Infant Behavior & Development 44 (2016) 240–248

Contents lists available at ScienceDirect

Infant Behavior and Development

Full length article

Perception of occlusion by young infants: Must the occlusion event be congruent with the occluder?

J. Gavin Bremner[a,*], Alan M. Slater[b], Uschi C. Mason[a], Jo Spring[a], Scott P. Johnson[c]

[a] Lancaster University, United Kingdom
[b] University of Exeter, United Kingdom
[c] University of California, Los Angeles, United States

ARTICLE INFO

Article history:
Received 8 March 2016
Received in revised form 19 July 2016
Accepted 21 July 2016
Available online 1 August 2016

Keywords:
Occlusion
Trajectory continuity
Accretion
Deletion

ABSTRACT

Four-month-old infants perceive continuity of an object's trajectory through occlusion, even when the occluder is illusory, and several cues are apparently needed for young infants to perceive a veridical occlusion event. In this paper we investigated the effects of dislocating the spatial relation between the occlusion events and the visible edges of the occluder. In two experiments testing 60 participants, we demonstrated that 4-month-olds do not perceive continuity of an object's trajectory across an occlusion if the deletion and accretion events are spatially displaced relative to the occluder edges (Experiment 1) or if deletion and accretion occur along a linear boundary that is incorrectly oriented relative to the occluder's edges (Experiment 2). Thus congruence of these cues is apparently important for perception of veridical occlusion. These results are discussed in relation to an account of the development of perception of occlusion and object persistence.

The ability to detect the persistence of objects during temporary occlusion by a nearer object is crucial to perceiving an enduring world, and there is now evidence that this capacity emerges in at least rudimentary form in early infancy. Most of the evidence supporting this conclusion arises from work investigating infants' response to moving object occlusion events in which an object moves across a display, disappearing and reappearing at the boundaries of an occluding screen.

One approach involves measuring eye tracking while the object is out of sight, and there is now converging evidence from different laboratories indicating that the proportion of anticipatory eye tracks increases from 4 months through the first year (Gredebäck & von Hofsten, 2004; Johnson, Amso, & Slemmer, 2003; Rosander & von Hofsten, 2004).

Another approach is to harness the habituation-novelty method to investigate object trajectory perception (Fig. 1). Infants are habituated to a display in which an object moves back and forth across a display screen, disappearing behind a centrally placed occluder, and looking preference is assessed between two test trials in which the occluder is absent but the object either moves continuously or discontinuously. The rationale is that if infants perceive continuity in the habituation trajectory they should exhibit a novelty preference for the discontinuous test display, whereas if they perceive discontinuity, they should show a novelty preference for the continuous test display.

Application of this approach suggests that 4 months is a pivotal age for the emergence of perception of trajectory continuity. Two-month-olds do not perceive an object's trajectory as continuous even across the shortest gap in perception, whereas 6-month-olds exhibit robust perception of trajectory continuity (Johnson, Bremner, Slater, Mason, Foster, & Cheshire, 2003).

* Corresponding author.
E-mail address: j.g.bremner@lancaster.ac.uk (J.G. Bremner).

http://dx.doi.org/10.1016/j.infbeh.2016.07.007

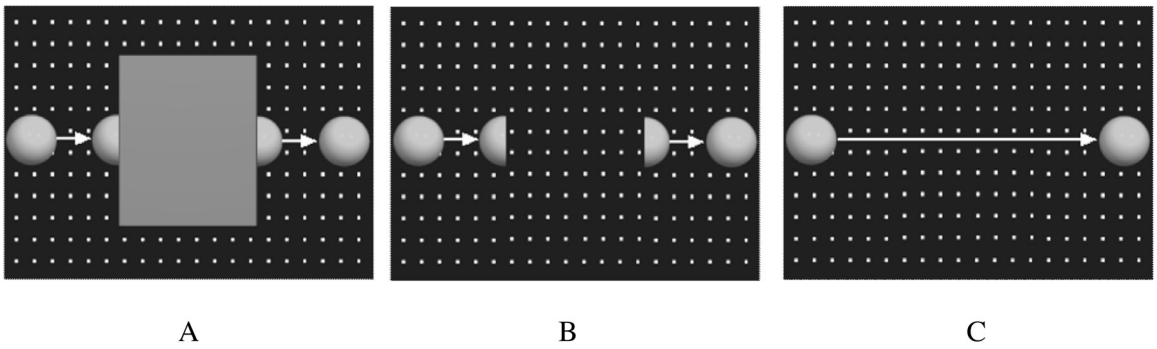

Fig. 1. Displays used by Johnson, Bremner et al. (2003) to investigate infants' perception of trajectory continuity, a) the habituation display, b) the discontinuous test display, and c) the continuous test display.

