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Note

Swimming-style synesthesia

Danko Nikolić [a,b,*], Uta M. Jürgens [a,c], Nicolas Rothen [d], Beat Meier [d] and Aleksandra Mroczko [a,e]

[a] Max-Planck Institute for Brain Research, Frankfurt, Germany
[b] Frankfurt Institute for Advanced Studies, Germany
[c] Christian-Albrechts-University, Department of Psychology, Kiel, Germany
[d] University of Bern, Switzerland
[e] Johannes-Gutenberg-University, Department of Philosophy, Mainz, Germany

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ABSTRACT

The traditional and predominant understanding of synesthesia is that a sensory input in one modality (inducer) elicits sensory experiences in another modality (concurrent). Recent evidence suggests an important role of semantic representations of inducers. We report here the cases of two synesthetes, experienced swimmers, for whom each swimming style evokes another synesthetic color. Importantly, synesthesia is evoked also in the absence of direct sensory stimulation, i.e., the proprioceptive inputs during swimming. To evoke synesthetic colors, it is sufficient to evoke the concept of a given swimming style e.g., by showing a photograph of a swimming person. A color-consistency test and a Stroop-type test indicated that the synesthesia is genuine. These findings imply that synesthetic inducers do not operate at a sensory level but instead, at the semantic level at which concepts are evoked. Hence, the inducers are not defined by the modality-dependent sensations but by the "ideas" activated by these sensations.

1. Introduction

Some individuals report that when seeing an alphanumeric symbol (e.g., an "A"), they experience also color sensations (e.g., red). Others may perceive colored patterns when hearing a music piece. Those people are called synesthetes. Synesthesia is traditionally understood as a perceptual phenomenon, such that a sensory stimulus, presented within one modality, triggers an additional perception in the same or a different modality (e.g., Baron-Cohen and Harrison, 1997; Mattingley et al., 2001; Ramachandran and Hubbard, 2001; Cytowic, 2002).

However, recently, a possibility of a different perspective on synesthesia emerged. Grossenbacher and Lovelace (2001) introduced the term "synesthetic conception" to account for the properties of synesthesia that did not match the classical descriptions of this phenomenon. The authors noted that either the inducer or the concurrent can operate at a conceptual rather than perceptual level, as for many types of synesthesia no obvious perceptual basis exists. One example is time-unit-space synesthesia (e.g., Smilek et al., 2007; Jarick et al., 2008; Mann et al., 2009), where individuals experience units of time—mostly hours, days and months—being placed

* *Corresponding author*. Max-Planck Institute for Brain Research, Deutschordenstr. 46, D-60528 Frankfurt am Main, Germany.
E-mail address: danko.nikolic@gmail.com (D. Nikolić).
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at specific locations in space relative to their body. Other evidence about a strong semantic component in synesthesia (Dixon et al., 2000, 2006; Rich and Mattingley, 2003; Ward et al., 2006; Simner and Ward, 2006) and about an ability to transcend sensory modalities by imagining or just thinking of a stimulus (Grossenbacher, 1997; Frith and Paulesu, 1997; Ramachandran and Hubbard, 2001; Cytowic, 2002; Rich et al., 2005) has been collected meanwhile. Even a substitution of old graphemes with new ones, never seen before, can result in a transfer of synesthesia in less than 10 min of such experiences (Mroczko et al., 2009). Thus, synesthesia seems to depend strongly on the interpretation of the stimuli and the meaning that they have for the subject, rather than being caused by low-level pre-wired connections between sensory representations (Nikolić, 2009).

If an activation of the underlying concept alone elicits synesthetic concurrents, evidence is provided that low-level perceptual processes—i.e., modality-dependent processes—are not necessary to evoke synesthetic experiences (e.g., Dixon et al., 2000). We report here a novel form of synesthesia in which the concurrent can be easily elicited without a specific sensory stimulation. Two synesthetes report perceiving colors while swimming—each swimming style (e.g., breaststroke or butterfly) being associated with a different color. This newly discovered form of the phenomenon, which we named *swimming-style synesthesia*, had the interesting property of allowing us to segregate the direct sensory inputs—i.e., proprioceptive inputs during the act of swimming—from those that evoke conceptual representations—i.e., pictures or words associated with this sport. Thus, if synesthesia occurs while direct sensory inputs are absent and only indirect ones exist, a conclusion follows on the conceptual nature of the phenomenon.

