Happy is Pink: Designing for Intuitive Use with Color-to-Abstract Mappings

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Abstract
My research aims to provide a theory of how abstract, intangible information is linked to specific color attributes in order to deliver guidelines that facilitate the design of intuitive human-computer interaction in abstract domains. The theory predicts which color attributes induce information processing and behavior that is consistent with these color-to-abstract mappings. As a result, designers do not need to rely on exploratory research but can systematically use color as a means to design for intuitive interaction.

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H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces – Theory and methods

Research Situation
I am a full-time research assistant at the chair of Psychological Ergonomics at the University of Würzburg, Germany. I teach courses in the Human-Computer-Systems Undergraduate Program. My responsibilities include giving lectures, tutorials and project work on ‘Usability and Software Ergonomics’ as well as ‘Methods for User-Centered Design’. I would identify myself as a psychologist with a strong interest in HCI, especially in the design of intuitive interaction. I started my PhD in January 2013 and anticipate completing my thesis in summer 2015. By attending the Doctorial Consortium I wish to gain interdisciplinary feedback on my approach to mapping abstract information on color, as well as a boost in inspiration as regards the possibilities of how to apply color-to-abstract mappings for the design of intuitive human-computer interaction.
Context and Motivation
Our digital world is full of abstract information and intangible meanings, such as feelings, values or abilities, also need to be expressed in human-computer interaction. Concrete design guidance on intuitive interaction with abstract information is rare [3]. However, a promising approach to transferring abstract meaning into intuitive human-computer interaction is to use physical-to-abstract mappings, so-called image-schematic metaphors [e.g., 7]. Image-schematic metaphors [6] describe environmental experiences that ground abstract concepts with which they are co-experienced. For example, the frequent experience of warmth together with social closeness ties the physical experience of temperature to social proximity, described by the image-schematic metaphor INTIMATE IS WARM – DISTANT IS COLD. This unconscious metaphorical mapping defines the relationship between the abstract representation of social proximity and the physical attribute of temperature. It is so strong that the mere perception of a higher temperature evokes metaphor-consistent affect, cognition, and behavior [e.g., 5].

Following conceptual metaphors in interaction design leads to intuitive human-computer interaction [e.g., 4]. However, it is technically challenging to dynamically manipulate physical object attributes (e.g., weight, temperature, surface properties). This PhD thesis therefore aims to investigate whether another powerful form of communication, which is nevertheless easily implemented and inexpensive, is systematically linked to abstract concepts via image-schematic metaphor as well: color.

Background and Related Work
Color plays a vitally important role in our world. Color can affect perception, cognition and behavior. It can alter judgments of weight and size, attract attention or raise the blood pressure. Although color is a ubiquitous perceptual experience, little scientific theoretical or empirical work about the influence of color on psychological functioning was conducted in the past century [1]. Research on this topic has only slowly emerged during the past decade. Theoretical considerations as to where color associations come from and why color effects occur, focus on biology-based and learned sources of color associations and effects, claiming that color associations are the product of repeated couplings between perceived colors and particular co-experienced properties of the world and are context-specific [2]. Couplings of physical attributes and colors can also be found in language (“a painting in heavy colors”, “a cold blue”) and have received a lot of empirical investigation (e.g., [8, 9]). Due to the lack of a theory that generates clear hypotheses on which color attributes are linked to particular abstract information, only few authors have sought to investigate this field. Currently, research mainly focuses on the signal value of colors, especially red [1], and some authors have demonstrated that black and white are, as a consequence of learning, linked to abstract concepts of morality [e.g., 10] and happiness [e.g., 11]. However, whether these effects are culturally specific or not as well as their application in designing intuitive human-computer interaction has been greatly understudied.

Statement of Thesis or Problem
Is abstract information such as social proximity, importance or power, linked to specific color attributes
via image-schematic metaphor? If so, a variety of precise hypotheses about color-induced associations that should facilitate information processing and behavior consistent with these associations can be generated (e.g., because color temperature is associated with temperature, and temperature is in turn associated with social proximity, red and blue are associated with social proximity as well). By systematically identifying links between colors and abstract information using image-schematic metaphors, the hypothesis of this research is that the application of color-to-abstract mappings in interface design will result in a more intuitive human-computer interaction. In addressing the hypothesis, the following research questions will be answered: (1) Which physical attributes are associated with color attributes and do these physical-color associations vary across different countries? (2) Which color attributes can function as a source domain for abstract information? (3) Do color-to-abstract mappings qualify as guidelines for the design of intuitive use in abstract domains?

**Research Goals and Methods**

The main research goal of the PhD is to investigate whether color-to-abstract mappings lead to intuitive human-computer interaction in tasks where abstract information is involved. In order to tackle this research goal of linking colors to abstract information, preliminary work on the relation between physical attributes and colors is required (1). Therefore, a literature review will be complemented by an online survey in which participants rate how well different physical object attributes match different colors (varying in hue, saturation and brightness). To check the cross-cultural stability of the derived physical-color associations, the same survey is replicated in other countries. Next, a literature study on conceptual metaphors and linguistic analyses in three languages (English, German, Japanese) will identify abstract target domains that correspond to the physical source domains identified in the survey (2).

At the core of my work selected examples of the derived color-to-abstract mappings will then undergo empirical validation in subsequent HCI experiments. E.g., if participants have to select which of two colored objects corresponds most closely to a given adjective (e.g., important), participants will most probably choose the object in metaphor-consistent color (e.g., the object in a heavy color will be preferred over the object in a light color, according to the metaphor IMPORTANT IS HEAVY – UNIMPORTANT IS LIGHT). If these color-to-abstract mappings are applied to user interface design, participants should be faster, make fewer errors, require less mental effort and prefer user interfaces that are consistent with color-to-abstract mappings (3). Finally, empirically validated color-to-abstract mappings will be formulated as design guidelines to facilitate the design of intuitive use in abstract domains (3).

**Dissertation Status**

After researching literature about the relationship of physical attributes and colors, I conducted a survey in which 112 German undergraduate students rated how well 27 colors (varying in hue, saturation and brightness) match 30 different physical attributes (e.g., old, heavy, far, warm). A multiple linear regression analysis revealed the most important color attribute(s) for each physical attribute - mostly lightness and saturation. The survey results were replicated with 80 Japanese undergraduate students. Spearman's rank
correlation coefficients were calculated between the rankings of German and Japanese subjects. On average, correlation coefficients revealed very strong relationships, which were highly significant (1). The ongoing literature study and the linguistic analysis of 16 physical attribute dimensions have revealed 66 image-schematic metaphors so far (2). In summary, the results indicate that physical attributes are associated with color attributes (mostly saturation and brightness), and these physical-color associations are similar in the case of two different countries, providing first evidence for human universals. My research in the next two years will examine whether color is also associated with abstract information via image-schematic metaphor and if the application of color-to-abstract mappings leads to intuitive human-computer interaction in abstract domains (3). By the time the Doctoral Consortium takes place, I will have conducted two experiments to test the hypothesis that color-to-abstract mappings facilitate intuitive interaction and thus I am eager to discuss the results and get feedback and suggestions concerning future experiments.

**Expected Contributions**

The expected contribution of this research is to provide a theory of how abstract, intangible information is mapped on color attributes. The validity of selected color-to-abstract mappings derived from this theory will be empirically tested, resulting in guidelines that can help to facilitate the design of intuitive human-computer interaction in abstract domains.

**References**


