To see or not to see: Importance of color perception to color therapy

Domicele Jonauskaite, Irina Tremea, Loyse Bürki, Cécile Ndeyane Diouf, and Christine Mohr

Institute of Psychology, University of Lausanne, Switzerland

Corresponding author:

Domicele Jonauskaite

Institute of Psychology

University of Lausanne

Quartier Mouline, Bâtiment Géopolis

CH-1015, Lausanne, Switzerland

+44 21 692 32 52

Domicele.Jonauskaite@unil.ch

ORCID: 0000-0002-7513-9766

Abstract

Color therapy, healing through color, supposedly works through the physical exposure to color. In two studies, we assessed stress and anxiety reduction after color exposure using a commercially available relaxation-through-color routine. Participants either completed the full procedure looking at the accompanying color disks or a white patch. In Study 1 (longitudinal), 60 participants completed the routine three times, each testing session separated by a week. In Study 2 (cross-sectional), 63 participants completed half of the trials once. In both studies, we recorded a decrease in stress and anxiety levels comparing before-after scores. In Study 1, we recorded incremental decreases with each week. Crucially, decreases were the same whether participants i) physically saw colors or not, and ii) completed the full or shortened version. We conclude that other factors but physical exposure to color explain changes in affective states associated with this and probably other color therapy routines.

Keywords: chromotherapy, color interventions, color psychology, health, meditation, body-mind

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Introduction

Popular understanding widely assumes that exposure to color brings about psychological effects (e.g., change in mood and behavior). One can read, for instance, that, "Colors are very important in our lives as they directly influence our well-being and mood. Each of us has his own range of popular colors and colors that do not respond to him. Consequently, the colorful world around us affects our health" [1]. One can also read that each color has a unique psychological effect. For instance, red is believed to excite and activate, blue to calm and relax, green to offer equilibrium, yellow to uplift [2]. Such assumptions manifest also in the health sector [3,4]. Many forms of color therapy, also called chromotherapy, promise enhanced well-being, or even healing, through exposure to color in general [5,6] or through exposure to particular color(s) [3,7,8]. At present, however, empirical evidence for such beneficial effects are weak, as most forms of color therapy have not been submitted to scientific investigation [9]. To this end, we took a commercially available form of color therapy [5] to empirically assess its effectiveness on stress and anxiety reduction by focusing on the importance of actually seeing colors when engaging with this routine.

Proponents of color therapy presume that physical and biological mechanisms underlie the effectiveness of color therapy. It is assumed that vibrations of color (presumably different frequencies/wavelengths of visible light) influence one's body and mind (e.g., [10]). Colors should then "generate electrical impulses and magnetic currents or fields of energy that are prime activators of the biochemical and hormonal processes in the human body, the stimulants or sedatives necessary to balance the entire system and its organs" ([11], p. 482). Yet, such and other claims [1,3,10] are difficult to test due to the vagueness of the described mechanisms. Taking the example from two sentences above, researchers are halted by an array of open questions. For instance, the exact meaning of "electrical impulses and magnetic currents or fields of energy" is not clear. Maybe, one could assume that here we are dealing with action potentials generated in the nervous system or certain electromagnetic external stimulation. We would have to decide which sensory system is supposed to be affected by these impulses – the eye, the skin, the respiratory system, the brain, etc. We would have to consider the "biochemical and hormonal processes" at work. Do they relate to specific neurotransmitters (e.g., serotonin plays a role in depression [12]), specific hormones (e.g., adrenaline is involved in stress reaction [13]), specific ions involved in neurotransmission (e.g., sodium and potassium are crucial for action potential generation and synaptic transmission [14]), or something else? Finally, we would have to decide what a "balanced" system means. The lack of scientific precision leads to claims that can neither be confirmed nor disproven in a systematic, scientifically valid and reliable way [1].

To evaluate potential links between color and positive intervention effects, we consider independent studies that systematically assessed if color could be indicative of felt affective states (mood). For instance, Carruthers and colleagues [15] presented participants with an array of colors and asked them to match a color to their current mood. Participants without a mood disorder matched bright colors (in particular yellow) to their current mood while anxious and depressed participants matched different shades of grey to their current mood (also see [16]). In another study, Jonauskaite and colleagues [17] experimentally induced different mood states in healthy participants. The authors asked participants to match a color from an unrestricted array of colors to their current (induced) mood. Participants often chose shades of yellow when feeling joy, muted colors (especially yellow-green) when feeling relaxation, and dark shades of grey when feeling fear or sadness. These studies

[1] One should note, however, that colour therapy is not the same as light therapy, which works through better-defined biological mechanisms but does not necessitate colour perception per se. Exposure to light has been shown to improve mood disorders [62,63], increase alertness, wakefulness, and concentration [64] as well as modulate emotional brain processing [65]. Beneficial effects of light are largely mediated by intrinsically photosensitive retinal ganglion cells (ipRGCs) in the retina. IpRGCs produce melanopsin and connect with numerous brain regions involved in regulating circadian rhythm [66]. IpRGCs are most sensitive to short wavelength (blue; ~460 nm) light, which is not the same as being sensitive to colour blue. Rather, it should be referred to as blue-enriched light (i.e., all or most frequencies of the visible light spectrum are present but the frequencies in the blue range are relatively over-represented).

demonstrate systematic mappings between current mood and color choices. Nevertheless, these studies do not allow inferring the reverse relationship; that is, that an exposure to a specific color would cause a specific mood.

Other studies targeted causal relationships by testing the impact of color on physiological arousal and self-reported affect or behavior. In the case of physiological arousal, studies used recordings of electrodermal activity [18], cardiac response [19], respiration [20], or electroencephalography (EEG) [21]. The goal of these studies was to assess whether certain colors (warm – red, orange, yellow) were more arousing than others (cool – blue or green). Results are so far inconclusive. Several studies demonstrated that warm as compared to cool colors increased heart rate [19], skin conductance [20,22] or EEG responses [21]. Other studies, however, failed to observe measurable differences between these colors on one or several physiological parameters [18,20,23–25]. Finally, additional studies reported effects that were opposite to the originally expected effects [21,26]. Wilms and Oberfeld [18] concluded that saturation and brightness were better predictors of physiological arousal than hue (see also [23]). Presumably, colors of any hue may arouse human physiology if these colors are sufficiently saturated and/or bright.

In the case of self-reported affect or behavior, some researchers tested if brief exposure to color would have behavioral consequences. For instance, in a series of studies, Elliot and colleagues [27] assessed whether red, which is associated with danger, would impede intellectual performance. Indeed, participants who saw their participant number written in red as compared to green or black performed worse on an IQ test – they solved fewer anagrams in a given time. In another study [28], red versus green progress bars impeded performance on a general knowledge test, but only for men. However, yet another study failed to replicate these effects completely. Larsson and Von Stumm [29] asked participants to solve diverse intelligence tests. They reported no difference in the test scores between red and green participant number conditions, questioning whether red impedes intellectual performance only for some task and not intelligence in general. Other researchers looked at the effects of ambient color on cognitive performance or affect. As for cognitive performance, Von Castell and colleagues [30] seated their participants in cubicles whose walls were painted in red, pink, or blue. Performance on a battery of cognitive tests did not differ between the three color conditions. As for affect, Costa and colleagues [31] investigated if different colors of living spaces in a dormitory affected participants' mood, but no differences were observed. Hence, evidence for color effects on behavior and affect remain inconclusive (also see [32]).

