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On the relationship between strength of simultaneous color contrast and global/local perceptual styles

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Summary. — Color perception is closely tied to our global approach to vision. A striking example of this is the phenomenon of simultaneous color contrast, in which an otherwise achromatic target is perceived as chromatic due to color induction from the background in which it is embedded. In this study, we investigated whether individual variability in the prioritization of local *versus* global information within a visual scene might relate to individual differences in the strength of simultaneous color contrast. To this end, the strength of simultaneous color contrast was quantified using a behavioral test developed in our laboratory (the "Train Test"), while local *versus* global perceptual styles were assessed using the "Navon Test." Our results revealed considerable interindividual variability in the strength of chromatic induction, ranging from achromatic to vivid color perception. However, no significant correlation was observed between the strength of simultaneous color contrast and perceptual styles. Statistical analyses further showed no significant differences in saturation values between participants classified as "global" or "local" in their perceptual styles. These findings suggest that perceptual styles, as defined in our study, do not significantly influence the strength of simultaneous color contrast. Future research may benefit from employing more fine-grained methodologies to explore whether these results hold under alternative experimental conditions or with more precise measures of perceptual variability.

1. – Introduction

Color perception arises from a global integration of visual information. Specifically, the color of an object is not determined in isolation but rather emerges from the visual system's comprehensive analysis of the scene, considering its relationship with surrounding objects and lighting conditions [1]. This process is highly context-dependent, with external factors, such as the environment in which the color is observed, exerting significant influence [2].

A compelling example of how object color relates to the overall visual scene is the phenomenon of simultaneous color contrast. Simultaneous color contrast occurs when a grey, achromatic stimulus is perceived as possessing an illusory color that shifts toward the complementary hue of its background [3].

Notably, the strength of simultaneous color contrast has been found to vary among individuals, although the underlying sources of this variability remain poorly understood [4]. One potential factor influencing this phenomenon could be the degree to which individuals integrate spatial information across a visual scene. Indeed, variations in how people process spatial information define what is known as their "perceptual style."

Perceptual styles are broadly categorized as either local or global. Individuals with a local perceptual style tend to focus on the finer details of an image, often at the expense of considering its broader context. Conversely, those with a global perceptual style prioritize the overall structure of the visual scene, paying less attention to specific details [5].

Given these distinctions, we hypothesized that perceptual styles might significantly influence the strength of the simultaneous color contrast phenomenon.

To test this hypothesis, we conducted our study using two distinct tests. The first was a test designed to quantify individual differences in the strength of simultaneous color contrast and was developed from our laboratory ("Train Test"). The second was the "Navon Test", a test classically used to evaluate individual tendencies toward either a more local or a more global perceptual style [5].

2. – Materials and methods

2·1. *Participants*. – A total of 51 participants (23 females and 28 males; mean age: 26.7 years; age range 18 to 61) took part in the study.

2·2. *Procedure and data collection*. –

2·2.1. The Train Test. Stimuli used for the assessment of simultaneous color contrast were built as follows. A semi-transparent cyan filter was applied on an image depicting a red train (HSV coordinates: H: 2.95°; S: 0.96; V: 0.75) embedded on a white snowy background. The resulting image was a physically grey train surrounded by a cyan background which made the train appear as reddish (fig. 1). This image was then rotated

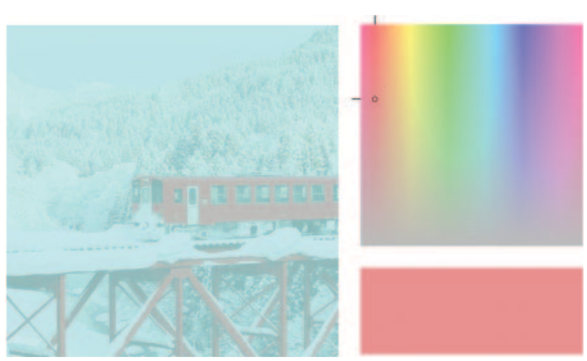

Fig. 1. – Example of stimuli and procedure used in the Train Test. Participants navigated a cursor on a fixed luminance colorspace diagram to find the color that better matched the perceived color of the train.

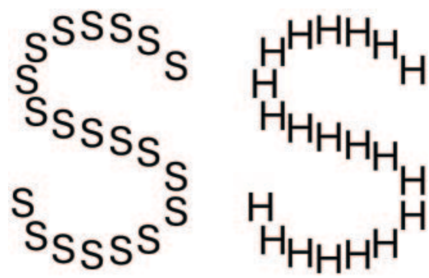

Fig. 2. – Example of stimuli used in the Navon Test. On the left an example of a congruent stimulus and on the right an example of an incongruent one.

in the HSV color space in steps of 45° leading to the construction of eight different stimuli characterized by the same grey train which appeared to be of different color shades depending on the background it was embedded in.

