This is the peer-reviewed version of the following article:

Jonauskaite, D., & Mohr, C. (2022). Discussing color representations and implicit assumptions in Schloss et al.'s (2020) study on conventional notions of color-emotion associations. *Color Research & Application*, *47*(6), 1224–1228. https://doi.org/10.1002/col.22815

It has been published in final form at https://doi.org/10.1002/col.22815.

Color Forum: Discussing color representation and implicit assumptions in Schloss et al.'s (2020) study on conventional notions of color-emotion associations

Domicele Jonauskaite[1,2]* and Christine Mohr[1]

[1] Institute of Psychology, University of Lausanne, Lausanne, Switzerland

[2] Faculty of Psychology, University of Vienna, Vienna, Austria

* Corresponding author: Faculty of Psychology, Department of Cognition, Emotion, and Methods in Psychology, University of Vienna, Liebiggasse 5, 1010 Vienna, Austria.

Domicele.Jonauskaite@univie.ac.at

ORCID: 0000-0002-7513-9766

Acknowledgements: We thank the Swiss National Science Foundation for providing financial support to D.J. via the Doc.CH and Postdoc.Mobility fellowship grants (P0LAP1_175055; P500PS_202956) and to C.M. via the project grant (100014_182138). No conflicts of interest are declared.

Abstract

After controlling for lightness and chroma statistically or colorimetrically, Schloss et al. (2020, *JOSA A*) showed that yellow hues were not judged to be happier than blue hues. They concluded that high lightness and high chroma rather than yellow hue drive yellow-happy associations. We agree with their main conclusions but wish to expand on two underdeveloped discussion themes: i) the notion of experience vs. concept, and ii) implicit assumptions. Our commentary highlights the complexity of psychological studies on color-affect associations, including possibilities of alternative data interpretations and directions for future studies.

Main text

Schloss, Witzel, and Lai[1] tested associations between yellow and happiness[2–5] and blue and sadness[3,4,6]. They hypothesized and confirmed that yellow scored high on happiness because of its lightness and chroma, and not because of its yellow hue. When lightness and chroma were controlled statistically or colorimetrically, yellow hue did not receive happier scores than blue hue. These results confirmed that light colors are thought to be positive and dark colors to be negative, irrespective of hue[4,7,8].

Schloss et al.'s[1] article is a prime example of a systematic and thorough investigation into mechanisms driving color-affect relationships. In this case, the authors experimentally dissociated a unique contribution of hue from the other color dimensions – lightness and chroma. We most appreciate and welcome their study, which we read very closely. Actually, we became so stimulated by their article that we decided to write this commentary. We extracted two discussion themes we felt could be further developed, namely i) experience vs. concept, and ii) implicit assumptions.

Experience vs. Concept

In our studies, we constantly ask ourselves whether we are testing i) what people see or how people think about color[5]; and ii) what people feel or how they think about this feeling[9]. Schloss et al. face the same challenge. They acknowledged testing "semantic associations between colors and emotion words", not the "effects of color on emotion"[1] (page 813). Later, however, the authors discussed studies testing color associations with felt emotions[9] and emotion concepts[4,10], as if the respective results can be compared[1] (page 819). For now, there is little evidence to suggest that conceptual color-emotion associations translate into color impacting emotions[11]. We look forward to studies that inform on this matter.

Schloss et al.[1] precisely controlled color dimensions to achieve the highest precision of color presentation. In this commentary, we wish to add that this high precision does not have to be essential or key to studies on the affective connotations of colors. Recent studies showed that emotion

associations with focal colors and basic color terms were highly similar, at least in trichromatic participants [5,12]. Consequently, seeing a color physically is not decisive for associations between colors and emotions. It was sufficient that the color concept had been activated, for instance, via a color term. These results were true for adults with and without intact color vision, and when dealing with easily recognizable colors.

To further develop this argument, we remind readers of the difference between "hue" and "color". We see colors as combinations of hue, chroma, and lightness. Hue is what laypeople refer to as "color" (e.g., red, blue, see ref [13]). People name similar hues by the same color term, but not *all* colors with a particular hue are named with the same color term. For instance, dark yellow hue is usually labelled as *brown*, while light red hue as *pink* [14]. Schloss et al.[1] had participants evaluate color patches as yellow vs. blue, or green vs. red. Participants perceived "yellow" when evaluating light yellow patches but not when evaluating dark yellow patches (Figs 4 and 6 in ref [1]). Also, participants associated happiness only with the light but not dark yellow patches. We wonder whether it is justified concluding that "yellow" was not associated with happiness, when "yellow" was actually not *yellow* but likely *brown*.