Notwithstanding the little scientific support, popular opinion assumes a causal relationship between color and affect. To start bridging the gap between popular opinion and actual evidence, we here examined the necessity of seeing color for changes in participants' affective states. In two studies, we used a commercially available color therapy routine [5]. This relaxation-through-color routine is supposed to control stress and increase relaxation in its users. Following the recommended procedure, we exposed half of the participants to both the spoken text and the accompanying color disks. Making the crucial change to the recommended procedure, we showed the other half of the participants a white sheet of paper. We collected participants' self-reported state and trait anxiety and stress levels before and after the sessions to estimate the change in their affective states (quantitative measures). In study 1, we tested the long-term effects of the relaxation-through-color routine by testing participants in three sessions, leaving one week between each session. In study 2, we tested the effectiveness of a shortened version of the routine. In study 1, we also collected participants' subjective impressions regarding the routine (qualitative information). We hypothesized that the relaxation-through-color routine should reduce stress and anxiety after the session as compared to before the session and be overall positively appreciated by participants. If there were long-term effects, we expected participants' stress and anxiety levels to be cumulatively reduced after each session. Finally, given the assumption that color is a key ingredient to this and other similar color-based interventions, we expected these reductions to be more markedly expressed in the group that was exposed to color compared to the group that saw a white sheet of paper.

Study 1: Longitudinal

Method

Participants

We tested 60 student participants (15 men). Their ages ranged from 18 to 29 years (mean age = 20.53 years, *SD* = 2.14 years). None of the participants was color blind, as assessed with the Ishihara's test for color deficiency [33]. All participants were proficient English and French speakers currently residing in Switzerland. Participants were studying psychology and included local as well as international students. Participation was voluntary and rewarded with course credit. Study 1 was conducted in French, and in accordance with the principles expressed in the Declaration of Helsinki [34].

The relaxation-through-color routine

The commercially available relaxation-through-color routine [5], is advertised as a routine that helps an individual to relax and reduce stress. The routine is loosely based on some mindfulness principals and acts as a form of guided meditation. For example, participants are encouraged to concentrate on the current moment and on their breathing pattern. At the same time, they visualize colors. With color being the main focus of the routine, it can be considered as a form of color therapy.

At the core of this relaxation-through-color routine are seven color disks [35] (Table 1). Each color disk is positioned on white background (21.0 x 21.0 cm) and has a radius of 9.6 cm. The color disks are fully saturated in the periphery near the rim and become lighter towards the center with an exception of the red disk, which becomes darker towards the center. During the session, participants are invited to focus their gaze on a color disk in front of them. Colors are presented in a fixed sequence roughly resembling the colors of the rainbow, or the colors of the chakras (top to bottom in Table 1). The session starts with the red disk, then participants look at the orange, yellow, green, blue, purple, and magenta disks. After the magenta disk, there is a closing sequence with a guided visualization without visual support. While focusing their gaze on the color disks, participants listen to the guidance text, which directs their attention to different parts of their body and aids in controlling their breathing. At certain moments during the session, participants are encouraged to imagine that they are "breathing color" of the disk in front of them. The guidance text can be read by a licensed practitioner or played as an audio CD. If the latter option is chosen, the guidance text is read out loud and it is accompanied by music [36]. One session lasts 53 minutes in total when using the audio CD (see Table 1 for the length of recordings per color). When we launched the study, the color disks, the accompanying text in a book format and the audio CD could be ordered online. We received the book and the color disks as part of the welcome kit at the *Progress in Colour Studies* conference in 2016. The CD was not part of the kit. We purchased the accompanying CD from the official website. At the time of testing, this routine was available in English only.

Table 1. CIE *xyY* color coordinates for all the color disks [5,35]. The CIE *xyY* color coordinates were measured with the Konica Minolta CS-100A chroma meter on the edge of each disk (0°), where saturation was highest (*disk edge)*, and in the center of each disk, where saturation was lowest (*disk center*). The measurements were averaged across the three sets of color disks used in the studies. Presentation of the color disks was accompanied by the recording which included guidance text and music played on an audio CD [36]. The length in minutes of each recording per color appears in the column *Recording length.* In study 1, all color disks but white were used; in study 2, red, yellow, blue, and magenta disks were used (in bold). In both studies, white was presented to the participants in No Color condition.

	Disk edge			Disk center			Recording
	CIE *x*	CIE *y*	CIE *Y*	CIE *x*	CIE *y*	CIE *Y*	length (min)
Red	0.622	0.335	153.33	0.401	0.329	67.50	5:41
Orange	0.586	0.365	206.33	0.487	0.466	327.67	5:29
Yellow	0.513	0.449	373.33	0.430	0.478	460.33	5:48
Green	0.314	0.518	127.33	0.414	0.518	304.67	6:24
Blue	0.207	0.233	54.07	0.313	0.357	333.67	7:33
Purple	0.332	0.229	49.80	0.385	0.337	211.00	7:34
Magenta	0.442	0.257	89.33	0.390	0.346	261.67	8:43
White	0.355	0.380	665.00	0.354	0.379	456.00	NA

Questionnaires

We used four questionnaires to measure changes in participants' affective states. All the questionnaires were completed in a paper-and-pencil format. The order of the questionnaires was randomized between participants and between testing sessions.

Anxiety. Anxiety levels were assessed with the State-Trait Anxiety Inventory [37] to measure participants' general self-reported predisposition for anxiety (STAI-T) and self-evaluated current state of anxiety (STAI-S). The STAI-T and STAI-S questionnaires have 20 statements each. Each statement presents a certain affective state (e.g., "I feel calm") and participants are asked to indicate how much they agree with each statement. Their responses are recorded from "not at all" (score of 1) to "very much so" (4). The STAI-T questionnaire asks participants to evaluate statements about how they "generally feel" whereas the STAI-S questionnaire asks to evaluate statements about how participants feel "right now, at this moment". The total score is the sum of responses, after having inverted reversely scored items. The total score is calculated separately for STAI-T and STAI-S. Both total scores range from 20 to 80 with higher scores indicating higher anxiety levels. We used the validated French versions [38].

Stress. We also assessed participants' general levels of stress with the 10-item version of the Perceived Stress Scale (PSS; [39]), showing good psychometric properties [40]. In the PSS, participants are presented with questions about their affective state in the last month (e.g., "In the last month, how often have you felt nervous and "stressed"?") and are asked to indicate how often they felt that way. Responses range from 0 (never) to 4 (very often). The total score is obtained by averaging all responses, resulting in a score that ranges from 0 to 4 with higher scores indicating higher perceived stress. The PSS was translated into French by one of the co-authors (IT). We also assessed participants' current levels of stress with the one-item stress questionnaire (S-one). The latter asks participants to draw a line indicating how stressed they felt on that day on a visual analogue scale ranging from "not at all" to "very much". Participants' responses were converted into values 0 (not at all) to 100 (very much). A similar single-item stress measure has shown good construct validity [41].