To quantify chromatic induction we asked participants to match the color of the train by using an interactive procedure in which the color of a nearby rectangle changed in hue and saturation as participants moved a cursor on a fixed luminance colorspace diagram (fig. 1).

2·2.2. The Navon Test. This test is a classical test widely used to define individual perceptual style [5]. It investigates whether a person tends to focus more on details (local style) or on the overall picture (global style). During the test, a large capital letter (either an "H" or an "S") is briefly flashed (200 ms) at the bottom left/right or top left/right of a central fixation point. These letters are either composed of small letters of the same identity (congruent condition; *e.g.*, a large "S" composed of small "S") or of a different identity (incongruent condition; *e.g.*, a large "S" composed of small "H", fig. 2). Participants are instructed to get focused either on the large letter (Global Task) or on the small ones (Local Task) and asked to report as quickly as possible which letter was presented. The rationale is that, for instance, a person having a global perceptual style would suffer a robust interference of the large letter's identity when asked to detect the identity of local incongruent letters.

From each of the four conditions employed (*i.e.*, Global-Congruent, Global-Incongruent, Local-Congruent, Local-Incongruent) we derived the inverse efficiency score (IES), a compound measure of reaction times and accuracy given by their ratio. Interference of local component on global component and global component on local component was calculated as follows:

$$I_L = (IES_{GC} - IES_{GI}) * \frac{2}{IES_{GC} + IES_{GI}}; \tag{1}$$

$$I_G = (IES_{LI} - IES_{LC}) * \frac{2}{IES_{LC} + IES_{LI}}; \tag{2}$$

I_L (1) defines the interference index of the local component on the global one. IES_{GI} corresponds to IES obtained in the condition of Global-Incongruent while IES_{GC} corresponds to IES obtained in the condition of Global-Congruent. I_G (2) defines the interference index of the global component on the local one. IES_{LI} corresponds to

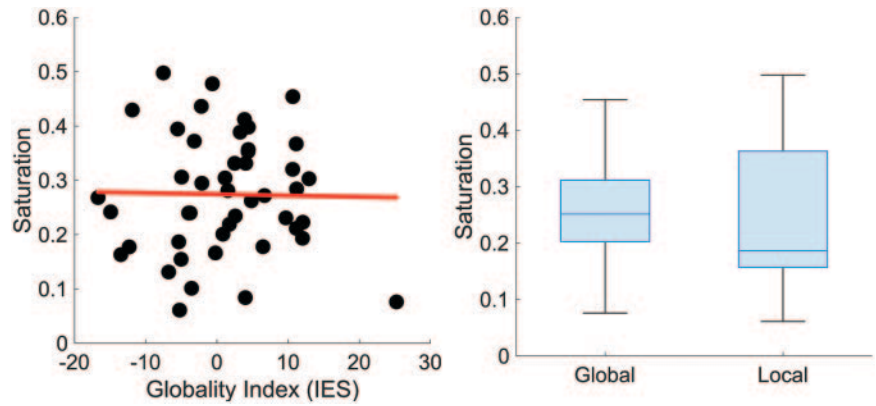

Fig. 3. – Left: scatterplot depicting correlation between Globality Index obtained from IES (inverse efficiency scores) and average saturation reported in the Train Test. Red line represents the best linear fit to the data. Right: boxplot comparing median saturation obtained in the group of participants that were classified as "global" *vs.* "local".

IES obtained in the condition of Local-Incongruent while IES_{LC} corresponds to IES obtained in the condition of Local-Congruent.

3. – Results

First, results revealed a huge variability in the strength of chromatic induction (mean: 0.274; std: 0.11). Indeed, some participants reported very low saturation values, suggesting the perception of a mostly achromatic stimulus, while others reported to perceive very vivid colors within the train (see variation in the y-axis of fig. 3). To investigate whether such variability could be explained by individual perceptual styles, we correlated saturation reported in the Train Test with Globality Index (GI). More specifically, for each participant, the strength of simultaneous color contrast was defined as the average value of saturation reported across all the stimuli employed while the GI was defined as the average percentage of I_L and I_G.

