Impact of hand and object colors on object temperature perception

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Dear Editor-in-Chief,

This is our reply to the letter by Prof. Maria V Sanchez-Vives,1 which answers the riddle published in the recent editorial.2 This riddle asks the readers of Temperature to explain 2 unexpected effects of color on object temperature perception that we recently discovered.3 One is that blue objects are more likely to be judged as warm than red ones of the same temperature. The other is that when the hand in contact with an object is colored red or blue (rather than the object being colored red or blue), the effect is reversed. With red hands participants tended to judge the touched objects as warmer than with blue hands.

Prof. Sanchez-Vives pointed out that there is a strong association between red skin and the experience of warmth. She suggested that skin color is able to determine the temperature perceived based on this association, and this explains why red hands feel the objects warmer. As for why touching a blue object feels warmer than touching a red one, she proposed 2 possible explanations. One is based on the color contrast between the skin and the object. That is, when near a blue object, the skin in contrast looks more reddish. Given that red skin is linked to warmer temperatures, the blue object would feel warmer. The other is based on prediction contrast bias. That is, the contrast between the expectation of a blue object being at lower temperature and the actual temperature perceived upon contact may have a reverse effect of feeling it warmer than expected. In brief, Prof. Sanchez-Vives suggested that (1) skin color is the primary determinant of the perceived temperature and (2) object color influences the object temperature perception through a contrast effect.

The explanation that we have considered is in some aspects in agreement to (2). We interpret the effects of both object and skin colors in terms of a contrast effect, or “the prediction contrast bias” as referred by Prof. Sanchez-Vives. Our hypothesis is that the skin and object colors modulate expectations of the relative temperatures of hand and object based on the “red-warm, blue-cold” association. The relative temperatures of hand and object are considered here, because it is known that the perceived warmth upon contact depends on the temperature difference between object and hand.4 However, when it comes to estimating the object temperature, the warmth or coldness perceived upon contact depends on the heat transfer between the skin and the object, and in turn depends on the temperature difference between them.4 In this case, the skin temperature acts as a reference. Objects with temperatures higher (lower) than the skin temperature are perceived as warm (cold), with larger differences producing warmer sensations. In other words, in estimating an object’s temperature, which is the situation in the present riddle, the primary determinant of perceived temperature

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should be the temperature difference between the skin and the object.

In the framework of cross-modal sensory integration, Prof. Sanchez-Vives’ explanation and our explanation suggest 2 different integration strategies. Prof. Sanchez-Vives’ explanation (1) implies that the brain integrates expectations based on skin color with direct sensory inputs in an averaging fashion, biasing the temperature perception toward the expectations. On the other hand, Prof. Sanchez-Vives’ explanation (2) and our explanation suggested that the brain integrates the expectation based on the visual information with direct temperature inputs in a way that emphasizes the contrast between the 2. It is known that our brain uses both strategies to integrate visual and tactile information when estimating an object property: In the case of the size or surface roughness the averaging strategy is used,8,9 while in the case of the weight or force the contrast strategy is used.10,11 Thus, for object temperature estimation, either integration strategy could be the candidate and further experiments are needed to clarify this issue. In addition to the experiments proposed by Prof. Sanchez-Vives, we think that manipulating both skin color and object color to be either in the same color (e.g., blue hand-blue object) or in different colors (e.g., red hand-blue object) may also help to clarify this issue, because such experiment allows us to examine the roles of skin color and object color and their combined effect in object temperature estimation.

Lastly, we’d like to thank Editor-in-Chief for posting this riddle in the editorial. We enjoy the discussion with Prof. Sanchez-Vives via letters. As it remains unanswered why cross-modal integration by the brain is an averaging effect in some cases, while a contrast effect in other cases, we hope that this correspondence will lead to a better understanding on how the brain integrates the multisensory information.

Disclosure of Potential Conflicts of Interest
The authors HH, JW, SN are employees of NTT Communication Science Laboratories, which is a basic-science research section of Nippon Telegraph and Telephone Corporation.

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