Self-report questions. Finally, we asked six self-report questions at the end of each testing session. Participants were asked if 1) they experienced a reduction in their stress levels after the session (*yes, no, I don't know*); 2) they experienced a reduction in their anxiety levels after the session (*yes, no, I don't know*); and 3) they thought the routine was beneficial (*yes, no, I don't know*). We further asked participants to freely elaborate on the other three self-report open questions: 4) how they experienced this study; 5) whether they would be willing to perform the session again at their own space and convenient time. Why or why not; and 6) whether they would recommend the routine to their friends. Why or why not.

We implemented a small design change at session 4 (i.e., at the fourth testing session). We did not ask participants the last three questions (how they experienced the study, whether they were willing to participate again, and whether they would recommend the routine to a friend). Instead, we asked which aspect(s) of the routine contributed the most to its effectiveness: 1) music, 2) voice in the recording, 3) color disks, 4) being alone in the room, 5) sitting down on a chair, 6) being concentrated, 7) other. Participants were allowed to choose more than one response and also provide other reasons. When creating these categories, we were inspired by participants' answers to open questions in previous sessions.

VeriVide CAC 60

The color disks were placed in the center of VeriVide CAC 60 light cabinet to ensure homogeneous color presentation (see https://www.verivide.com/product/colour-assessment-cabinets). The VeriVide light cabinet homogeneously emitted D65 artificial daylight from two lamps and 840P15 warmer type of light from two other lamps, which had good color rendering. The inside walls of the VeriVide light cabinet were colored in neutral grey (N5 in Munsell color system). The VeriVide light cabinet was warmed up for at least 10 minutes before the testing session to ensure that the lights have reached their full power.

Procedure

Participants were invited to take part in study 1 three times on three consecutive weeks (i.e., three sessions of testing). For each participant, all testing sessions took place on the same day of the week, at the same time of the day, and in the same experimental room (e.g., Mondays at 9 am). The procedure was identical for all three sessions of testing (Figure 1). Upon signing an informed consent, participants' color vision was tested with the Ishihara's test for color deficiency [33]. Participants then completed the STAI-T, STAI-S, PSS and S-one (i.e., before the routine; see *Questionnaires*). Afterwards, participants were randomly allocated to one of the two experimental conditions. Participants in the Color condition (n = 30; 6 males) underwent a standard session [5]. Participants in the No Color condition (n = 30; 9 males) underwent an analogous session without looking at the color disks. These participants were presented with a homogenous white rectangular patch (21.0 x 21.0 cm). Participants were encouraged to imagine the colors mentioned in the audio recording. Half of the participants in the Color condition (n = 15; 3 males) performed the session in the experimental room with the VeriVide light cabinet while the other half of the participants in Color condition (n = 15; 3 males) performed the session in the experimental room without the VeriVide light cabinet (see *VeriVide CAC 60*). Participants in the No Color condition all performed the session in the experimental room without the VeriVide light cabinet. Experimental rooms without the VeriVide light cabinet were illuminated with a standard office light and had no windows. During the session, participants in both conditions listened to the recording on high quality around-ear Sennheiser headphones, set to volume of a comfortable listening level (approximately 70dB). After the session, participants again completed the STAI-T, STAI-S, PSS, and S-one questionnaires (i.e., after the routine). After each session, participants answered six self-report questions (see *Materials*). Finally, they were thanked and debriefed on session 3. One experimental session took approximately 80 minutes. We tested up to 4 participants in one testing session. The routine was performed in English while the other parts of the experiment, including the questionnaires, were performed in French (the official language of the local university).

Originally, we had intended to run session 4 two months after the session 3 testing to evaluate long-term benefits of the relaxation-through-color routine. However, only 12 participants (20% from total; 5 males, 7 participants in the Color condition) returned to session 4 testing. This low turn-up rate was unaffected by monetary remuneration and initial willingness to take part again (see Table 2). Potentially, the testing time of session 4 was unfavorable as it fell during the exams period. Due to an insufficient number of participants, we performed limited analyses on session 4 data (*Design and data analysis*).

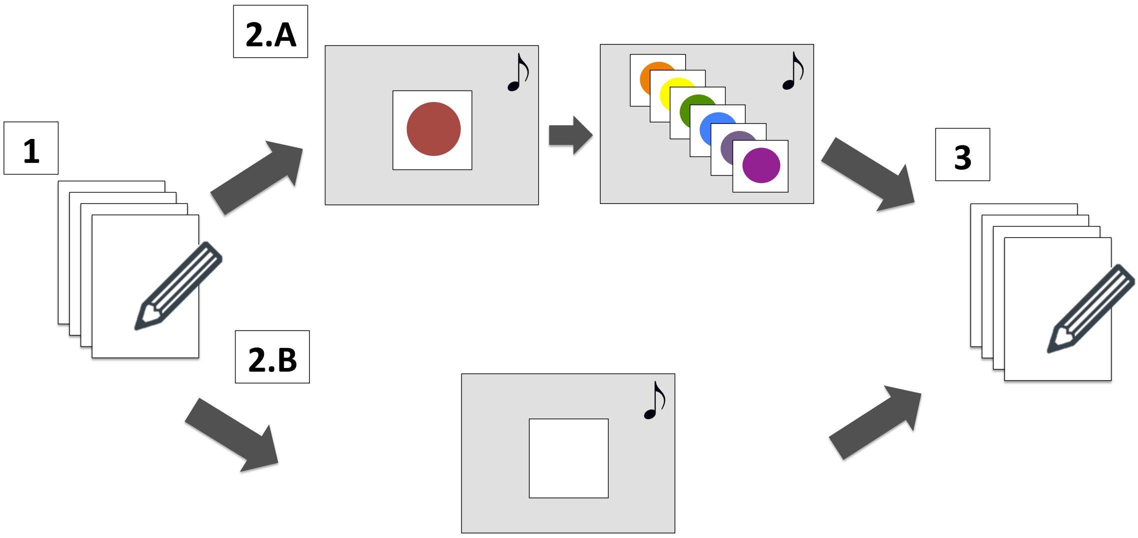

Figure 1. Procedure of study 1 and 2. (1) Participants completed questionnaires before the session. (2.A) Participants in the Color condition started by fixating on a red color disk and listening to the accompanying music with guided text. Afterwards, they fixated on different color disks presented in fixed order (orange, yellow, green, blue, purple, and magenta). (2.B) Participants in the No Color condition listened to the accompanying music with guided text while looking at a white rectangular. (3) All participants completed the same questionnaires again. The same procedure was repeated three times in consecutive weeks (three sessions of testing). The procedure in study 2 was identical with some notable modifications. Participants in study 2 performed only one testing session and were exposed to four rather than seven colors (red, yellow, blue, and magenta). Colors in this figure are presented for illustrative purposes only and do not attempt to reproduce the exact colors of color disks.

Design, coding and data analysis

Quantitative analyses. One female participant in the Color condition was excluded due to incomplete data (did not participate at session 3). The final sample consisted of 59 participants (15 males). Another female participant in Color condition had two missing values on S-one (before and after the session at session 2). These values were substituted with the average values of the sample to retain the participant for the complete statistical model.

