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Infants' perception of curved illusory contour with motion☆

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ABSTRACT

Recently, Masuda et al. (submitted for publication) showed that adults perceive moving rigid or nonrigid motion from illusory contour with neon color spreading in which the inducer has pendular motion with or without phase difference. In Experiment 1, we used the preferential looking method to investigate whether 3–8-month-old infants can discriminate illusory and non-illusory contour figures, and found that the 7–8-month-old, but not the 3–6-month-old, infants showed significant preference for illusory contour with phase difference. In Experiment 2, we tested the validity of the visual stimuli in the present study, and whether infants could detect illusory contour from the current neon color spreading figures. The results showed that all infants might detect illusory contour figure with neon color spreading figures. The results of Experiments 1 and 2 suggest that 7–8-month-old infants potentially perceive illusory contour from the visual stimulus with phase-different movement of inducers, which elicits the perception of nonrigid dynamic subjective contour in adults.

1. Introduction

Illusory contour is the illusory edges of surface in the absence of any local variations in luminance in the display (Kanizsa, 1976). Illusory contour is typically composed of three or four "pacmen" which induce the perception of an illusory triangle or square. Kanizsa-type illusory contour has distinct characteristics: the illusory figure is perceived as being both brighter than the ground which surrounding the illusory surface and as being without any variations in luminance (illusory brightness); a sharp boundary is perceived to be surrounding the area of bright intensification (illusory contour); the illusory surface seems to be closer than the inducers and to occlude them (apparent depth); and the occluded inducers are perceived to complete the shape behind the illusory figure (amodal completion).

A recent psychophysical study with adult observers found new aspects of the perception of illusory contour using a Kanizsa-type figure. Masuda et al. (submitted for publication) reported that a novel variation of illusory contour can occur depending on the phase difference in the movement of the pacmen' notches. They manipulated the phase difference

☆ You can see demonstrations of the stimuli used in this research and used in Yoshino et al. (2010) on our website. The URL of the website is http://c-faculty.chuo-u.ac.jp/~ymasa/sato/demo_ibad.html

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between the pendular motion in the two top and two bottom pacmen. The modes of the phase difference were changed by delaying the beginning of the pendular motion. When the phase difference was close to 0°, the impression of a rigid plane swinging in depth was dominant. In contrast, when the phase difference was close to 90°, the impression of a waving motion was dominant. They also reported that adult observers perceived curved illusory contour in all conditions. Their findings suggest that adding motion information to a Kanizsa figure can elicit a variety of illusory contour perceptions, and that the perceptions can be manipulated in a systematic way by controlling the motion information of pacmen.

The developmental aspects of the perception of illusory contour have been relatively well investigated. For instance, Bertenthal, Campos, and Haith (1980) used the habituation paradigm to demonstrate that 7-month-old, but not 5-month-old, infants discriminate between a Kanizsa-type illusory contour figure and a non-illusory contour figure with the same elements of illusory contour when all or half of the elements are rotated 180°. On the other hand, Ghim (1990) used the familiarization paradigm to establish that 3-month-old infants can perceive illusory contour by presenting 2 stimuli simultaneously, unlike Bertenthal et al.'s prior study. More recently, Otsuka and Yamaguchi (2003) used the preferential looking paradigm to investigate 3–8-month-old infants' perception of illusory contour. They tested infants' preference for illusory contour under two experimental conditions: moving and static. In the moving condition, the subjective square moved back and forth in a horizontal direction. In the static condition, the subjective square had no motion. They found that while 3–8-month-old infants successfully detected the illusory contour under the moving condition, only 7–8-month-old infants perceived illusory contour in the static condition (see also Kavšek & Yonas, 2006). Likewise, by using other types of subjective contour, Johnson and Aslin (1998) showed that 4-month-old infants could perceive the illusory contour from motion with no local variations in luminance. Furthermore, Otsuka, Kanazawa, and Yamaguchi (2004) demonstrated that the support ratio, the ratio of the physically specified contour to the total edge length, affects infants' perception of illusory contour. They found that even 3–4-month-old infants could detect a static illusory contour when the support ratio of the illusory contour was relatively high. This finding is consistent with a study with adult subjects showing the effect of the support ratio on the perception of illusory contour (Shipley & Kellman, 1992). Moreover, a recent newborn study showed that even newborn infants preferred the Kanizsa-type illusory contour from dynamic figures in high support ratio (Valenza & Bulf, 2007).

These developmental studies showed that even young infants perceive illusory contour. On the other hand, some reports suggest some differences between infant and adult perception of illusory contour under some conditions. Yoshino, Idesawa, Kanazawa, and Yamaguchi (2010) used a familiarization method to examine the perception of the rotating Kanizsa square. When the Kanizsa square was rotated across the pacmen, adults perceived not only a rotating illusory square, but also illusory nonrigid motion such as expansion and contraction of this square. However, their study found that the infants perceived only a rotating illusory square without any illusory expansion and contraction motion even when they observed the same visual stimuli as the adults.

As shown above, although the ability of illusory contour perception seems to be relatively well-developed in early infancy, there has been a potential inconsistency between the results of infants and adults. Hence, it is an important task to investigate the development of the novel illusory contour perception reported by Masuda et al. (submitted for publication) to expand our knowledge about the development of illusory contour perception. In this study, we investigated infants' ability to detect illusory contour with Masuda's illusory contour figures which had a phase difference of 0° and 90°. When the phase difference was 0 degrees, adult observers could perceive the rigid motion with illusory contour. On the other hand, when the phase difference was 90°, they could perceive the nonrigid motion with illusory contour (Masuda et al., submitted for publication). Previous studies (Otsuka et al., 2008; Yang, Kanazawa, & Yamaguchi, 2009) have shown that young infants prefer figures which can induce illusory contour perception to those which induce no illusory contour perception in adults. Hence it would be expected that infants would show significant preferences for the illusory contour figures if they were sensitive to the visual information related to the perception of illusory contour.

2. Experiment 1

We used visual stimuli composed of the pacmen in pendular motion with a phase difference of 0° (no-phase-difference condition) and 90° (phase-difference condition). In the no-phase-difference condition, adult observers could perceive the rigid motion from illusory contour. In contrast, in the phase-difference condition, they could perceive the nonrigid motion (Masuda et al., submitted for publication). We presented an illusory counter figure and a non-illusory contour figure (contained by rotating all the inducers 180°) side by side in both conditions and examined infants' preference to the illusory counter figure (the preferential looking method). The preferential looking method is a well-established way to examine the infant' perception of illusory contour and has been applied in many previous studies (e.g., Otsuka & Yamaguchi, 2003; Otsuka et al., 2004; Kavšek & Yonas, 2006; Valenza & Bulf, 2007). Those studies have shown that even infants as young as 3 months show significant preference for illusory contour if the visual stimuli has enough visual cues. Those previous empirical findings are comparable to those obtained by other experimental techniques such as the familiarity-novelty preferential looking method or the habituation/dishabituation method (e.g., Ghim, 1990; Kavšek, 2002, 2009). Thus, it was reasonable to use the preferential looking method and to expect that infants would prefer the illusory contour figures if they were sensitive to visual cues regarding illusory contour from the figure in which the pacmen had pendular motion in both conditions.