From a quick look to the scatterplot (fig. 3, left panel) it is rather evident that the two variables were not related to each other. This was confirmed by the lack of a statistically significant correlation (Pearson; $r_{(49)} = 0.12$; $p = 0.39$). A similar result was obtained after clustering participants based on their GI. More specifically, participants with positive GI were defined as "Global" while those with a negative GI were defined as "Local". When comparing saturation values assigned to the train by the two groups no statistically significant difference emerged ($t_{(49)} = -0.73$, $p = 0.46$) (fig. 3, right panel).

Very similar results were obtained when GI was calculated with the sole reaction times. Again, neither a correlation emerged between strength of simultaneous color contrast and GI (Pearson; $r_{(49)} = -0.01$; $p = 0.94$) nor a statistically significant difference emerged between participants classified as global or local ($t_{(49)} = -0.65$, $p = 0.52$) (fig. 4).

4. – Conclusions

Our study aimed to investigate the relationship between perceptual styles and strength of simultaneous color contrast. We observed large interindividual variability in the strength of chromatic induction, ranging from nearly achromatic perceptions to vividly

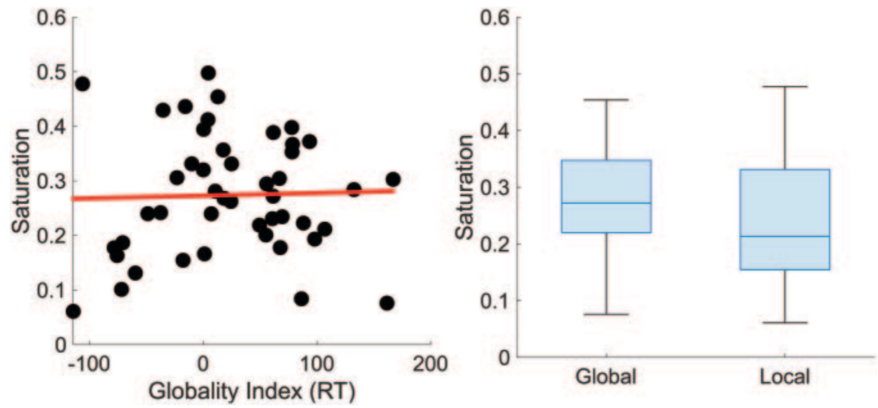

Fig. 4. – Left: scatterplot depicting correlation between Globality Index obtained from reaction times (RT) and average saturation reported in the Train Test. Red line represents the best linear fit to the data. Right: boxplot comparing median saturation obtained in the group of participants that were classified as "global" *vs.* "local".

colored ones. However, we found no evidence that individual perceptual styles might account for such variability. Indeed, no correlation emerged between the strength of simultaneous color contrast and the quantification of "globalitiness" as assessed with the Navon test. This was evident both when the Globality Index (GI) was calculated by a compound measure of speed and accuracy (IES) and also when the sole reaction times were considered. Furthermore, group comparisons based on global or local processing tendencies revealed no statistically significant differences in the amount of chromatic induction experienced by the two groups.

Overall, our findings indicate the absence of an association between chromatic induction and hierarchical dimensions within perceptual patterns, such as processing information in a more global or big-picture manner.

However, several considerations must be addressed. First, we cannot exclude the possibility that the Navon Test may not be the most appropriate tool for investigating our primary experimental question. While the Navon Test has been widely used, it has also faced significant criticism regarding its ability to fully encapsulate the complexity of perceptual styles. Specifically, the test may fail to capture the multifaceted mechanisms contributing to individual perceptual variability. This perspective is supported by prior studies, such as Pomerantz *et al.* [6], which suggest that Navon Test results could be influenced by factors such as greater perceptual discriminability of the global level rather than exclusively reflecting cognitive tendencies toward global or local processing. Additionally, the Navon Test predominantly relies on response speed and error rates to infer processing style. In contrast, participants in our Train Test were not subjected to time constraints during the task. This methodological difference might have influenced the outcomes, and thus we cannot entirely rule out its impact. Future research could address this potential confound by employing a quantification of simultaneous color contrast that also relies on speeded responses.

As a broader observation, quantifying a complex phenomenon like perceptual style remains inherently challenging, given its susceptibility to numerous factors, including cognitive strategies and neural variability. Reducing perceptual styles to a single index risks oversimplifying the intricate nature of this phenomenon. Looking ahead, we propose that interindividual differences in global and local processing styles could be more effectively quantified through advanced techniques, such as eye-tracking methodologies, which provide finer-grained insights.

Nevertheless, if we simply stick to the data, our results suggest that no relationship exists between individual perceptual styles and the strength of simultaneous color contrast and this is what can be inferred from the current work.

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