The data were analyzed using a 2 x 2 x 3 mixed MANOVA model. The independent variables (IVs) were condition (between subjects; Color vs. No Color), time (within-subjects; before vs. after), and session (within-subjects; session 1, session 2, and session 3). The dependent variables (DVs) were scores on STAI-T, STAI-S, PSS, and S-one questionnaires. Additionally, we performed an analogous 2 x 2 x 3 mixed MANOVA model with testing environment (VeriVide light cabinet vs. standard room) as a between-subjects variable instead of condition to test whether testing environment impacted the outcome variables. Significant differences were interpreted with planned simple contrasts (session 1 vs. session 2, and session 1 vs. session 3), to determine whether the change during subsequent testing sessions occurred when comparing outcomes with the first testing session.

Out of interest but without sufficient statistical power, we ran a 2 x 2 repeated MANOVA model to test for the effects of time and session at session 4, presented in supplementary material (Table S3**)**.

Self-report questions. We analyzed the following self-report questions: whether participants thought 1) the routine reduced anxiety, 2) the routine reduced stress, 3) the routine was beneficial, 4) they would consider to participate at an identical testing session again (coded into *yes*, *no*, *maybe* categories), and 5) they would recommend the routine to their friend (coded into *yes*, *no*, *maybe* categories). We used McNemar's tests to compare frequencies of *yes/no* answers for each question between session 1 and session 3. We did not include session 2 due to missing data. Afterwards, we compared frequencies of *yes/no* answers for each question between Color and No Color conditions using chi-square tests of independence at session 1. All tests were controlled for multiple comparisons using the False Discovery Rate (FDR) correction [42].

Theme coding. We extracted participants' responses to the three open questions: 1) how they experienced this study; 2) would they be willing to perform the testing session again at their own space and a convenient time; and 3) would they recommend the routine to their friends. We analyzed answers to these questions from all 59 participants collected at session 1 and session 3. At session 2, there were missing data due to an experimenter's error. Thus, we analyzed 16 participants for whom the data were available at session 2. We did not collect the same qualitative data at session 4, and therefore did not analyze these data.

As the answers to the three questions turned out to be rather similar, we pooled them together for analyses. We used qualitative analysis approach to identify the underlying themes in participants' answers. Our approach was partly based on "open coding" in grounded theory [43] and partly on "clustering" or "theme identification" as referred to in more eclectic approaches [44]. Guided by these approaches, we developed a stepwise procedure for coding. We read half of the participants' answers given in session 1 and identified major themes (see Table 3). Then, we evaluated and refined the original codes with a new set of participant responses (i.e., the other half of the session 1 responses), both times equally distributed between Color and No Color conditions. This allowed us to see how popular each theme was and if further themes evolved. After this step, we found no additional themes and eliminated the theme *sleepiness* as few participants reported feeling that way. Hence, we concluded that we reached the saturation point and our codes were adequate. A pair of trained raters coded the entire dataset on these themes. Their inter-rater reliability was excellent, with a Kappa value of κ = .848 [45]. This procedure takes into account that raters could choose similar codes by chance. Disagreements were resolved through discussion. We present the final themes, including sub-categories and quotes, in Table 3.

Once themes were extracted, we further compared the frequencies of responses on session 1 versus session 3 to identify if participants' opinion changed over time. We compared the proportion of answers (e.g., *calmness* mentioned – *yes/no*) with McNemar's tests for each theme separately. We also compared frequencies of each theme between Color and No Color conditions with chi-square tests of independence at session 1. All tests were corrected for multiple comparisons with FDR correction [42].

Alpha level was set to 0.05. All analyses were performed and graphs created with the R [46] and SPSS v.24 [47] statistical software programs.

Table 2. Participants' responses to the five self-report questions at the three sessions of study 1. Percentages of valid responses (*yes, no, I don't know/maybe*) are calculated from valid cases (i.e., after excluding missing cases). Percentages of missing data are calculated from all the available data. Percentages might not perfectly add up to 100% due to rounding. Please note that session 4 included a reduced number of participants due to low turn-up rate.

		Session 1		Session 2		Session 3		Session 4	
		N	%	N	%	N	%	N	%
Reduced stress	Yes	47	79.7	31	52.5	34	57.6	8	66.7
	No	10	16.9	19	32.2	14	23.7	3	25.0
	I don't know	2	3.4	9	15.3	11	18.6	1	8.3
	Missing data	0	0	0	0	0	0	0	0
Reduced anxiety	Yes	34	57.6	30	50.8	24	40.7	10	83.3
	No	14	23.7	18	30.5	21	35.6	1	8.3
	I don't know	11	18.6	11	18.6	14	23.7	1	1.7
	Missing data	0	0	0	0	0	0	0	0
Beneficial	Yes	39	66.1	44	74.6	42	71.2	10	83.3
	No	1	1.7	1	1.7	2	3.4	0	0

	I don't know	19	32.2	14	23.7	15	25.4	2	16.7
	Missing data	0	0	0	0	0	0	0	0
Return	Yes	37	62.7	10	62.5	33	55.9	NA	NA
	No	5	8.5	1	6.3	9	15.3	NA	NA
	Maybe	17	28.8	5	31.3	17	28.8	NA	NA
	Missing data	0	0	43	72.9	0	0	NA	NA
Recommend to a friend	Yes	53	89.8	15	93.8	52	88.1	NA	NA
	No	2	3.4	0	0	0	1.7	NA	NA
	Maybe	4	6.8	1	6.3	7	11.9	NA	NA
	Missing data	0	0	43	72.9	0	0	NA	NA

Table 3. Themes extracted from the answers to the open questions regarding the tested relaxation-through-color routine. Themes, sub-categories, frequencies of mention at each session (session 1; session 2; session 3) and quotes to exemplify the themes are presented. Authors inserted text in squared brackets for clarity.

Theme	**Sub-category**	**Quote**
Calmness (81%; 88%; 64%)		*"I really enjoyed this experiment since it made me feel calm after being stressed today."* *"During the experiment I was surprised because certain colors made me feel calm."* *"Very calming"* *"I relaxed completely and let my body and mind be guided by the voice of the recording."*

