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The development of object-based attention in infants

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ABSTRACT

We examined whether infants aged 6–8 months show object-based attention using the preferential looking method. In object-based attention, which is a prerequisite function for efficient real-world processing of various stimuli, a target that appears at a cued object is detected and processed faster than a target appearing at an uncued object. We presented 6- to 8-month-old infants with the visual stimuli consisting of two white vertical rectangles side by side, in which a target appearing at 1) the cued location, 2) the end opposite to the cued location, and 3) another rectangle's end following the cue, using an established paradigm, and measured each infant's first saccade to the target. We found that (1) infants of all ages could make the first saccade to the target appearing at the cued location, (2) only 8-month-old infants made the first saccade to the target appearing at the opposite end to the cued location more accurately than to the target appearing at the other rectangle's end. These results indicate that object-based attention might be acquired around 8 months compared with the spatial cueing effect that appears at around 6 months. Our findings suggest that the objects play a role in visual attention in 8-month-old infants.

1. Introduction

In this study, we investigated whether 6- to 8-month-old infants show object-based attention. Object-based attention is the important visual attentional function needed to adapt to this world, enabling us to direct our attention to a specific object rapidly and process a lot of information (Shomstein, 2012). Object-based attention is considered to be based on two visual attentional functions, 1) attentional disengagement, 2) attention shift toward cued direction (the spatial cueing effect). Previous studies have demonstrated that these functions had developed in young infants.

Attentional disengagement is required in object-based attention to correctly show a preference for the target. In Hood and Atkinson (1993), 1.5-, 3-, and 6-month-old infants were shown a target in their peripheral region after center fixation, and their saccade latency to the target from fixation was measured. They found that even 1.5-month-old infants could correctly make saccades to the target after the fixation offset, and 6-month-old infants made the fastest eye movements to the target. Matsuzawa and Shimojo (1997) replicated this study, and found that 6-month-olds could disengage their attention and make saccades to the peripheral stimulus readily in the same manner as adults. These studies suggest that attentional disengagement emerges by 1.5 months of age and develops more sophisticated form by 6 months.

In object-based attention tasks, in which a cue and target are presented in the same object or different object, saccades should be more accurately made to the same object's target than to the different object's target. In such a case, the spatial cueing effect is necessary to direct attention to the cue followed by the target. Johnson and Tucker (1996) measured infants' first gaze movement and

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saccade latency to a cued target. Participants were 2- to 6-month-old infants, and they used a cueing task in which two identical targets appeared at both the right and left sides after a 100-ms presentation of the cue at either the right or left side. The results showed that even 2-month-old infants made saccades to the cued target, suggesting that they could direct their attention to the cue before target onset. The endogenous cueing effect of an adult's gaze was thus also confirmed in infants. Hood, Willen, and Driver (1998) measured infants' saccade latency and first gaze movement to targets presented at either the right or left side following the presentation of an adult face whose gaze was directed to either the right or left. According to that study, infants as young as 3 months detected the direction of the adult gaze and made an eye movement to that target faster and more accurately when the adult's gaze direction was toward the location of the target. This result indicated that infants aged 3 months directed their attention according to the adults' gaze direction. These previous infants' attention studies showed that the spatial cueing effect has been observed at 2 months, and the attentional disengagement is sufficiently developed at 6 months. Although there are many studies investigating infants' visual attention, few studies examine how infants direct their attention toward objects among a wide range of complicated objects.

These previous studies revealed that the two basic functions of visual attention develop by 6 months of age. Recently, there have been few infant studies on object-based attention. Harman, Posner, Rothbart, and Thomas-Thrapp (1994) showed that 6-month-old infants tend to direct their attention more toward objects than location, and Johnson and Gilmore (1998) showed object-based attention in 8-month-old infants using the modified rectangle paradigm developed by Egly, Driver, and Rafal (1994). Following these studies, Bulf and Valenza (2013) revealed object-based attention in 8-month-old infants using the original paradigm by Egly et al. (1994). Furthermore, Valenza, Franchin, and Bulf (2014) showed 8-month-old infants' object-based attention with inverted faces. Bulf and Valenza (2013) measured the 8-month-old infants' saccade latency to target appearing at the cued end, the other end of cued rectangle, and the end of different rectangle with the same distance from cued end using Egly et al.'s (1994) paradigm. They found that the saccade latency to target appearing at the cued end was faster than the other target's locations, and also found that the saccade latencies to targets appearing at the other end of cued rectangle was faster than the end of different rectangle, suggesting that the object-based attention was observed at 8 months of age. Bulf and Valenza (2013) showed object-based attention in 8-month-old infants. However, there are no studies investigating object-based attention before 8 months old. It is unclear whether the infants younger than 8 months old also show object-based attention. The aim of this study is to examine the developmental changes of object-based attention in 6- to 8-month-old infants.

Object-based attention is necessary to perceive stimuli effectively in the real world. We process much information effectively by directing attention to a specific object among various visual stimuli. One famous paradigm for studying object-based attention in adults was developed by Egly et al. (1994). They showed participants displays consisting of two rectangles, which were placed on equal positions vertically right and left or horizontally above and below a central fixation point. After a few seconds, one end of one rectangle brightened as a cue, then a target appeared at one end of one of the rectangles. Targets were presented at not only the cued end, but also at the other end of the cued rectangle or the end of a different rectangle at the same distance from cued end. The participants' task was to detect the target as fast as they could. The results showed that detecting the targets presented at the same location as the cue was fastest, indicating spatial attention. Interestingly, although the distance from the cued end was the same, participants detected the target appearing at the other end of the cued rectangle faster than that in a different rectangle. Other previous studies also replicated this study in various ways (Malcolm & Shomstein, 2015; Moore, Yantis, & Vaughan, 1998). Moore et al. (1998) used subjective contour rectangles and confirmed the object-based attention. Malcolm and Shomstein (2015) found the effect of object-based attention in real world scenes. These findings showed that object-based attention was observed regardless of different tasks.

For infants, it is ecologically important to recognize a specific object in a complicated environment that has many visual stimuli. Before acquiring object-based attention, infants should have many different types of object perceptions. For example, infants at 8 months could use both configural and physical knowledge to organize stationary adjacent displays (Needham & Baillargeon, 1997) and could perceive the constant surface of objects, ignoring the dynamic light field changes (Yang, Kanazawa, Yamaguchi, & Motoyoshi, 2015). Kwon, Luck, and Oakes (2014) showed that 8-month-old infants maintained the information of a single object among multiple-item arrays, reflecting visual short-term memory for complex objects. Neurological study also revealed that 8-month-old infants showed the pattern of event-related potentials similar to those of adults when perceiving illusory objects that require feature binding of spatially separate elements (Csibra, Davis, Spratling, & Johnson, 2000). These behavioral and neurological studies showed that the wide range of object perceptions had developed at 8 months. The aim of this study is to investigate the developmental process of object-based attention. Although 8-month-old infants showed object-based attention (Bulf & Valenza, 2013), it has been unclear when its development began. In this study, we examined the developmental process of object-based attention in 6- to 8-month-old infants.

In the current study, we examined whether infants aged 6 to 8 months show the object-based attention by a preferential looking method. We aimed to confirm that infants 1) preferred a target following a cue as in the spatial cueing effect, and 2) preferred a target appearing at the opposite end of the cued object over a target appearing at the end of an object different from the cued object, as in the object-based attention.

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