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Body Perception in Newborns

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Summary

Body ownership and awareness has recently become an active topic of research in adults using paradigms such as the “rubber hand illusion” and “enfacement” [1–11]. These studies show that visual, tactile, postural, and anatomical information all contribute to the sense of body ownership in adults [12]. While some hypothesize body perception from birth [13], others have speculated on the importance of postnatal experience [14, 15]. Through studying body perception in newborns, we can directly investigate the factors involved prior to significant postnatal experience. To address this issue, we measured the looking behavior of newborns presented with visual-tactile synchronous and asynchronous cues, under conditions in which the visual information was either an upright (body-related stimulus; experiment 1) or inverted (non-body-related stimulus; experiment 2) infant face. We found that newborns preferred to look at the synchronous condition compared to the asynchronous condition, but only when the visual stimulus was body related. These results are in line with findings from adults and demonstrate that human newborns detect intersensory synchrony when related to their own bodies, consistent with the basic processes underlying body perception being present at birth.

Results and Discussion

Studies investigating body ownership and awareness in adults have highlighted the importance of the temporal synchrony and spatial congruency of sensory stimuli [12], in addition to body morphology and anatomical posture [4, 5, 10, 16]. These studies show that body-related cues, here defined as information attributable to the current position of one’s own body, are fundamental for body perception. Despite several studies on infants that have shown the important role of proprioception (where movements are self-produced) and multisensory integration in the development of body awareness during infancy [17–20], to our knowledge, only one study has investigated the role of body-related synchrony detection during infancy solely based on affective information [21]. However, it remains unknown whether these factors play a role from birth or whether the detection of body-related intermodal synchrony develops gradually with experience throughout infancy. We addressed this issue and hypothesized that, in the absence of any visual feedback from self-generated movements, newborns would show a preference (as measured by longer looking) to a synchronous visual-tactile condition when viewing a video of an upright infant face as compared to an asynchronous, temporally delayed condition (experiment 1). Furthermore, we predicted that this increased attention to intersensory synchrony would not be present in the context of a visual stimulus that did not resemble themselves (the same infant face video, but inverted; experiment 2). By inverting the visual stimulus, we reduced the likelihood that the newborns would relate it to their own bodies [12, 18, 21]. In other words, rather than a general preference for synchrony of observed and felt actions, newborns would prefer this perfect matching only in the context of stimuli that are related to their own bodies (see an example of the experimental paradigm in Figure 1).

The data from the two experiments were analyzed with a two-way mixed ANOVA, with visual-tactile stimulation (synchronous versus asynchronous) as a within-subject factor and type of video (upright versus inverted) as a between-subject factor. The analysis showed that while there were no significant main effects of inversion [F(1,38) = 0.48, p = 0.49] or synchrony [F(1,38) = 1.79, p = 0.19], the predicted interaction effect was significant [F(1,38) = 8.29, p = 0.007, r = 0.80], indicating that the looking time during the synchronous and asynchronous conditions differed according to whether the video was upright or inverted (see Figure 2). To investigate this interaction further, we performed two separate paired-sample t tests. The results of experiment 1 showed that there was a significant difference between the synchronous (mean = 54.54, SE = 3.66) and asynchronous (mean = 39.28, SE = 5.04) conditions [t(19) = 2.92, p = 0.009]. The results of experiment 2, in which newborns were presented with synchronous and asynchronous visual-tactile stimulation while they watched the inverted face video, showed no significant difference between the two conditions [synchronous condition, mean = 40.77, SE = 4.02; asynchronous condition, M = 46.36, SE = 4.18; t(19) = −1.12, p = 0.30; see Table 1 for additional analyses]. Several studies on human newborns (for a review, see [22]) have shown that they respond differentially to viewing upright, as compared to inverted, face-like stimuli. Results of the present study confirm the importance of the upright face for the detection of synchronous intersensory information. There was no effect of order of presentation of the conditions in either experiment [experiment 1, F(1,18) = 1.62, p = 0.22; experiment 2, F(1,18) = 2.52, p = 0.13].