Self-reflection (31%; 31%; 22%)	*"It makes me calm and more aware of myself."* *"It was a completely immersive experience. For 45 minutes, I forgot about my life, my comforts and myself."* *"One can really focus on one's body without being disturbed."* *"I feel I needed those minutes to relax and think of myself."*
Doubt in effectiveness (14%; 19%; 14%)	*"I had a really hard time imagining that I was breathing in color, so I don't know if it's worth doing this experiment at home or not."* *"I don't really think colors have an influence on us."* *"Bringing colors to a meditation is not beneficial."* *"It's the 3rd time so it's nothing new. I still don't know if [the routine] is beneficial, personally, I don't find it [to be beneficial]."*
Belief in effectiveness (32%; 25%; 25%)	*"At the beginning, I was quite ambivalent because I did not believe it at first. However, during the experiment I was surprised because certain colors made me feel calm."* *"I think it can really help to relax or even fall asleep more quickly at night."* *"I am more and more convinced by the*

		method" *"This is the 3rd time that I participate and it is true that I feel more relaxed"*
Selectivity of the routine	The routine is for everyone (7%; 6%; 5%)	*"I think everyone could benefit from this kind of experience."* *"Whatever the character of the person, it [the routine] can relax, in my humble opinion. Moreover, in such a context of serenity everyone can work it out so that each color would help them better and thus relax more easily."*
	The routine is only for some people (49%; 25%; 39%)	*"This routine is probably beneficial, only not for me."* *"I think it can be beneficial for a lot of people, but I don't think for everyone."*
Duration is too long (12%; 13%; 22%)		*"Yes [I would do it again] but maybe not as long because it is beneficial and it distresses a lot but it can become too repetitive and tiring."* *"So, in my opinion, this experience is effective but it takes a lot of time. I think when feeling stressed, I will do it again at home but maybe only with 2-3 colors."* *"No [I would not do it again] because it takes too much time for the obtained results and effects."*

	"Too long and not ideal for me."
Color (31%; 19%; 25%)	*"I don't really think colors have an influence on us. I didn't really feel big differences between the colors."* *"It really relaxed me a lot and I felt the interest and the impact of the colors. However, I feel that music and voice had more impact on me than colors themselves."* *"I have a hard time visualizing colors without hardware support, which may have prevented me from being totally comfortable in this experiment."* *"The orange color touched me the most, immediately I felt the good energies running through my body."*
Voice (20%, 13%, 12%)	*"I had an opportunity to not think about my usual life but only about voice and think about nothing"* *"Furthermore, voice is relaxing and the routine takes into account chakras which help to become aware of the body"* *"I would keep the same voice and the same background sounds. However, I would have preferred colors to be presented in a larger format so that one could focus on them*

	better." *"If the experiment with colors (and not only the white patch) gives better results than the hypnosis of the voice, then yes [I would participate again]"*
Music (8%, 13%, 10%)	*"I had an impression that music and voice had more impact on me than colors themselves"* *"It was relaxing because of music and especially because of the voice that spoke"* *"I don't think [I would participate again] because I didn't find that it was especially good and I think that simple meditation music can help to relax"* *"I don't think [I would participate again]. I prefer to meditate on my own in silence or simply with calm music. (…) Here, in the experiment, I feel obliged to think, confined."*

Results

Participants

Independent samples t-test showed that participants in the Color condition (*M* = 20.14, *SD* = 1.85) were of similar age as participants in the No Color condition (*M* = 20.90, *SD* = 2.37); $t(57) = -1.38$, $p = .174$, $d = .357$. Similarly, participants tested in the VeriVide light cabinet (*M* = 19.60, *SD* = 1.50) were of similar age as participants tested in standard testing rooms (*M* = 20.71, *SD* = 2.05); $t(27) = -1.68$, *p*

= .105, *d* = .618. The gender distribution was equal between the two conditions, $\chi^2(1) = 0.67$, *p* = .412, *V* = .107; and the two testing environments, $\chi^2(1) = 0.01$, *p* = .924, *V* = .018.

Testing environment

Mixed MANOVA did not show the main effect of testing environment, $F(4, 24) = 1.80$, $p = .161$, $\eta_p^2 = .231$. The interactions between time and testing environment, $F(4, 24) = 1.75$, $p = .172$, $\eta_p^2 = .226$; session and testing environment, $F(8, 20) = 1.26$ $p = .317$, $\eta_p^2 = .335$; and time, session, and testing environment, $F(8, 20) = 0.52$, $p = .831$, $\eta_p^2 = .171$; were not significant either. Thus, we analyzed participants from the two testing environments (i.e., VeriVide light cabinet and standard room) together in the subsequent analyses.

Color vs. No color condition

Mixed MANOVA showed main effects of time, $F(4, 54) = 19.27$, $p < .001$, $\eta_p^2 = .588$; and session, $F(8, 50) = 6.65$, $p < .001$, $\eta_p^2 = .516$. The main effect of time was present for STAI-T, $F(1, 57) = 53.59$, $p < .001$, $\eta_p^2 = .485$, $\varepsilon = 1.00$; STAI-S, $F(1, 57) = 32.62$, $p < .001$, $\eta_p^2 = .364$, $\varepsilon = 1.00$; PSS, $F(1, 57) = 25.28$, $p < .001$, $\eta_p^2 = .307$, $\varepsilon = 1.00$; and S-one, $F(1, 57) = 51.32$, $p < .001$, $\eta_p^2 = .474$, $\varepsilon = 1.00$; indicating that the scores on all four questionnaires were lower after as compared to before the session. The main effect of session was present for STAI-T, $F(2, 114) = 23.45$, $p < .001$, $\eta_p^2 = .292$, $\varepsilon = .912$; PSS, $F(2, 114) = 12.75$, $p < .001$, $\eta_p^2 = .183$, $\varepsilon = .914$; and S-one, $F(2, 114) = 4.63$, $p = .012$, $\eta_p^2 = .075$, $\varepsilon = .880$; but not STAI-S, $F(2, 114) = 0.09$, $p = .918$, $\eta_p^2 = .001$, $\varepsilon = .839$. Planned simple contrasts indicated that the scores on STAI-T ($p < .001$) and S-one ($p = .031$) but not STAI-S ($p = .858$) and PSS ($p = .083$) were lower when measured during the second session as compared to the first session (session 1 vs. session 2). Scores on STAI-T ($p < .001$), PPS ($p < .001$), and S-one questionnaire ($p = .002$) but not PSS ($p = .769$) were also lower when measured during the third session as compared to the first session (session 1 vs. session 3; see Figure 2).

There was no main effect of condition, $F(4, 54) = 0.08$, $p = .988$, $\eta_p^2 = .006$. Furthermore, there were also no two-way interactions between condition and time, $F(4, 54) = 0.98$, $p = .427$, $\eta_p^2 = .068$; or session and condition, $F(8, 50) = 0.50$, $p = .853$, $\eta_p^2 = .074$; indicating that participants in the Color condition experienced equivalent decline in the STAI-T, STAI-S, PSS, and S-one scores after each session and in subsequent sessions as participants in the No Color condition (see Table S1 & Table S2 for descriptive data). However, there was an interaction between time and session, $F(8, 50) = 2.38$, $p = .030$, $\eta_p^2 = .276$. This interaction was present only for S-one, $F(2, 114) = 5.04$, $p = .008$, $\eta_p^2 = .081$, $\varepsilon = .820$; and not for STAI-T, $F(2, 114) = 2.13$, $p = .124$, $\eta_p^2 = .036$, $\varepsilon = .914$; STAI-S, $F(2, 114) = 0.11$, $p = .900$, $\eta_p^2 = .002$, $\varepsilon = .667$; or PSS, $F(2, 114) = 1.42$, $p = .247$, $\eta_p^2 = .024$, $\varepsilon = .930$. Although S-one values were lower when measured after compared to before the session in each session, this difference was the largest for session 1 (session 1, Cohen's $d = .517$; session 2, $d = .278$; session 3, $d = .294$). Finally, a three-way interaction between time, session, and condition did not reach significance, $F(8, 50) = .72$, $p = .670$, $\eta_p^2 = .104$.