Notably, *brown* bears connotations of disgust[6,15], boredom[16] sadness[10], but not of happiness (see also Fig 1). In their introduction, Schloss et al.[1] appreciated the fact that dark yellow is frequently named as "brown" (page 814). The same is true for their result section (pages 817-818), but, in our view, this possibility was underdeveloped in their discussion. Thus, we wanted to highlight that crossing a naming boundary from "yellow" to "brown" might impact color-emotion associations, and that this could have been tested in the current case. Such a possibility should be addressed empirically in future studies.

Implicit Assumptions

Happy-sad scale. In Schloss et al.'s[1] study, color-affect associations were analyzed on a one-dimensional scale anchored with the terms "happy" and "sad" at opposite ends. In Experiment 1, data were collected on separate happy and sad scales, but later combined due to a high negative

correlation[1] (page 815). In Experiment 2, data were directly collected using a single happy-sad scale. This approach suggests that "happy" is opposite to "sad" (i.e., more happiness results in less sadness). The authors used the two terms as antonyms, such as here, "colors with blue hue were no sadder than colors with yellow hue, and in some cases, colors with blue hue were actually happier" [1] (page 813). While some affective scientists agree that positive and negative emotions are inversely related [17], others believe they should be treated separately[18,19]. One can feel happy and sad at the same time[18], one can derive pleasure from sad music[19], and associate both positive and negative emotions with the same color[15]. These are just a couple of examples showing that despite a strong negative correlation, these affective concepts should be treated independently. Such a design would avoid a possibility that an effect remains undetected because of one-dimensionality assumptions and leaves open a possibility to also consider interactions.

In addition, the happy-sad scale made us wonder what it actually measures. First, happiness is a positive, but also high arousing and powerful emotion. Sadness is a negative, but also low arousing and low power emotion[20]. Therefore, the happy-sad scale contrasts the affective dimension of valence as well as the affective dimensions of arousal and potency. Thus, in the end, we cannot be sure whether the results are due to variations in valence, arousal, or potency. This possibility seems justified, because differences in arousal and potency, in addition to valence, impact color-emotion associations[8]. Furthermore, the happy-sad scale might measure broader constructs beyond the three dimensions, such as approach-avoidance, pleasantness-unpleasantness, or even like-dislike (i.e., preference). To further improve the understanding of the affectivity of colors, studies should more carefully contrast these different affective concepts, ideally within a single study.

Matching colors to multiple emotions. The narrative used in Schloss et al.'s study [1] risks giving the impression that matches between yellow-happiness and blue-sadness are exclusive. In their introduction, the authors talk about color associations with emotions. For instance, they write "it is unclear whether "yellow" is associated with happiness (or joy) and "blue" with sadness because of the hue or lightness attributed to the terms "yellow" and "blue."" [1] (page 814). Considering that a number

of earlier studies assessed associations between colors and emotions [4–6,10,15], it would be reasonable to assume that Schloss et al. would also test such associations. However, later on, the authors phrase their hypothesis in terms of a comparison between yellow and blue hues. As such, they set out to test whether "yellow hues were happier than blue hues when lightness and chroma were controlled" [1] (page 814).

We agree that their approach is appropriate to test their hypothesis as the happy-sad scale allows for both yellow and blue hues to be evaluated as being equally happy (or sad). Nonetheless, assessing a color on a happy-sad scale does not allow for the possibility to measure mappings between this color and multiple emotions or other affective dimensions. For instance, previous studies showed that blue was associated with sadness[3,4,6], but also with calmness[4,6,16], relaxation[4], relief[5,15], contentment[4,5,15], happiness and joy[4,15,16]. *Blue*, *yellow*, and *brown* being the pertinent colors to our argument, we here present own data to further illustrate our point (Fig 1, see ref. [15]). Participants came from 30 nations, including participants from the USA). Our data highlight that the terms *blue* and *yellow* mainly evoked positive associations, the term *brown* mainly evoked negative associations. Considering the diverse emotion associations with *blue*, it comes with little surprise that blue hues were not evaluated as particularly sad. Rather, as expected, both yellow and blue hues, especially light ones, were evaluated as happy. Associations with multiple emotions could provide an alternative explanation of why yellow hues, when controlled for lightness and chroma, did not score happier than blue hues.

Closing remarks

Psychological studies on color-affect associations are not trivial. First of all, working with color requires a solid understanding of color in the visual and conceptual domains. Handling subjective experience and conceptual understanding is also a challenge when manipulating affect. From our reading, Schloss and colleagues [1] approached the study of color-affect associations from a predominantly visual perspective. Whilst the authors introduced some challenges when studying color, and mentioned

color naming, we wished to extend on the links between color perception, color conceptualization and naming.

