Newborns Are Sensitive to Impending Collision Within Their Peripersonal Space

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Abstract

Immediately after birth, newborns are introduced within a highly stimulating environment, where many objects move close to them. It would therefore be adaptive for infants to pay more attention to objects that move towards them - on a colliding pathway - and could therefore come into contact and interact with them. The present study aimed at understanding if newborns are able to discriminate between colliding vs. non-colliding trajectories. To address this issue, we measured the looking behaviour of newborns who were presented with videos of different pairings of three events: approaching objects along a colliding course, approaching objects along a non-colliding trajectory, and receding objects. Results outlined that newborns preferred looking at the approaching and colliding movement than at both the receding and the approaching but non-colliding movements. Data also suggest the possible occurrence of a configural effect when two colliding events are displayed simultaneously. Furthermore newborns appeared to look longer at movements directed towards the Peripersonal Space than at those directed away from it.

Keywords: newborns; peripersonal space; collision; looming; depth perception.

Theoretical Background

The space immediately around the body is invested of great importance, as it mediates every physical interaction between the body and the surrounding environment. It is in fact within this delimited space that we can reach and act upon objects and appropriately react to potentially dangerous stimuli (Canzoneri, Magosso, & Serino, 2012).

This confined portion of space is called Peripersonal Space (PPS) and is conceived as a multisensory-motor interface mediated by a fronto-parietal network integrating tactile, visual and auditory stimulation occurring near the body (Teneggi, Canzoneri, di Pellegrino, & Serino, 2013).

The essential multisensory feature of PPS has been extensively investigated with studies on animals (Graziano, Yap, & Gross, 1994) as well as human beings (Làdavas, di Pellegrino, Farnè, & Zeloni, 1998; Canzoneri et al., 2012). Interestingly, by using a dynamic audio tactile interaction task, recent research on healthy human subjects detected the boundaries of adults' PPS (Canzoneri et al., 2012) and their sensibility to social modulation (Teneggi et al., 2013).

Despite the vast amount of research with adults, there is a lack of research on the perception of the PPS and the role of multisensory integration within it in very young infants (Savelsbergh, van der Kamp, & van Wermeskerken, 2013). However, in order to explore the development of the PPS, it is imperative to first address some important questions. First of all, how and when do infants start to respond to different movements happening within the space immediately surrounding their body? This ability, in fact, appears to be highly relevant for adaptation since indicators of depth like kinetic information produced by object displacement are critically important determinants of the space to be perceived for survival (Schmuckler, Collimore, & Dannemiller, 2007). Regarding this specific question, relevant previous research (Yonas, 1981) investigated the perception of impending collision in infancy through the analysis of defensive behaviour. In particular, this line of research investigated the appearance of defensive blinking, identified as the best indicator of awareness to stimuli on a colliding course in early infancy (Yonas, 1981). Results outlined that infants do not show any consistent defensive reaction to impending collision at birth and start blinking appropriately to visual stimuli only later. In particular, Yonas (1981) claimed that infants generally do not blink from birth to 8 weeks of age and that consistent blinking is observed at 7 weeks only in a small percentage of infants. Later on Nañez (1988) showed that - given a high-contrast display - already at the age of 3 to 4 weeks infants would blink at 44% of looming trials, indicating that sensitivity to collision appears at an earlier stage than formerly believed. These studies led to the conclusion that newborns are not aware of colliding movements, if only the absence of defensive reactions is considered.

In our research, using a preferential looking paradigm, we measured newborns' looking behaviour in order to evaluate their ability to discriminate between stimuli moving in different directions (including a colliding trajectory) and their preference for the approaching and colliding movement. We presented newborns with two different pairings of three events showing different movements. The three events were shown within two different sessions of the same experiment. A first event was an approaching and colliding movement (AC): a ball started from distant space and moved towards the newborn on a colliding pathway. The second event was a receding movement (R), consisting in the time-reversed AC movement: a ball started from near the newborn's face and moved backwards. The last event showed an approaching but non-colliding movement (ANC): the ball started from distant space and moved towards the newborn, following a non-colliding course. In each session we compared colliding vs. non-colliding events. Importantly, the non-colliding event was receding in one session while approaching (but non-colliding) in the other.

We hypothesized that if newborns were able to perceive the space surrounding their body, they would then be able to discriminate between the three different trajectories. Moreover, we expected newborns to show a preference for movements that - if continued - would culminate with the collision between the ball and their face. We hypothesize that these movements could be adaptively more relevant as they would lead to an interaction - either positive or negative (danger) - between the moving object and the newborn. Finally, we expected newborns to look longer at those movements that were directed towards the PPS (i.e. approaching movements, either on a colliding pathway or not) compared with the movement directed outside the PPS (i.e., the receding movement).

Method

Participants

The study was conducted at the Paediatric Unit of the Hospital of Monfalcone (GO – Italy), where all newborns were born. One experiment made of two sessions was conducted. Twenty newborns took part in the study, all completing both sessions; ten additional newborns participated but were later excluded due to fussiness (four), sleepiness (two) and to the presence of a strong side bias (four). Testing took place when babies were awake and alert, usually during the hour preceding feeding time. Parents were informed about the procedure and gave their consent to their child's participation. The local ethics committee approved the study protocol.