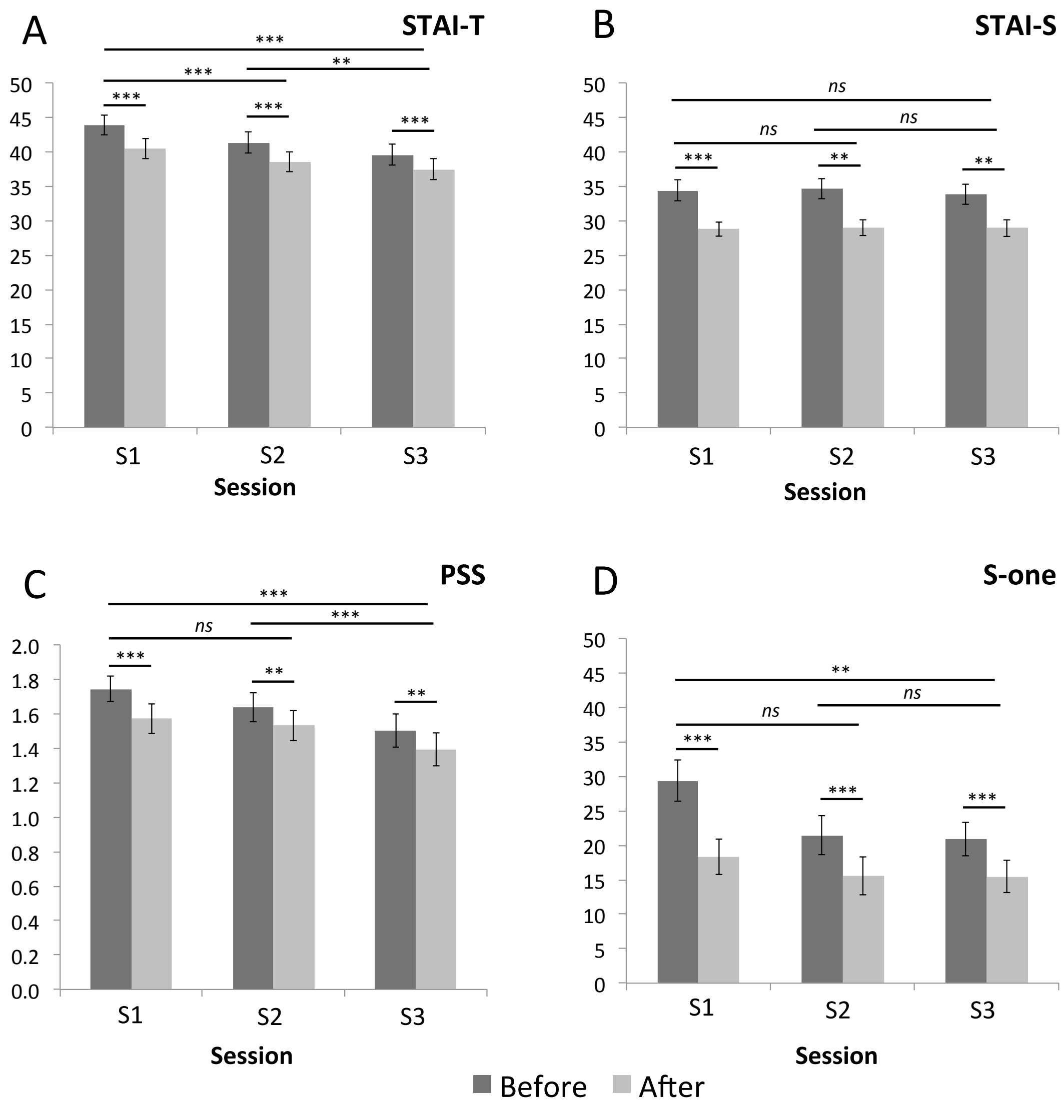

Figure 2. Average levels of anxiety – STAI-T (A) and STAI-S (B) – as well as stress – PSS (C) and S-one (D) – collected before and after each testing session (session 1, session 2, and session 3). Error bars indicate one standard error of the mean. Significance (FDR corrected) is coded as such: * $p \leq .050$, ** $p \leq .010$, *** $p \leq .001$.

Self-report questions and themes

Overall, participants evaluated this relaxation-through-color routine positively. The majority of participants believed that it reduced stress and anxiety and that it was a beneficial routine (see Table

2). Also, the majority of participants claimed they would use this routine again and would recommend it to a friend. The frequencies of participants endorsing each statement (*yes/no*) did not differ between session 1 and session 3 as shown with exact McNemar's tests – *anxiety* (p = .365), *stress* (p = .365), *beneficial* (p = 1.00), *return* (p = .833), or *recommend* (p = 1.00), all tests corrected for multiple comparisons. The frequencies did not differ between Color and No Color conditions, as shown with chi-square tests, – *anxiety* (p = .400), *stress* (p = .280), *beneficial* (p = .400), *return* (p = .400), or *recommend* (p = .979).

We then compared the proportion of participants mentioning each theme (Table 3) at session 1 and session 3 with exact McNemar's tests. None of the frequencies differed significantly between the sessions – *calmness* (p = .189), *self-reflection* (p = .481), *doubt* (p = 1.00), *belief* (p = .722), *selectivity, this routine applies to some* (p = .481), *duration* (p = .481), *color* (p = .747), voice (p = .481), or music (p = 1.00). The frequencies also did not differ between Color and No Color conditions, as shown with chi-square tests – *calmness* (p = .639), *self-reflection* (p = .661), *doubt* (p = .639), *belief* (p = .639), *selectivity, this routine applies to some* (p = .639), *duration* (p = .723), *color* (p = .639), voice (p = .661), or music (p = .723).

At session 4, all participants (100%) chose music as a potential factor for the effectiveness of this relaxation-through-color routine, followed by being alone (58.3%), being able to concentrate (58.3%), using color disks (50.0%) and hearing voice in the recoding (41.7%). Sitting on a chair was not commonly chosen (16.7%).

Study 2: Cross-sectional

Method

Participants

We tested 63 student participants (25 men). Their ages ranged from 18 to 37 years (mean age = 22.13 years, *SD* = 3.6 years). No participant was color blind, as assessed with the Ishihara's test for color deficiency [33]. All participants were proficient English speakers currently residing in Switzerland. Participants studied diverse disciplines and came from an international student community. Participation was voluntary and rewarded with course credit. Study 2 was conducted in English and in accordance with the principles expressed in the Declaration of Helsinki [34].

Materials

In study 2, we tested a shortened version of the relaxation-through-color routine [5] with four colors only – red, yellow, blue, and magenta. The audio CD recording was cut at appropriate locations and merged together to obtain a homogeneous recording. The shortened version lasted 27 minutes and 38 seconds (see Table 1). Apart from this difference and the fact that Study 2 run in English, the procedure was the same was in study 1. In study 2, we employed the same questionnaires (STAI-T, STAI-S, and PSS) as in study 1 but omitted S-one questionnaire, since its results were similar to those obtained with PSS. We also did not collect self-report questions and qualitative data. The questionnaires were completed in an electronic format rather than in paper-and-pencil.

