Emotional response to map design aesthetics

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1. Introduction

With this work in progress report we propose a novel approach to capture human emotive responses to assess map design aesthetics. Specifically, color is one of the most exciting aspects of map design, but the effect of colors on map use is also one of the least studied by cartographers (Dent, 1999: 288). While cartographers have developed principles for the systematic application of color in maps (Bertin 1967/1983), and produced widely used software to support users in selecting appropriate color schemes (Brewer, 2012), the psychological reaction to color has not been systematically studied in cartography, and cognate disciplines (Robinson, 1967).

On a general level, inspired by the tenets of embodied cognition (Wilson, 2002) our research agenda is driven by this fundamental research question: *How might display design, human emotion and affect (i.e., aesthetic response) interact with cognition and perception during spatio-temporal inference making with visuo-spatial displays?* We thus include the measurement and control of emotional activity in our research framework, as it is unclear how display design might interact with emotions, such as fear, surprise, joy etc. when viewing visuo-spatial displays. Emotions involve body changes like increased sweat secretion, by distinct bursts of sudomotor nerve activity, which follows excitation of sympathetic arousal of the autonomic nervous system. Measuring the concomitant changes in skin conductivity (phasic skin conductance responses, SCR) is an established measure of sympathetic arousal (Boucsein, 1992).

Our work fits within long-standing scientific aesthetics perception research in psychology (Berylne, 1974), and more recently, in cognitive-neuroscience (Chatterjee, 2010), which has not been adequately addressed in cartography, and cognate disciplines dealing with visuo-spatial displays. While researchers in cartography, cognitive science and psychology have started to systematically investigate spatio-temporal decision-making with maps and graphics from a spatial cognition and perception perspective, almost no respective research exists that investigates the emotional component in decision making with visuo-spatial displays. We thus propose a novel methodological framework to systematically study human emotion responses to display design decisions, and apply this framework in a first case study to investigate how humans react psycho-physiologically to unusual color schemes in topographic maps.

2. Methods

We designed a human-subject experiment to test our approach by measuring human emotive responses to a set of topographic maps with varying color schemes, inspired by the color palettes of Master Painters (Christophe, 2011). Figure 1 depicts the twelve map stimuli (A to L) employed in the experiment. We extracted colors from well-known paintings by Derain, Matisse (Figure 1L), and van Gogh (Figure 1F, 1H, 1J), and applied them to an identical vector dataset of the French city of Royan (Christophe, 2011). We also included two maps with traditional color schemes currently employed in topographic map series of two national mapping agencies in Europe, i.e., IGN France (Figure 1K) and Swisstopo (Figure 1D).

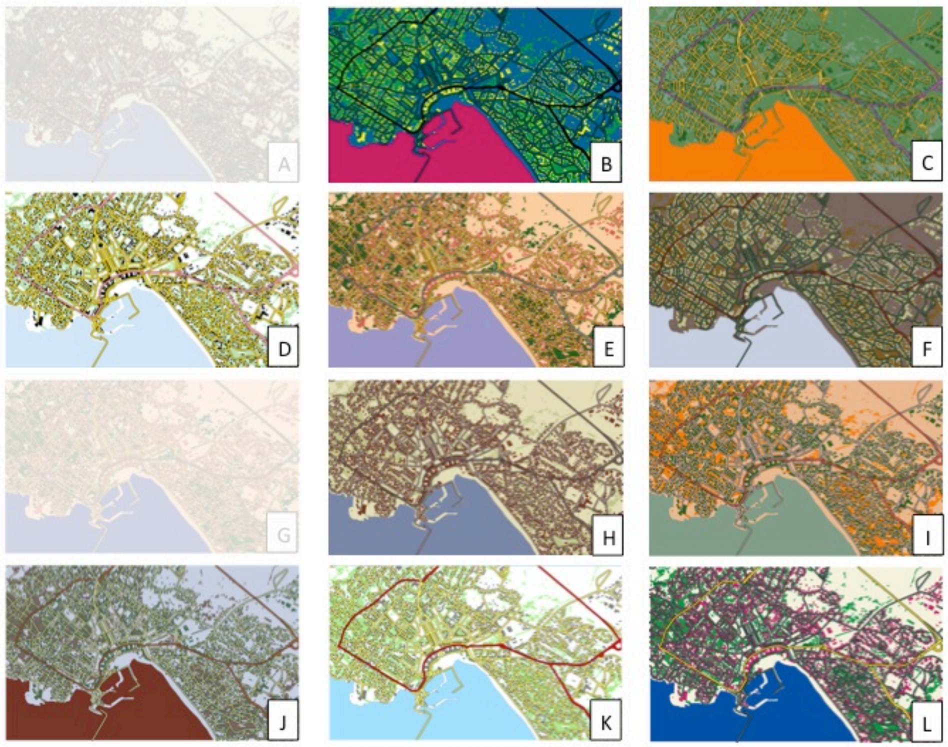

Figure 1. Twelve map stimuli used in the experiment.