Apparatus and Stimuli

Newborns sat in front of a monitor on the experimenter's lap. The distance between the monitor (size 27") and the newborn's head was approximately 30 cm, the distance at which acuity at birth is shown to be better (Fantz, Orly & Udelf, 1962; Slater, Earle, Morison, & Rose, 1985). Black cardboard and black curtains covered the area around the monitor to prevent light and other stimuli to engage newborn's attention.

Newborn's eye level was aligned to the centre of the screen. A video camera on top of the screen recorded the newborn's eyes allowing subsequent coding of his/her eye movements. An additional small screen, placed outside the newborn's view, allowed the experimenter to monitor his/her head position throughout the experiment.

In both sessions newborns were presented with two events, on the left and right sides of the screen, respectively. Stimuli were located in the peripheral area of the screen to assure newborns' attention was engaged and to avoid sticky fixation.

Procedure

The experiment began as soon as the newborn was seated and was attending to the centre of the screen. Each baby took part in both sessions of the experiment, both including two trials. The two sessions and the two trials within each session were presented in counterbalanced order across subjects. During Session 1, the baby was presented with two different events on the two sides of the screen: on one side s/he could see the approaching and colliding movement and on the other side the receding movement; the side of presentation of each event was counterbalanced between the two trials (AC-R and R-AC conditions). During Session 2, the baby was presented with the same event on both sides of the screen: on one trial s/he could see two approaching and colliding movements paired together (AC-AC condition), whereas on the other trial s/he could see two paired approaching but non-colliding movements (ANC-ANC condition).

Video recordings of the newborns' eye movements were subsequently analysed. The observer coded how long each newborn looked at each side of the screen during both the sessions. In this way, we obtained relative measures of the time newborns spent looking at the Colliding vs. Non-Colliding events in both Session 1 (AC vs. R) and 2 (AC vs. ANC).

Results

Data from the two sessions were independently analysed with two paired planned comparisons based on proportions of looking time directed towards each movement on the total time the newborn could see that movement.

Results of both sessions showed a significant difference between the looking times for Colliding and Non-Colliding (either R or ANC) events. In both sessions newborns looked longer to the approaching and colliding movement (AC). No effect of order of presentation neither of the two sessions, nor of the trials within each session was found.

We also compared the whole time newborns spent looking at the whole screen. This analysis highlights that the whole looking time in the AC-AC condition of Session 2, when two simultaneous approaching and colliding events were shown, was longer than the average looking time in Session 1, when the approaching and colliding event was paired with a simultaneous receding event. Moreover, taking the no-collision condition (ANC-ANC) as a baseline, the increment of the whole time spent looking at the screen displaying two colliding events (AC-AC condition) was considerably higher than the increment of the whole time spent looking at the screen displaying only one colliding event (AC-R or R-AC condition).

Furthermore, we compared the proportion of looking time directed at movements towards the PPS (AC event in the two trials of Session 1 plus both AC and ANC events of Session 2) and the proportion of looking time at movements directed away from the PPS (R event in the two trials of Session 1). The average total looking time was larger for movements towards the PPS than for movements directed away from the PPS. We compared the distributions of individual proportions running another paired planned comparison, under the hypothesis that newborns would have looked longer at those movements that approached them (i.e., were directed towards their PPS), independently from the trajectory (colliding or not). As expected, newborns looked significantly longer at movements towards the PPS.

Discussion

Our results show that newborns seem to be able to discriminate between different movements that take place in the space surrounding their body. In particular, they show a visual preference to the approaching and colliding movement when compared to both the receding and the approaching but non-colliding movements. Hence, even though newborns do not show a defensive reaction towards a potentially dangerous movement directed towards their face (Yonas, 1981; Nañez, 1988), they discriminate it from a movement directed somewhere else. We speculate that the preference for the approaching and colliding movement could be attributed to the major adaptive salience of a stimulus that, approaching the newborn on a collision course, could come into direct contact with him/her. The stimulus could either have a positive value, or be negative and dangerous, but in both instances it appears to be worth to be looked at.

Moreover, newborns looked at the approaching and colliding movement for a longer proportion of time in Session 2, when it was shown as a component of a pair of movements converging towards the viewpoint, than in Session 1, where it was paired together with a receding movement. In addition, relative to the "no-collision condition" (ANC-ANC), the increment of total looking time to the screen was much higher for the "two collisions condition (AC-AC)" than for the "one collision condition" (AC-R; R-AC). Taken together, these additional findings could be attributed to the existence of a configural effect: we speculate that two paired, simultaneous colliding events (showing two converging trajectories both signalling an impending collision) are more relevant and salient than predicted by the additive combination of two single collision movements.

Despite our study did not directly investigate newborns' PPS, we provide here the first pioneering evidence of newborns' preference for movements directed towards their PPS (either on a colliding course or not) if compared with movements directed away from their PPS. This finding could be linked to the enhanced attention that adults direct to objects that enter their PPS over objects that exit from it, as showed by Canzoneri et al. (2012).

Despite the exploratory character of our study, we claim the possibility that at birth human infants could be equipped with an initial ability to differentiate the space surrounding them. More specifically, newborns seem to be able to recognize movements directed towards their PPS and, in particular, towards their physical self.

Further research is needed in order to assess how this basic perception develops during infancy and whether multisensory stimulation could either facilitate or impair the processing of infants' PPS.

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