Procedure

Procedure of study 2 was analogous to the procedure of study 1 but was performed only once (one session of testing; Figure 1). Participants were randomly allocated to one of the two experimental conditions: Color (*n* = 32; 13 males) and No Color (*n* = 31; 12 males). The testing session took place in an individual testing room with the VeriVide light cabinet and we tested one participant at a time. Like in study 1, participants completed the questionnaires before and after the session. The experiment lasted around 50 minutes.

Design and data analysis

The data were analyzed with the 2 x 2 mixed MANOVA model. The independent variables (IVs) were condition (between subjects; Color vs. No Color) and time (within-subjects; before vs. after). The dependent variables (DVs) were scores on STAI-T, STAI-S, and PSS questionnaires.

Results

Participants in the Color condition (*M* = 22.52, *SD* = 4.31) were of similar age as participants in the No Color condition (*M* = 21.74, *SD* = 2.74); *t*(60) = 0.84, *p* = .402, *d* = .216; and their gender distribution was comparable, $\chi^2(1) = 0.45$, *p* = .503, *V* = .084.

Mixed MANOVA showed the overall main effect of time, *F*(3, 59) = 19.92, *p* < .001, $\eta_p^2 = .503$. The main effect of time was present for STAI-T, *F*(1, 61) = 28.51, *p* < .001, $\eta_p^2 = .318$; STAI-S, *F*(1, 61) = 36.19, *p* < .001, $\eta_p^2 = .372$; and PSS, *F*(1, 61) = 6.46, *p* = .014, $\eta_p^2 = .096$, indicating that the scores on all three questionnaires were lower after the testing session than before the session. There was no main effect of condition, *F*(3, 59) = 1.36, *p* = .226, $\eta_p^2 = .064$. There was also no interaction between condition and time, *F*(3, 59) = 1.03, *p* = .384, $\eta_p^2 = .050$, meaning that participants in the Color condition experienced equivalent decline in the STAI-T, STAI-S, and PSS questionnaire scores as participants in the No Color condition (see Table 4).

Table 4. Descriptive statistics of the three questionnaires (STAI-T, STAI-S, and PSS) for the two conditions (Color and No Color) completed before and after the testing sessions in study 2.

	Color	No Color

	Before		After		Before		After	
	M	SD	M	SD	M	SD	M	SD
STAI-T	43.66	9.82	39.34	10.01	45.61	10.83	42.77	11.39
STAI-S	36.69	8.90	31.81	5.94	42.39	12.54	34.71	9.81
PSS	18.88	6.39	17.78	6.24	20.26	6.63	19.19	7.20

Discussion

Popular opinion assumes that exposure to color has positive psychological effects [1–4,6–8,10,11]. As empirical evidence to such claims is weak [9], we performed two studies testing the importance of color perception in reducing self-reported stress and anxiety. In both studies, we used the same commercially available color therapy routine [5]. We assessed whether such reductions could be observed when comparing respective measures before and after the intervention. We also assessed participants' subjective opinions through open questions. Our major findings are that participants' self-reported stress as well as state and trait anxiety levels were lower after the session when compared to before the session. This was true whether running the full version or only half of the proposed trials, reducing its total duration from 53 minutes to 27.5 minutes. We also observed that the reduction of participants' self-reported stress and anxiety levels were incremental, from one week to another, over a three-week period. Finally, and most importantly, we found reduced self-reported stress and anxiety levels irrespective of whether participants saw colors or not. Thus, these reductions do not seem rooted in the physical perception of color.

When considering what could explain the reduction of participants' self-reported stress and anxiety levels, we have to think beyond the physical perception of color. First, we wish to highlight additional facets of the routine such as music, focus on one's body and the current moment as well as rhythmic breathing. All these facets showed favorable therapeutic effects when used in mind-body interventions [48–50]. When asking participants how they experienced the routine, some spontaneously mentioned color, music, and voice. Such responses would imply that these facets were remarkable and memorable. Second, whether showing color or not, we observed comparable reductions in self-reported stress and anxiety levels after the testing sessions. Yet, this similarity cannot exclude the importance of color. Our participants listened to a voice encouraging them to imagine colors (e.g., "breath in red"). This encouragement likely benefited the mental visualization of color. Guided visualization plays an important role in stress, anxiety, or pain reduction in some mind-body interventions [51,52]. Furthermore, empirical evidence demonstrated that emotion associations are highly similar when physically perceiving colors or reading color words [53]. Hence, a simple mention of color might activate affective concepts and could have promoted the observed reductions in self-reported stress and anxiety levels after the testing sessions. Worth noting, most participants appreciated the routine and considered it effective, whether they saw colors or not. They reported being willing to engage with the routine again or recommend it to others. However, some considered that the standard routine was too long.

As reduction in subjectively experienced stress and anxiety levels was not rooted in the physical perception of color, we have to consider alternative factors that could explain the effects. We used subjective, self-report measurements (i.e., questionnaires) to assess stress and anxiety, which is a limitation to the current study. Participants might have guessed the goal of the studies and consciously, or unconsciously, reported lower affective scores after each testing session to conform to the experimenter's expectations [54,55]. Such expectations could be reduced with more objective measures like measurements of physiological arousal (e.g., [18–25]). It could also be reduced by having an experimenter, blind to the experimental conditions, evaluate participants' affective responses through observation (e.g., [56]). Even if participants did not alter their responses, they might have experienced a change in their affective states simply because of passage of time and not because of the routine itself. In order to understand the specific effects of this and similar routines, they should be compared with other mind-body interventions (e.g., see [57]). Such comparisons are especially important to clinical settings where an introduction of a new drug or a therapeutic technique is particularly costly. Thus, new drugs or techniques are only introduced if proven to outperform the ones already existing on the market. Not having a control group is another limitation to the current study. A comparison with a control group remains an important future direction. To sum up, we are aware of alternative explanations for the observed changes after the testing sessions. Future research is necessary to show if routines such as the current one outperform other interventions on the market and if observed reductions in self-reported stress and anxiety levels are supported by objective measurements of affective states.

Practical implications

We are aware of many widely held claims regarding the impact of color on psychological well-being and affective states (e.g., [1–4,6–8,10,11]). Many of these claims are still waiting for empirical verification. Studies like ours are important in bringing empirical evidence to such claims (see also [9]). The basic idea of color therapy – color has beneficial psychological consequences – is being integrated into many commercially available products like showers [58], saunas [8], hot tubs [7], and sunglasses [59]. Without solid empirical evidence, such products will likely disappoint users and provide an economic burden. To exemplify this notion, we refer to findings that suggested that pink is an aggression-reducing color. Many prisons in Europe and the United States have at least one pink prison cell (see pink cell counts in [56]). These cells have been installed since 1980s subsequent to reports indicating that a particular shade of pink (so-called Baker-Miller pink) reduced physical strength and aggressiveness in inmates at correctional facilities [60,61]. It was assumed that the visual processing of the Baker-Miller pink "influences" neurological and endocrine systems causing reduced physical strength, and consequently aggressive behavior. A recent publication, however, did not replicate the relationship between pink cells and reduced aggression in their inmate population[56]. In the latter study, aggressiveness simply diminished with the passage of time, irrespective of whether the prisoners were held in pink or white cells. Many factors could account for the discrepant findings. Perhaps, different prisoner populations were assessed in these studies, perhaps prisons in the USA differ from prisons in Switzerland, or perhaps, prisons have changed over the last 40 years. Whether public or private funds are involved, costly interventions and changes should ideally be executed only when solid empirical evidence has been provided.