Right-handed participants (N=4) recruited randomly from our own research lab at the University of Zurich (F=2, M=2) were asked to imagine that they were at an online art gallery, and told that they would be shown a series of maps of the same geographical footprint. They were asked to look at the maps as if they were visiting the art exhibition The maps were presented digitally on a computer monitor set to 1200x1600 pixel spatial resolution, with 24bit color depth. The maps were displayed automatically one-by-one for ten seconds, with an eight-second pause in between, showing a gray square of equal size, with a black cross hair in the middle.

We tracked participants' eyes while they looked at the maps, and participants also wore a wrist sensor (Papastefanou, 2009) on their left arm that monitored their psycho-physiological reactions (i.e., electrodermal activity, etc.) during the experiment. After viewing the maps, we asked participants to give us feedback on a series of Likert-scale type questions, e.g., on how they liked the colors in the maps, whether they thought that the color schemes were attractive/harmonious, and if they would use topographic maps with such color schemes. We additionally asked them to rank ten of the twelve shown map images shown in Figure 1 from least to most attractive. Participants also filled in a post-test questionnaire on their background and training. We finally interviewed them on how they felt wearing the wrist sensor during the experiment.

Although we only collected data for four participants to date, aimed at testing the robustness of the methods employed, we can already report promising results on how to systematically capture the aesthetic effects on human emotion of unusual color schemes in maps, by coupling the collection of psycho-physiological wrist sensor data together with eye tracking, and a traditional questionnaire.

3. Results and Discussion

Below we show results to date based on our four tested participants. First, we present participants' preference ratings followed by their emotional reactions, measured by phasic skin conductance responses. We excluded the more traditional looking first map (1A) and seventh map (1G) from the attractiveness rankings (i.e., grayed out in Figure 1), because they were very similar to other maps in the set. Interestingly, the two traditional topographic maps were ranked second most attractive (Figure 1K) and least attractive (Figure 1D). The map with the Matisse color scheme (Figure 1L) was considered most attractive. Figure 2 shows the aggregated ranking scores for each map, sorted from most to least attractive.

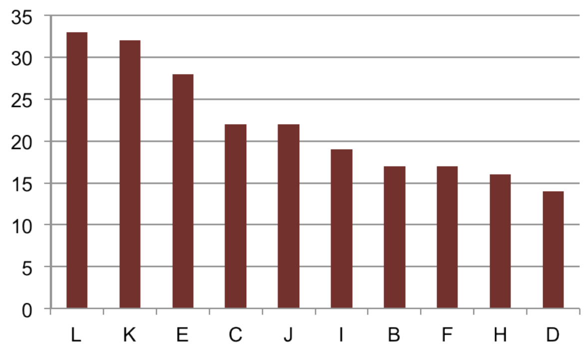

Figure 2. Participants' rankings of the maps, ordered from most to least attractive.

The top three ranked maps all show semantically correct color assignments, i.e., blue shades for water, green tints for vegetation, and a somewhat paler background for the rest, even though the color choices are unusual for topographic maps. This "overt" preference ranking is contrasted by the "covert" ranking of maps, when inspecting the emotional response data, as shown in Figure 3.

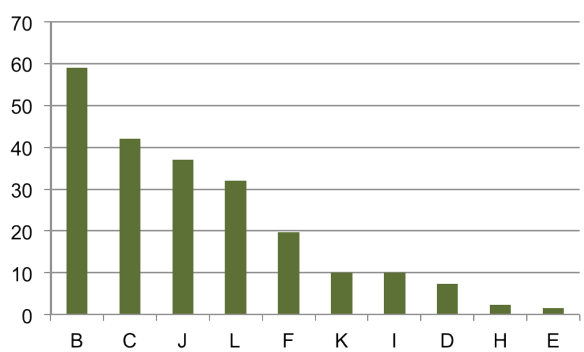

Figure 3. Emotional map rankings, ordered from most to least arousal.

First, event-related skin conductance responses (SCR) values were transformed to phi-scores using the range correction transformation procedure (Lykken, 1972), to be able to compare responses across subjects. We then computed momentary SCR response intensity. This expresses the average amount of skin conductivity increase per given time unit (i.e., one second). We then reduced the data to response peaks (local maxima) in an individual response curve (see Figure 4).

