Categorical color mechanisms of dichromats revealed by color naming and color memory

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Dichromats lack one of the cones so that they cannot discriminate colors on a confusion line. Red, green and yellow, for example, should not be discriminated by protanope and deuteranope. However they can actually use these color names in their everyday lives. Some previous studies suggested that several possible mechanisms, such as anomalous cone pigments, a nonlinear parallel chromatic channel or luminance cue, were responsible for this color naming ability of dichromats. We reported that protanopes and deuteranopes could perform trichromat-like color naming in normal observing conditions, but in restricted observing conditions, such as strong chromatic adaptation, small field, short duration and equal luminance, they showed some confusion in color naming along the red-green direction (Uchikawa, 2008, Asia-Pacific Conference on Vision Abstract 26). In the present paper we report a further investigation on color categorization mechanism of dichromats using a memory color-matching method. In an experiment we used the OSA color scales simulated on a CRT as stimuli. A test color, randomly selected from the 100 test-color set, was presented for 5sec, then after 30sec the observer started color matching by his memory. He changed colors on the CRT using the 3 variables of L, j and g of the OSA color space until he could choose one of the 1406 colors, which matched to the test color in his memory. He repeated this memory color-matching procedure for all 100-test colors. The categorical color naming experiment was also carried out for 424 OSA color samples with the Berlin and Kay's 11 basic color names. The results showed that color samples selected by color memory were restricted in the categorical color-naming regions for trichromats, but this tendency was not clearly shown for dichromats. This suggests that dichromats do not have categorical color perception based on a neural mechanism, but they use color appearance cues to show trichromat-like color categories.