks. The majority of participants used either smartphones (47.5%) or laptops (46.3%) for answering the survey. Tablet and Desktop PC were used by 5 individuals. No significant differences in participants' ratings by type of device was found according to Chi^2, at a significance level of $\alpha < .05$.

Preliminary findings strongly suggest that some geometric shapes lead to distinct affective responses and reveal unique affective shape profiles, while other shapes appear to be affectively more alike. Findings further indicate that some geometric shapes persist to evoke distinct affective responses when increasing visual complexity, such as when studying shape stimuli not only isolatedly but also in cartographic contexts. Yet, this effect was found to be of a lesser extent.

3. Conclusion and Outlook

Visual communication requires deliberate decisions to share and express information successfully. With a better understanding of map symbolization and their effects on map readers, more informed design choices can be made, allowing for effective and associative information visualization, in particular on small-sized displays. This research aims to contribute to this goal, by providing a differentiated perspective on the impact of symbolization on cognitive and affective responses.

The findings of this research strongly support the notion that even basic geometric shapes imbue particular qualities, leading to distinct associations, affective responses, and cognitive proximities. These effects were found in particular when studying shape stimuli deprived of complex visual context. Preliminary findings further suggest that some geometric shapes persist to evoke specific affective responses when increasing visual complexity, such as when studying shape stimuli in cartographic contexts. However, inasmuch as the present research contributes a cognitive-affective perspective on shape symbolization, the findings' transferability is yet limited. Future research in applied cartographic scenarios is therefore crucial to further advance our understanding of shape symbolization and its effects on the map user.

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