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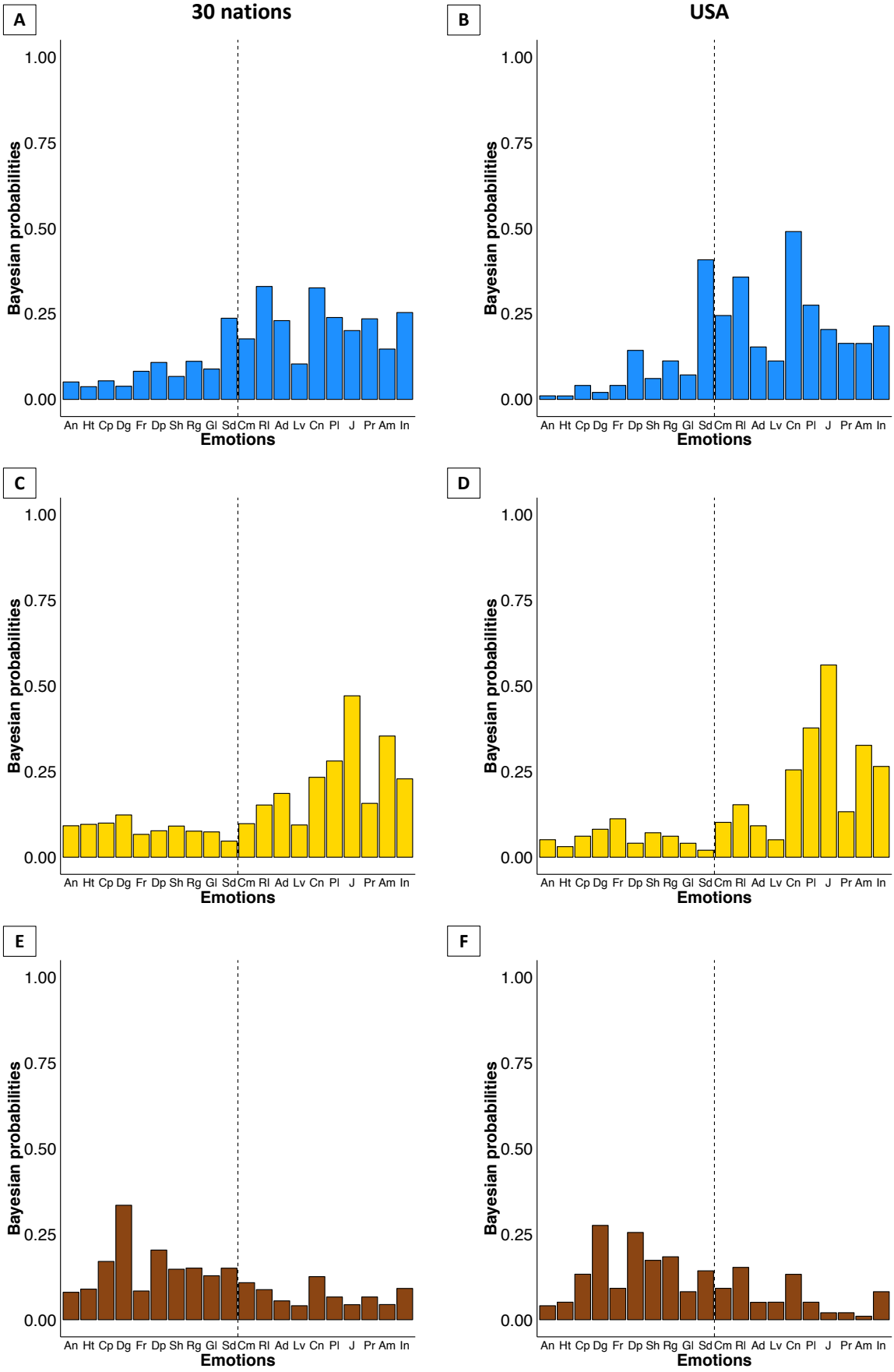
A
30 nations
B
USA
C
D
E
F
Bayesian probabilities
1.00
0.75
0.50
0.25
0.00
An Ht Cp Dg Fr Dp Sh Rg Gl Sd Cm Rl Ad Lv Cn Pl J Pr Am In
Emotions

Fig 1. Emotion associations with color terms *blue* (A & B), *yellow* (C & D), and *brown* (E & F) in 30 nations including the USA (*n* = 4598) and the USA separately (*n* = 96) (data taken from [15]). Y-axis displays Bayesian probabilities of each emotion being chosen, 1 = highest probability, 0 = lowest probability. X-axis displays emotions, abbreviated as such: An = Anger, Ht = Hate, Cp = Contempt, Dg = Disgust, Fr = Fear, Dp = Disappointment, Sh = Shame, Rg = Regret, Gl = Guilt, Sd = Sadness, Cm = Compassion, Rl = Relief, Ad = Admiration, Lv = Love, Cn = Contentment, Pl = Pleasure, J = Joy, Pr = Pride, Am = Amusement, In = Interest. Emotions are separated into positive (right) and negative (left) emotions by a dashed line. Colors are used for visualization purposes only.