What feels warmer? A red skin versus a red object

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Dear Editor-in-Chief,

This is a reply to the puzzle published in your recent editorial.¹ Blue objects have been reported by Hsin-Ni Ho (Nippon Telegraph and Telephone Corporation, Japan) and her colleagues² to feel warmer to the touch than red ones at the same temperature. However, 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 making objects feel warmer. I would like to discuss this issue here and propose a possible explanation as well as experiments for testing it.

I live in Spain where numerous light skinned Northerners come for summer vacation. If one walks around the streets of any beach town during the summer evenings it is not unusual to find people whose skin looks painfully reddish. Just seeing that, one can imagine the hot, burning feeling and the painful night ahead with the unbearable touch of the sheets on the skin. Our brains have a consistent association between red skin and warm temperature. The medical description of skin inflammation signs is that of the triad: swelling, redness and warmth. This triad is the consequence of the inflammatory response, a general response to different kind of lesions. Vasodilation is caused by the local release of vasoactive peptides and causes the swelling. Inflammation also causes sensitization of nociceptive fibers, which underlies the well-known feeling of painful touch of an inflamed area, providing a protection of that area from mechanical aggression. At the other extreme of the temperature range, extreme cold causes a vasoconstriction, which reduces the oxygen supply to different kind of lesions. Vasodilation is enough, via top-down mechanisms, to influence the temperature perception. In virtual reality experiments, it was demonstrated that putting the hand inside a virtual oven was perceived as “hot” while sticking the hand into a virtual bucket filled with virtual iced water was perceived as “cold,” even when in both cases there was the same room temperature (unpublished results). The brain is not only predicting the temperature but there is as well a “filling in” phenomenon that can fill in the congruent sensory input that is missing while in virtual reality.³

The paradox presented here is that blue objects are felt warmer to the touch than red ones at the same temperature. However, when the hand in contact with an object is colored red or blue,³ the effect is reversed, such that red hands feel the objects warmer. The solution that I propose to this paradox is the following:

The skin color is going to determine the temperature perceived, and this is supported by the literature presented above.³,⁴,⁶ Why then touching a blue...
object feels warmer than touching a red one? I propose 2 testable explanations:

1. The color-contrast explanation: while getting near a blue object, or rather, when in a blue surround, a light skin in contrast looks more reddish. Given that the skin color is the primary determinant of the perceived temperature, a reddish looking hand would perceive warmer temperatures, and thus blue objects would feel warmer. On the other hand, when near a red object, or when in a red surround, the hand will look less reddish and thus the perceived temperature will be cooler for red than for blue objects.

2. The prediction-contrast bias: While touching a red object, the prediction is that it is hot. The contrast between the prediction and the actual temperature may have a reverse effect of feeling it colder than expected.

Both of them, explanation 1 and 2, could interact and add up, since they both go in the same direction. These explanations are amenable of experimental testing and immersive virtual environments would provide a flexible frame for it. In short, an “owned” virtual hand3 co-located with the real hand (but of which we have a control of the color) could touch virtual objects of red vs. blue color. Each time an object is touched the subject should report the perceived temperature in a scale ranging from cold to hot (1 to 10). Red and blue objects could be randomly presented interspersed with objects of other colors acting as controls. A factor to consider would be the size of the object, since I would hypothesize that the larger the object, the larger the surround effect and thus the color contrast effect on the hand. In this design, both explanations would be interacting. However, we could design an experiment to test specifically for the “prediction-contrast bias.” For this, we would need to eliminate the hand color factor. This could be achieved by making the hand dark – thus eliminating color contrast phenomena – or by touching the object with the hand out of view. In this case, the subjective perception of temperature could be independently attributed to the color of the object and not to its influence on the perceived hand color. Of course this could be combined with a controlled variation of the touched object’s temperature making design and data analysis more complex, but probably providing richer results.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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