2. Methods

2.1. *Subjects*

Two synesthete subjects H.T. and U.J., male and female, both 24 years old, participated in the study. Both are active in swimming, which is an important aspect of their lives. They began swimming in early childhood and practice on a weekly basis. U.J. was competing at a communal level until the age of 13 and continues to swim regularly for leisure purposes until today. H.T. began competing at the age of 6, and won his first championship in butterfly style at the age of 8. He was the national champion of Syria for several years until he stopped competing at the age of 16, but has also continued swimming for leisure until today.

Both subjects have also other forms of synesthesia. H.T. reports having number–color synesthesia (but not letter–color), and U.J. has complete grapheme-color synesthesia (i.e., numbers and letters), ordinal linguistic personifications, and time-units-space synesthesia, among others. For the color-consistency test, three other swimmers were recruited as control subjects, two who matched H.T. (H.P. and D.R.) for gender, age and swimming experience and one who matched U.J. (F.M). For the swimming styles breaststroke, butterfly, backstroke and front crawl, subject H.T. had associated colors: medium blue, deep red, light yellow, and white, and subject U.J. had colors: red-brown, sky-blue, purple-blue, and yellow, respectively.

For the Stroop-type test we recruited additional two non-synesthete subjects, matched by gender, age (24 and 27 years old) and education (A.M.L. and P.L.W.). These subjects were not active swimmers but were familiar with all four swimming styles.

2.2. *Experimental procedures*

The synesthetes were subjected to a consistency test of the colors associated with four main swimming styles (breaststroke, butterfly, backstroke and front crawl). Also a Stroop-type test was performed (e.g., Schneider and Kaernbach, 2001; Odgaard et al., 1999; Nikolić et al., 2007; Mroczko et al., 2009). In the consistency test, the subjects were presented with a sheet of paper with four black-and-white close-up photographs of single swimmers engaging in one of the four main swimming styles. The photographs were never seen before by the subjects. The task was to find in a book containing more than 5500 shades of colors (Küppers, 2003) the one that matched best the synesthetic color associated to that swimming style. All procedures were conducted in a laboratory in a sitting position and did not involve any motor activities associated with swimming. Subjects were not aware that they would be required to complete the same color selection procedure once again several weeks later. For each swimming style, the color was reported once for test and once for retest. The test–retest interval was longer for synesthetes (four weeks for H.T. and three weeks for U.J.) than for non-synesthete control subjects (two weeks in all cases). U.J. is one of the authors of this study but was originally fully naïve about the study and the purpose of the color selection procedure and was, at the time of the first selection, unaware that a second one would follow. For each swimming style, subjects were asked only once at test and once at retest to give the best-matching color. The control subjects were given the same tasks but were asked to choose the color that, according to their opinion, suited the individual swimming styles best.

To quantify color consistency, the chosen colors were first calculated in red-green-blue (RGB)-space using a custom-made computer program. For each participant and each swimming style, the Euclidian distance was calculated in RGB-space for the colors reported at the two occasions, and these distances were used as a measure of the difference in the chosen colors (a test–retest error). The RGB-values 0–255 were first normalized to the range 0–1. Hence, theoretically, the maximal possible distance between a pair of colors was $\sqrt{3} = 1.73$ RGB-units. A pair of randomly chosen colors would on average have a distance of .67 RGB-units (Schneider and Kaernbach, 2001).

In the Stroop-type test, the synesthetes were presented with the same four photographs used for the consistency test but on a computer screen with a colored tone. Instead of being black-and-white, photographs were painted with another ink such as red or yellow. The hue was chosen to be either the same as the synesthetic color associated to that swimming style (congruent) or to be different (incongruent). The incongruent colors were chosen as the opponent color and one of the two possible orthogonal colors in a color wheel. Thus, for each congruent picture two incongruent ones were presented,