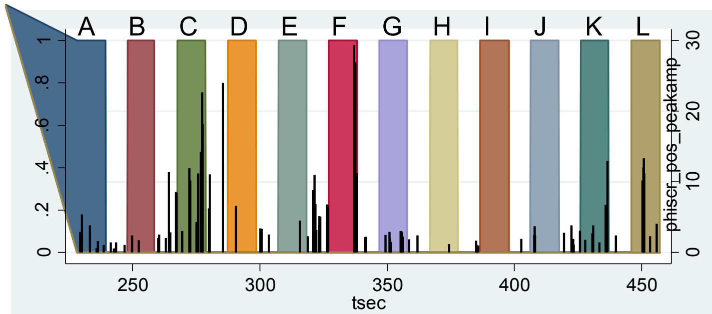

Figure 4. Individual emotional response curve with arousal peaks
(colored bands are the map viewing events A to L).

To get an overall comparable impression of the emotional responses for each of the maps, the bar graph in Figure 3 shows total phasic skin conductance change scores for the entire display duration of each map, summed across subjects and weighted by subject's individual distribution percentage.

A clear emotional ranking is revealed, with maps B, C and J arousing most emotional responses. Additional analyses of the emotional response patterns can help distinguish positive from negative emotional activity, especially when cross-validated with explicit preference ratings, or other kinds of collected human responses. The arousal signature for B, C, and J suggests a tendency for negative emotional responses. These high-contrast maps feature unconventional color schemes, with water shown in orange, brown, or pink. The blue-pink map (1B) was mentioned by all participants in the post-test interviews as being "shocking", "strange" or akin to "a glowing in the dark/night-vision" color scheme. Interestingly, these potentially negatively arousing color schemes still feature in mid-range of subjects' attractiveness rankings. The most attractive map 1L triggers the highest emotional response of the more traditional color schemes, and suggests also a positive arousal response pattern. In contrast to the participants' attractiveness rankings, the more conventional, low-contrast, and dull maps 1D, 1H, and 1E, seemed to have elicited no arousal.

As we present only results for a small sample of four subjects varying widely in gender-age status, an aggregation of the individual emotional response patterns seems not to be adequate at this stage of our research, because of the large heterogeneity. Looking at the total of responses in Table 1, we see large differences between individuals. For instance, the young female shows a significantly higher level of responsivity to the maps, than the middle-aged female, and the two young males.

Table 1. Emotional map rankings, from most to least arousal.

Young female		Middle-aged female		Young male 1		Young male 2	
Sum of phasic responses by map stimulus (see Figure 1)							
C	95.6	B	18.0	B	34.7	J	26.5
F	56.3	L	4.4	L	18.6	I	8.2
L	53.0	C	3.0	C	1.2	B	0.0
K	29.5	D	1.6	I	1.1	C	0.0
J	8.6	H	0.6	H	0.8	D	0.0
D	6.6	J	0.4	D	0.0	E	0.0
E	4.5	F	0.2	E	0.0	F	0.0
B	4.1	K	0.0	F	0.0	H	0.0
H	1.2	E	0.0	J	0.0	K	0.0
I	0.0	I	0.0	K	0.0	L	0.0
Total	259.4	Total	28.2	Total	56.4	Total	34.7

Remarkably, map 1L ranks in the top three for three of the subjects, while 1B scored in the top three for two of the four subjects.

4. Summary and outlook

We presented a systematic approach to capture and analyze emotional responses to color schemes extracted from well-known paintings by Master Painters applied to topographic maps. Firstly, our promising preliminary results suggest that human emotions can be systematically captured and meaningfully analyzed to investigate aesthetic effects of display design decisions, specifically when coupled with other evaluation methods (i.e., questionnaires, etc.). Secondly, emotional responses can be used to validate the application of unusual and artistic color schemes to conventional topographic maps. This can be particularly useful to better understand how and why different map color schemes applied to identical geographical data can influence differently the rated trustworthiness and likeability of a map display, as Skarlatidou et al. (2011) and colleagues have found. Thirdly, our results also suggest that cartographic expertise triggers emotional responses to unusual color schemes in predictable ways, which requires further empirical investigations. Our methodological framework may also be used to study other design aesthetics criteria, such as saliency, balance, complexity, harmony, etc. in maps. It may be additionally employed for studying map-based decision making contexts where the influence of emotional responses to decision-making might be critical, such as under stress (i.e., real-time navigation, search and rescue, etc.), or due to varying motivations (i.e., survival, boredom, leisure, fun, etc.). In doing so, we hope to provide a generic approach to disentangle perceptual and cognitive, from emotional and affective aspects of human-display interactions, specifically when assessing the aesthetic qualities of visual displays used for spatio-temporal inference making.

5. References

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Acknowledgements

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