Conclusion

Our study showed that participants reported lower levels of stress and anxiety after as compared to before a session of a commercially available relaxation-through-color routine [5]. The same effect was observed whether participants physically saw colors or not. We observed these reductions within sessions, and further reductions over repeated sessions. Moreover, within-session reductions were observed whether performing the standard or a shortened routine. For now, we do not know the factors that were responsible for these reductions. The physical experience of color, however, seemed not to be the cause. Future studies could assess whether color visualization might explain our observed reductions, for instance, by eliminating color terms in the accompanying text. Alternative explanations should be also considered. For instance, the importance of other facets such as music, guided breathing, or focus on one's body should be evaluated. Indeed, it would be important knowing how such color-based interventions compare with other available mind-body interventions (e.g., mindfulness, guided imagery, meditation, progressive muscle relaxation, etc. [57]), or simply how they compare with changes in psychological states over time.

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Author biographies

Domicele Jonauskaite is a doctoral student at the Institute of Psychology University of Lausanne, Switzerland. Her doctoral position is financially supported by the Swiss National Science Foundation with a personal Doc.CH grant. Within its framework, she investigate the importance of perceptual vs. linguistic routes in affective connotations of colour. She holds a BSc degree in Psychology (Royal Holloway, University of London, UK) and MSc degree in Neuroscience (University of Geneva, Switzerland). Together with Christine Mohr and Nele Dael, they have founded *Colour Experience* (colourexperience.ch) platform designed to disseminate scientifically validated empirical research on psychological effects of colour.

Irina Tremea was a master student at the University of Lausanne, where she completed her Masters of Science degree in Child and Adolescent Psychology in 2018. She worked on creativity for her Bachelor thesis. She pursued her interests in cognitive psychology during her Master studies. She wrote her master thesis on the contribution and pertinence of colors in relaxation techniques under the supervision of Christine Mohr and Domicele Jonauskaite. She now works outside of academia as a children educator.

Loyse Bürki obtained her Bachelor of Science in psychology at the University of Lausanne, Switzerland in 2019. Throughout her years at the University of Lausanne, she worked on various projects under the supervision of Christine Mohr and Domicele Jonauskaite at the Cognitive and Affective Regulation Laboratory (CARLA). She is keenly interested in the artistic aspect and practical implications of the current study.

Cécile N. Diouf was a bachelor student in psychology at the University of Lausanne for two years. During this time, she worked as a research assistant on various color experiments at the Cognitive and Affective Regulation Laboratory together with Christine Mohr and Domicele Jonauskaite. She is now studying for Master in Literature at the University of Lausanne.

Christine Mohr is Professor for Cognitive Psychology at the University of Lausanne, Switzerland. She graduated with a Psychology degree from the University of Konstanz, Germany. Subsequently she completed her PhD at the Institute of Psychology at the University of Zürich, Switzerland. After postdoctoral studies in Geneva, Switzerland, and Edmonton, Canada, she continued her academic career as a lecturer and later senior lecturer at the University of Bristol, UK. Now in Lausanne, she focuses on two major research lines: 1) colour psychology with a particular interest in the relationship between colour and affect, and 2) cognitive and affective factors in adult belief and its formation. By today, she authored or co-authored over 120 peer-reviewed research contributions.

Supplementary material

Table S1. Descriptive data (means and standard deviations) of four questionnaires (STAI-T, STAI-S, PSS, and S-one) completed before and after the session in each of the three sessions by participants in the *Color* condition of study 1.

	Color condition											
	Session 1				Session 2				Session 3			
	Before		After		Before		After		Before		After	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
STAI-T	45.21	11.70	40.62	10.57	41.90	11.69	38.97	11.45	40.10	11.28	37.14	11.20
STAI-S	34.83	11.29	29.03	7.94	35.24	11.08	29.83	10.95	34.10	11.30	28.41	9.02
PSS	1.78	0.54	1.60	0.66	1.68	0.66	1.56	0.72	1.57	0.73	1.40	0.78
S-one	32.37	22.63	18.85	19.28	21.57	18.89	13.73	19.75	20.48	17.65	14.39	16.78

Table S2. Descriptive data (means and standard deviations) of four questionnaires (STAI-T, STAI-S, PSS, and S-one) completed before and after the session in each of the three sessions by participants in the *No Color* condition of study 1.

	No Color condition											
	Session 1				Session 2				Session 3			
	Before		After		Before		After		Before		After	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
STAI-T	42.63	10.549	40.2	11.74	40.8	12.347	38.2	11.275	39.03	11.793	37.77	11.898
STAI-S	33.93	11.712	28.6	8.381	33.93	11.185	28.13	7.167	33.57	11.767	29.4	9.489
PSS	1.707	0.5948	1.543	0.6585	1.6	0.6518	1.507	0.6373	1.44	0.7623	1.397	0.7844
S-one	26.49	23.22	17.82	20.37	21.36	24.72	17.22	22.31	21.29	20.54	14.39	16.78

Session 4.

The IV1 was time (within-subjects; before vs. after) and the IV2 was session (within-subjects; session 3 and session 4). The DVs were scores on STAI-T, STAI-S, PSS, and S-one questionnaires. This analysis was performed on 12 participants. One male participant had missing data on S-one before and after the session at session 4. These missing data were substituted with the average values to retain the participant in the analyses.

Repeated-measures MANOVA with time (before vs. after) and session (session 3 vs. session 4) showed a significant main effect of time, $F(4, 8) = 6.67$, $p = .012$, $\eta_p^2 = .769$, indicating that questionnaire scores were lower after the session than before the session. There was no main effect of session, $F(4, 8) = 0.62$, $p = .663$, $\eta_p^2 = .236$; or an interaction between session and time, $F(4, 8) = 0.65$, $p = .644$, $\eta_p^2 = .245$. However, one should note that while observed power was relatively high to detect significant effects of time (.885), it was very low to detect effects of session (.136) or an interaction between session and time (.140). Visually, questionnaire scores at session 4 were lower than at session 3, indicating that the effect of the session might be going to a similar direction as reported for the previous sessions (see **Table S3**).

Table S3. Means and standard deviations of questionnaire scores (STAI-T, STAI-S, PSS, and S-one) at session 3 and session 4.

	Session 3				Session 4			
	Before		After		Before		After	
	M	SD	M	SD	M	SD	M	SD
STAI-T	44.33	11.18	40.58	11.23	38.75	7.62	36.42	8.14
STAI-S	35.67	8.65	29.00	7.20	33.42	8.88	26.67	9.41
PSS	1.79	0.64	1.67	0.67	1.51	0.58	1.34	0.65
S-one	20.11	18.91	11.17	13.88	20.85	13.76	10.69	12.24

