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The homogeneity effect on figure/ground perception in infancy

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ABSTRACT

We examined whether the homogeneity of the two profiles of *Rubin's goblet* affects figure/ground perception in infants. We modified the two profiles of *Rubin's goblet* in order to compare figure/ground perception under four test patterns: (1) two profiles painted with horizontal lines (horizontal-line condition), (2) two profiles painted middle gray (uni-color condition), (3) one profile painted light gray and the other dark gray (two-color condition), and (4) a goblet painted with concentric circles (concentric-circles condition). In the horizontal-line condition the homogeneity of the profile was strengthened, and in the two-color condition the homogeneity of the profile was weakened compared to the uni-color condition, which was an original *Rubin's goblet*. In the concentric-circles condition the homogeneity of the reversed areas of the horizontal-line were strengthened.

After infants were familiarized with each *Rubin's goblet*, the infants were tested on their discrimination between the two profiles and the goblet in the post-familiarization test. In horizontal-line condition, uni-color condition and concentric-circles condition infants showed a novelty preference for the two profiles in the post-familiarization test. On the other hand, in the two-color condition no preference was observed in the post-familiarization test. This means that infants perceived the goblet as figure and the two profiles as ground in the horizontal-line condition, the uni-color condition and the concentric-circles condition. We found that infants could not perceive the goblet area as figure when the homogeneity of the two profiles was weakened. It can be said that figure/ground perception in infancy is not affected by strengthened homogeneity, but is affected by weakened homogeneity.

1. Introduction

Figure/ground perception is important for visual processing because it organizes a visual scene into figures and backgrounds. This perception is fundamental to the visual perception of objects.

Gestalt psychologists were the first to recognize the importance of figure/ground perception for distinguishing figures and grounds in terms of their phenomenal appearance (Rubin, 1921). Rubin's goblet (Rubin, 1921) is one of the classical demonstrations of a reversible pattern of figure and ground. We can perceive Rubin's goblet either as a white goblet on a black

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background or as two black profiles on a white background. Rubin's goblet illustrates two phenomenological characters of figure/ground perception: that figures appear to have a definite shape, and that their bounding contours are seen as belonging to them. The grounds are shapeless near the contours they share with the figures and appear to extend behind the figures near those contours.

Many studies on figure/ground perception have been concerned with identifying the properties that determine which regions will appear as figures. For example, smaller regions are more likely to be perceived as figures (Graham, 1929; Oyama, 1960), as are symmetrical regions (Bahnsen, 1928), same-width regions (Morinaga, 1942), convex regions (Hoffman & Singh, 1997; Kanizsa & Gerbino, 1976; Kanizsa & Luccio, 1986, Luccio, 2003), lower regions (Ehrenstein, 1930; Vecera, Vogel, & Woodman, 2002), regions with a wide base (Hulleman & Humphreys, 2004), and regions depicting familiar objects (Peterson & Gibson, 1991, 1993, 1994).

Torii (1963) examined the figure/ground perception of *Rubin's goblet*. He presented a uni-color pattern in which the two profiles were the same color, and a two-color pattern in which the each profiles was different in color. Observers were asked which area they perceived as figure, and Torii calculated the looking time for the two profiles and the goblet. The looking ratio for the two profiles was calculated by dividing the looking time for the two profiles by the total looking time. The looking time ratio for the two profiles was 50.9 percent in the uni-color pattern, while the looking time ratio was 75.3 percent for the two-color pattern.

Takashima, Fujii, and Shiina (2012) presented these two patterns and a horizontal line pattern in which the two profiles were painted with horizontal lines, and recorded observers' perception (either a goblet or the two profiles). Results showed that the two-color pattern was judged as two profiles by 92.5 percent of the observers, while the horizontal line pattern was judged as two profiles by only 11 percent of observers. The uni-color pattern was judged as two profiles by 50.4 percent of observers.

Torii (1963) and Takashima et al. (2012) showed that the two-color pattern was more likely to be perceived as two profiles and that the horizontal line pattern was more likely to be perceived as a goblet. From these phenomenological experiments with adults, it has been found that the color or texture of the two profiles affects perception of figure and ground. From these results we assume that the degree of homogeneity is controlled by changing color and texture. That is, in a horizontal-line pattern the homogeneity of the two profiles is strengthened, while in a two-color pattern the homogeneity of the two profiles is weakened.

Koffka (1935) and Morinaga (1969) showed that the weaker the homogeneity, the less we can perceive ground. Conversely, the stronger the homogeneity, the more we can perceive ground. In a two-color pattern the two profiles tend to be figure, and we are more likely to perceive two profiles because the homogeneity of the two profiles is weakened. On the other hand, in a horizontal line pattern the two profiles tend to be ground, and we are more likely to perceive a goblet because the homogeneity of the two profiles is strengthened. (This means that homogeneity affects figure/ground perception in adults.)

Many studies of figure/ground perception have been concerned with adults, but few studies have investigated figure/ground perception during infancy.

Because ground area extends behind the figure area (Rubin, 1921) amodal perception is necessary for figure and ground perception. This means that the occluded area was perceived as ground while the occluding area was perceived as figure in amodal perception (Kanizsa, 1979).

For infant studies about amodal completion in 2-dimensional pattern, Kellman and Spelke (1983) observed that 4-month-old infants perceived an object as connected when the object's ends moved in a common translation behind an occluder (motion condition). Yet infants did not perceive an object as connected when its visible parts were stationary (static condition). Otsuka, Kanazawa, and Yamaguchi (2006) used the partly occluded pattern to show that while 5–6 month-old infants could amodally complete this pattern like adults, 3–4 month-old infants could not. Kavšek (2004) used a center-occluded rod in a static rod-and-box display and suggested that the capability of perceiving object unity emerges after about 8 months of age. Condry, Smith, and Spelke (2001) suggested that infants are able to use all the sources of information used by adults in perceiving object unity, including motion, contour alignment, and surface similarity (e.g., color, texture, and so on).

Recently, Braddick and Atkinson (2007) examined figure/ground perception in infancy. They used the curved shape ("figure shape") which was perceived as figure by adults and "ground shape", which was the background region of "figure shape". They measured infants' preference between "figure shape" and "ground shape". When these patterns were presented side by side, infants (7–21 weeks, mean 14 weeks) showed a significant preference for the "figure shape". They concluded that 4-month-old infants are important age for developing an understanding of the attributes of the distinction between ground shapes and figure shapes.

Needham, Baillargeon, and Kaufman (1997) used a partly occluded pattern with a black rectangle, in which the left side of the display was red and rectangular, but the right was green and irregularly-shaped, and showed that 4.5-month-old infants failed to perceive the boundary between the objects. It is possible that infants, like adults, are less likely to perceive two pieces which have weakened homogeneity as ground. There is the possibility that 4-month-old infants can perceive figure and ground the same as adults. Needham et al. (1997) also tested a 3-dimensional pattern, but it is unclear whether the homogeneity of ground provides more effective information for infants in 3-dimensional patterns than in 2-dimensional patterns. We examined whether the homogeneity of ground affected figure/ground perception in infants.

We used the habituation paradigm to examine whether a goblet or two profiles were perceived as figure by infants. After the infants were habituated with *Rubin's goblet*, they were tested for novelty preference between the profiles and the goblet. If infants perceived the two profiles as figure, they showed novelty preference for the goblet in the