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Infants' perception of subjective contours from apparent motion

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Abstract

We examined infants' perception of subjective contours in Subjective-Contour-from-Apparent-Motion (SCAM) stimuli [e.g., Cicerone, C. M., Hoffman, D. D., Gowdy, P. D., & Kim, J. S. (1995). The perception of color from motion. *Perception & Psychophysics*, *57*, 761–777] using the preferential looking technique. The SCAM stimulus is composed of random dots which are assigned two different colors. Circular region assigned one color moved apparently, keeping all dots' location unchanged. In the SCAM stimulus, adults can perceive subjective color spreading and subjective contours in apparent motion (http://c-faculty.chuo-u.ac.jp/∼ymasa/okamura/ibd_demo.html). In the present study, we conducted two experiments by using this type of SCAM stimulus. A total of thirty-six 3–8-month-olds participated. In experiment 1, we presented two stimuli to the infants side by side: a SCAM stimulus consisting of different luminance, and a non-SCAM stimulus consisting of isoluminance dots. The results indicated that the 5–8-month-olds showed preference for the SCAM stimuli. In experiments 2 and 3, we confirmed that the infants' preference for the SCAM stimulus was not generated by the local difference and local change made by luminance of dots but by the subjective contours. These results suggest that 5–8-month-olds were able to perceive subjective contours in the SCAM stimuli.

Keywords: Infant; Subjective contour; Color vision; Apparent motion

1. Introduction

Subjective contours are contours perceived in the absence of any physical boundary. Cicerone, Hoffman, Gowdy, and Kim (1995) created a Color-from-Motion stimulus which generated subjective color spreading bound by a subjective contour. In the CFM stimulus, it is possible to perceive subjective color spreading and a subjective contour. In this study, we used this type of CFM stimulus to investigate infants' perception of a subjective contour. In the CFM stimulus, adults are able to perceive subjective color spreading and a subjective contour from the apparent motion which is generated by the dots' changing of luminance. In our study, we investigated whether infants are able to perceive a subjective contour from the apparent motion which is generated by the dots' changing of luminance. So we call their stimuli to Subjective-Contour-from-Apparent-Motion (SCAM) below.

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The SCAM stimulus (Cicerone et al., 1995) is presented as an animation in multiple frames, and is composed of random dots. The dots in the circular region are assigned one color while the dots in the surround region are assigned a different color. The circular region is translated up and down by changing only the color assignment of the dots while keeping the locations of the dots unchanged. In this type of SCAM stimulus, it is possible to perceive subjective color spreading and a subjective contour. However, the subjective color spreading and subjective contour are not seen without translation of the circular region; in other words, it is not possible to perceive subjective color spreading and a subjective contour in a still view of a single frame of the SCAM stimuli (e.g., Chen & Cicerone, 2002; Cicerone & Hoffman, 1997; Cicerone et al., 1995; Miyahara & Cicerone, 1997).

Previous studies with adult subjects have revealed that the perception of subjective contours in the SCAM stimuli depend on the difference of luminance (e.g., Cicerone et al., 1995). Using a rating method, Cicerone et al. (1995) examined the effect of the difference of luminance on the subjective contour strength. They found that the absence of luminance differences between the circular and surround region produced no subjective contours, in spite of the existence of color differences between the circular and surround region.

In the present study, we examined 3–8-month old infants' perception of a subjective contour by using this type of SCAM stimulus (Cicerone et al., 1995). Many studies have reported that the perception of subjective contours in the classical illusory figures develops between 3- and 8 months of age (e.g., Bertenthal, Campos, & Haith, 1980; Ghim, 1990; Kavsek, 2002; Otsuka, Kanazawa, & Yamaguchi, 2004; Otsuka & Yamaguchi, 2003; Treiber & Wilcox, 1980). The perception of subjective contours in the SCAM stimulus is also expected to develop at around this time.

To perceive subjective contour in the SCAM, the luminance temporal contrast sensitivity function and the ability of the chromatic discrimination should be sufficiently matured.

The shape of the luminance temporal contrast sensitivity functions appears quite similar to those in adults by 3 months old (e.g., Dobkins, Anderson, & Lia, 1999; Dobkins & Teller, 1996; Hartmann & Banks, 1992; Rasengane, Allen, & Manny, 1997; Swanson & Birch, 1990; Teller, 1998). This suggests that the luminance temporal contrast sensitivity functions of over 3 months have similar feature those of adults. In the SCAM stimuli, the luminance temporal contrast sensitivity is necessary to perceive a subjective contour, and our participants who were over 3 months old had a quite similar shape of the luminance temporal contrast sensitivity function to adults.

Infants' chromatic discrimination has shown that infants' visual system responds to red/green chromatic differences by 2 months (e.g., Clavadetscher, Brown, Ankrum, & Teller, 1988; Hamer, Alexander, & Teller, 1982; Packer, Hartmann, & Teller, 1984; Teller, 1998). In this study, we used the SCAM stimuli composed of red and green random dots, and our participants who were over 3 months old had the ability to discriminate between red and green used in the SCAM stimuli.

This suggests that the luminance temporal contrast sensitivity and the ability of the chromatic discrimination are sufficient to perceive subjective contour in the SCAM even in 3-month-olds. So if only the maturity of the luminance contrast sensitivity function and the chromatic discrimination was related to the perception of subjective contour in SCAM, then the infants over 3 months old were expected to perceive subjective contour in the SCAM.

To examine 3–8-month-old infants' perception of subjective contours, we used the preferential looking method. Previous studies provided evidence that infants prefer the subjective contours' configurations to the non-subjective contours' configurations (Curran, Braddick, Atkinson, Wattam-Bell, & Andrew, 1999; Otsuka & Yamaguchi, 2003; Otsuka et al., 2004). Therefore, in this study we measured infants' preference for the SCAM stimulus to the non-SCAM stimulus. In experiment 1, we presented two stimuli to the infants side by side: one a SCAM stimulus, which induced the perception of a subjective contour around a circular region in adults; the other a non-SCAM stimulus, which produced no subjective contour in adults. If the infants were able to perceive a subjective contour in the SCAM stimulus, as adults are able to do, then the infants were expected to show a preference for the SCAM stimulus.

2. Experiment 1

We examined the development of the perception of a subjective contour by using the Color-from-Motion stimulus (e.g., Cicerone et al., 1995). We presented two kinds of stimuli to the infants side by side. One was a SCAM stimulus, consisting of different luminance dots between the circular region and the surround region. This stimulus induced the perception of a subjective contour around the circular region. The other was a non-SCAM stimulus consisting of isoluminance dots between the circular region and the surround region. The latter stimulus produced no subjective contour. If the infants were able to perceive a subjective contour in the SCAM stimulus, as adults are able to do, then the infants were expected to show a preference for the SCAM stimulus.