The results of experiment 1 could be interpreted as a preference for redundant sensory information and are in line with previous studies demonstrating that newborns are able to integrate intersensory stimulation [23, 24]. Our finding is also consistent with the intersensory redundancy hypothesis (IRH), which highlights the importance of amodal information, such as temporal synchrony, for early perceptual development and learning [25, 26]. However, our results go beyond this conclusion as we show a preference for visual-tactile temporal synchrony only when the visual stimulus presented is relevant to the infant’s own body. Since we did not use live video of the watching infant herself, we are able to rule out the contingent visual feedback from the viewing infant’s own self-performed actions. These findings are in accord with previous studies in older infants and adults, in which it has been shown that the

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In the current study, we specifically investigated the role of body-related synchrony detection during infancy in the absence of any efferent information [21]. These authors demonstrated that, when presented with a video display of life-like baby doll legs, infants aged 7 and 10 months discriminate between contingent and noncontingent visual-tactile stimulation. Importantly, because the infants were watching baby doll legs and could not control the visual feedback of their movements, they demonstrated the ability to discriminate contingency independently from movements of their own bodies [21]. Furthermore, the authors observed that this preference disappears when 10-month-old infants are presented with nonbody objects (i.e., wooden blocks), showing that morphological similarities between the stimulus and their own bodies are important in the detection of visual-tactile contingency at this age [21].

In the present experiments, we tested the role of body-related stimuli with newborns, finding that from the first days of life, infants can detect intersensory synchrony when related to their own bodies. Previous studies on illusion of owning a specific body part occurs only when the fake limb matches the physical and morphological features of the real one [10, 18, 21].

To our knowledge, only one other study has investigated the role of body-related synchrony detection during infancy in the absence of any efferent information [21]. These authors demonstrated that, when presented with a video display of life-like baby doll legs, infants aged 7 and 10 months discriminate between contingent and noncontingent visual-tactile stimulation. Importantly, because the infants were watching baby doll legs and could not control the visual feedback of their movements, they demonstrated the ability to discriminate contingency independently from movements of their own bodies [21]. Furthermore, the authors observed that this preference disappears when 10-month-old infants are presented with nonbody objects (i.e., wooden blocks), showing that morphological similarities between the stimulus and their own bodies are important in the detection of visual-tactile contingency at this age [21].

In the present experiments, we tested the role of body-related stimuli with newborns, finding that from the first days of life, infants can detect intersensory synchrony when related to their own bodies. Previous studies on infants showed that 3 s delay is sufficient for 3-month-old infants to differentiate between synchrony and asynchrony [27, 28]. We now provide evidence that newborns can discriminate between synchrony and asynchrony when presented with 5 s delay.

We do not know whether the newborns in our studies attributed the upright dynamic face seen on the screen as directly belonging to their own bodies. However, our findings are in line with research on self-identification in adults [12]. Studies on “enfacement” in adults show that seeing another person’s face being touched synchronously with one’s own face evokes a change in self-face recognition, whereby the other face becomes incorporated to some extent into the representation of one’s own face [9]. In these studies, the “other” becomes included in the mental representation of one’s own face as a consequence of viewing a perfect matching between the seen and felt sensory stimulation in the context of watching the other person’s face. In order to maintain a coherent and updated sense of one’s body, the internal body model and the new, external information provided are compared together, and irrelevant or incongruent information is discarded [29].

To our knowledge, this is the first study to investigate visual-tactile stimulation of faces in infants, solely based on afferent information. Legerstee et al. [30] showed that 5- and 8-month-old infants look longer at video of their own faces compared to those of peers and dolls, but only when it is moving (live video feed). This highlights the importance of self-generated movement by means of a matching between their executed actions and the visual feedback. In the present research, because the matching between seen and felt touch was the only congruent information that the newborns could rely on, we demonstrated that perception of visual-tactile synchrony may be important for differentiating between self and other in the absence of any self-generated movement.

In the current study, we specifically investigated the role of temporal synchrony in multisensory integration. In future work, it will be important to examine the role of bodily location...
In experiment 1, the criterion applied to ten out of 20 infants (five in the synchronous condition and six in the asynchronous condition). In experiment 2, the criterion applied to 11 out of the 20 newborns tested (eight in the synchronous condition and six in the asynchronous condition). Note that the final results remain the same even if this exclusion criterion is not applied.

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