So far, 4 months is the earliest age at which infants have been shown to perceive trajectory continuity under these conditions, and they only do so when the occlusion event is of short duration or takes place across a short spatial extent (Bremner et al., 2005; Johnson, Bremner et al., 2003). The evidence arising from the habituation-novelty method for emergence of this ability at 4 months and its increasing robustness across the following months is in keeping with the increase in predictive tracking emerging from eye-tracking research.

These data may be best explained in terms of a general perceptual processing account (Bremner, Slater, Johnson, 2014) in which infants attend selectively to different cues, singly and in combination, as indicators of both continuities and discontinuities in perceptual experience. For instance, 4-month-olds use changes in trajectory direction or height behind an occluder as a cue to discontinuity (Bremner et al., 2007), but do not use violation of smoothness of movement as a cue to discontinuity (Bremner et al., 2005). Also, 4-month-olds use the combination of color and shape change as information specifying a discontinuity in the moving object and hence perceive trajectory continuity, but do not do so when only shape or color is changed (Bremner, Slater, Johnson, Mason, & Spring, 2013). Likewise, information such as deletion and accretion of background, alignment of object parts (Johnson & Aslin, 1998), and figural goodness (Johnson, Bremner, Slater, & Mason, 2000) are cues that support perception of unity when an occluder hides part of an object.

This analysis leads to the question of minimum cues needed for young infants to perceive an occlusion event, and hence to perceive object continuity across occlusion. It is evident that deletion and accretion are sufficient to cue occlusion in adults, because they perceive object continuity even when there is no visible occluding surface (Kahneman, Triesman, & Gibbs, 1992; Kawachi & Gyoba, 2006; Michotte, Thines, & Crabbe, 1964/1991). On seeing an object that is deleted and accreted at the 'edges' of an invisible occluder, adults perceive it as disappearing into and reappearing from a slit or tunnel in the background (the tunnel effect, Burke 1952). Thus deletion and accretion appear to specify some sort of occluding surface. However, it appears that young infants are not subject to the tunnel effect cued by deletion and accretion information alone: Following habituation to a deletion and accretion event with a visible occluder, 4- and 6-month-olds often look longer at a deletion and accretion event without a visible occluder in comparison to a continuous trajectory without an occluder. This preference presumably arises due to stimulus novelty (Bremner et al., 2005, 2007; Johnson, Bremner et al., 2003; see Fig. 1). If young infants perceive deletion and accretion alone as sufficient information for an occluding surface, one would predict either a null result or a preference for the continuous trajectory because it differs more from either of the two deletion and accretion events (the habituation event and the discontinuous test event). Nevertheless, it does appear that deletion and accretion are important cues to occlusion for young infants (Granrud et al., 1984), and Bertenthal, Longo, and Kenny (2007) demonstrated that, in comparison with deletion and accretion, instantaneous disappearance or implosion were not good cues to object persistence.

This raises a question regarding what information in addition to deletion and accretion is needed to support young infants' perception of object persistence through occlusion. The clearest information specifying an occlusion event is the presence of a luminance defined bounded surface whose edges coincide with deletion and accretion events, and work on trajectory perception demonstrates that provision of this information, along with deletion and accretion, is sufficient even in computer generated displays containing minimal explicit depth information (Bremner et al., 2005, 2007; Johnson, Bremner et al., 2003).

Additionally, Csibra (2001) demonstrated that 8-month-olds perceive the Kanizsa figure (Fig. 2; Kanizsa, 1979) as an occluding surface. More recently, Bremner, Slater, Johnson, Mason, and Spring (2012) demonstrated that presentation of a rectangular Kanizsa figure as an 'occluder' in a moving object occlusion event is sufficient to support perception of trajectory continuity by 4-month-olds. It is particularly striking that the Kanizsa figure is perceived as an occluding surface, because all the information leading to the illusory percept of a surface is situated at the *inducing elements* (the circles at the corners of the square); there is no such information in the direct path of the object. Thus it appears that at the age that marks the beginning of perception of trajectory continuity, the information necessary to specify an occluding surface is the combination of deletion and accretion, visible boundary, and background occlusion.