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Perception of Munker–White illusion in 4–8-month-old infants

Jiale Yang[a,*], So Kanazawa[b], Masami K. Yamaguchi[c]

[a] Psychology Department, Chuo University, Japan
[b] Japan Women's University, Japan
[c] Chuo University, and PRESTO Japan Science & Technology Agency, Japan

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ABSTRACT

There have been numerous studies of the Munker–White illusion, but few have focused on the perceptual development of it in human infants. Therefore, this study explores the perceptual development of the Munker–White illusion in infants. In this study, we created two kinds of Munker–White illusion patterns that had different subjective saturation, and investigated infants' preference for these two kinds of patterns. Previous studies have shown that infants had a preference for high colorimetric saturation stimuli. Therefore, if infants could perceive the Munker–White illusion, we postulated that they would show a preference for stimuli that have high subjective saturation. In experiment 1, 4–8-month-old infants showed a preference for the stimuli that had a higher subjective saturation. In experiment 2, we confirmed that the preference shown in experiment 1 was not dependent on the difference of the 'color area ratio' that existed in the stimuli of experiment 1. Our results suggest that 4–8-month-old infants can perceive Munker–White illusion.

1. Introduction

In natural environments, the local color and lightness is hugely affected by the color and lightness of the immediately adjacent areas. The most famous example of this phenomenon is simultaneous contrast, which refers to the difference of perceived color or lightness between two identical patches surrounded by different areas (see Fig. 1). This phenomenon is usually explained by low-level visual mechanisms, such as lateral inhibition. Lateral inhibition is a kind of suppression by a neuron in response to a neighboring neuron at the same level in a sensory system, such as the suppression by neurons receiving information from the OFF region of a center-surround receptive field of neurons in the ON region when both regions are stimulated simultaneously. In Fig. 1, the lateral inhibition in the retina emphasizes the difference between the square and its surrounding, so that a square on a dark background looks extra light.

The Munker–White illusion is a striking lightness illusion (see Fig. 2, Munker, 1970; White, 1981). The chromatic version of the Munker–White illusion is called Munker illusion. In the Munker illusion (see Fig. 2a), all short colored patches have the same chromaticity, but the perceived hue and saturation of colored patches would be shifted (Lingelbach, Neustadt, Schmidt, & Ehrenstein, 2003). This illusion also exists in the achromatic domain, which is called White illusion. In the White illusion (see Fig. 2b), all gray patches have the same luminance, but the gray patches placed within black bars appear lighter than those placed within white bars. To the degree that the immediately adjacent region affects perceived color and lightness, the Munker–White illusion is similar to simultaneous contrast phenomenologically. However, the Munker–White illusion's change direction of color or lightness is the opposite to that of simultaneous contrast. In Fig. 2b, the gray patches in the two

* Corresponding author.
E-mail address: oc074006@grad.tamacc.chuo-u.ac.jp (J. Yang).

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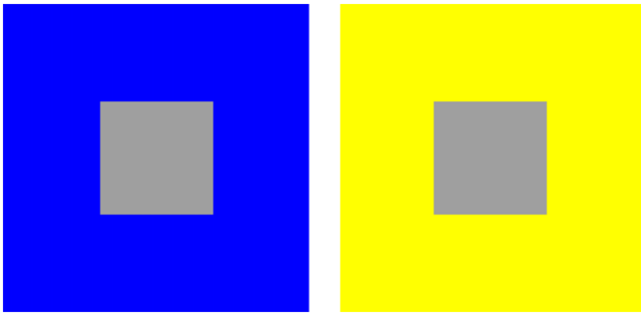

Fig. 1. The phenomenon of simultaneous contrast.

patterns have the same luminance, but the perceived lightness of gray patches are affected by the white bars and black bars, and those placed within black bars were perceived as lighter than those placed with white bars. In contrast, simultaneous contrast would predict that those placed within black bars should be perceived as darker, as the gray patches share a longer border with the white bar (Wallach's ratio rule: Wallach, 1948). Thus, the Munker–White illusion cannot be interpreted in terms of simultaneous contrast.

Recent research shows that perception of transparency plays an important role in the Munker–White illusion. Watanabe and Cavanagh (1993) showed that a special relationship of luminance exists in the transparent pattern. When the luminance on one side of the stem of a T-junction lies between the luminances of the other two regions (the top and the other side of the stem), the region of intermediate luminance could be perceived as overlapping the other regions. This scission of layers could induce a perception of transparency ultimately. Spehar, Gilchrist, and Arend (1995) found that the same luminance relationship of T-junctions also exists in the White illusion. They showed that the White illusion is only observed when the luminance for the gray patches (the region on one side of the stem of a T-junction) lies between the white/black strips (the other two regions of T-junctions). In the Munker–White illusion, Anderson (1997) emphasized that this luminance relationship of T-junctions induced the perception of transparency and the scission of layers (Watanabe & Cavanagh, 1993), and that the scission of layers ultimately causes an apparent lightness difference. We have used the same kind of pattern in our present study. In this pattern, Anderson (1997) showed that a transparent layer would appear on the gray patches covering its background strips. Because the transparent gray patch covering the black strip has the same luminance as the one covering the white strip, it should be interpreted as having a higher reflectance. Therefore, the gray patches placed within black bars appear lighter than those placed within white bars. In general, the Munker–White illusion has been considered a consequence of the perception of transparency (Anderson, 1997).

The Munker–White illusion has been studied in adults. However, there have been few studies of infants' perception of The Munker–White illusion. On the other hand, there are many studies of infants' perception of transparency (Johnson & Aslin, 2000; Otsuka & Yamaguchi, 2003; Otsuka et al., 2008), which plays an important role in the White–Munker illusion (Anderson, 1997). According to the transparency interpretation of the Munker–White illusion (Anderson, 1997) as mentioned above, it is reasonable to predict that perceptions of the Munker–White illusion and of transparency emerge in the same developmental period.

In infant experimental studies, transparency pattern with X junctions (Johnson & Aslin, 2000; Otsuka & Yamaguchi, 2003) and T junctions (Otsuka et al., 2008) have been investigated, respectively. According to these studies, perceptions of these two kinds of transparencies both emerge at 4 months of age. For the transparency pattern with X junctions, Johnson and Aslin (2000) found that 4-month-old infants could perceive transparency when the figures of transparency were chromatic and moving. In a static display, 4-month-old infants could perceive transparency in the achromatic pattern, which was composed of a partially overlapping circle and square (Otsuka & Yamaguchi, 2003). For the transparency pattern with T junctions, Otsuka et al. (2008) found that 4 infants preferred the Kanizsa figure that induces the perception of an illusory transparent surface and only contains the cue of T-junctions to perceive transparency. Thus, these results demonstrated that 4-month-old infants could perceive transparency. According to the transparency interpretation (Anderson, 1997), the Munker–White

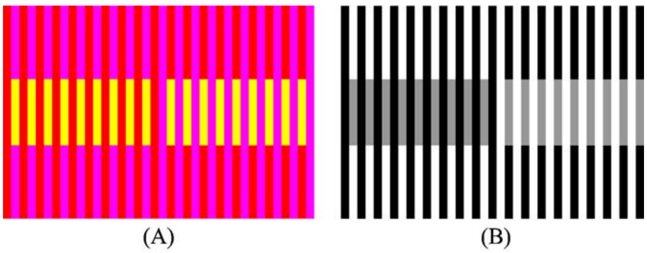

Fig. 2. The Munker illusion (A) and the White illusion (B).