Five-month-old infants' discrimination of visual-tactile synchronous facial stimulation.

Keywords: multisensory perception, body perception, face processing, infancy

Multisensory information has been regarded as a crucial source of stimulation in the context of body awareness. In fact, in adult research, manipulation of multisensory cues related to the body has been used to create powerful perceptual illusions, able to disrupt and update body representation (e.g. Botvinick & Cohen, 1998; Blanke & Arzy, 2005; Tsakiris, 2008). Specifically, the illusion of owning a specific body-part has been experimentally manipulated through the use of a paradigm initially developed by Botvinick and Cohen (1998), known as the rubber hand illusion (RHI). This refers to the illusion of perceiving a rubber hand as belonging to oneself when it is synchronously touched with one's own hidden hand (Botvinick & Cohen, 1998). By manipulating the temporal synchrony and spatial congruency of visual and tactile information, several replications, as well as revisited forms of the original version of the RHI, have shown that it is a feasible paradigm for scientifically investigating body awareness (see Makin, Holmes, & Ehrsson, 2008; Tsakiris, 2010). More recently, researchers have applied the principles of the RHI to elicit body awareness of another person's face (Sforza, Bufalari, Haggard, & Aglioti, 2010; Tajadura-Jiménez, Grehl, & Tsakiris, 2012a; Tajadura-Jiménez, Longo, Coleman, & Tsakiris, 2012b; Tsakiris, 2008). In the enfacement illusion (EI), multisensory synchronous visual-tactile stimulation between the participant's cheek and viewing another person's cheek being stroked evokes a change in self-recognition, whereby a certain percentage of the other person's face observed during the enfacement procedure is identified as "self" (Tajadura-Jimenez et al., 2012a). Similarly to the RHI –where the rubber hand becomes part of one's own body – during the EI 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 (Tsakiris, 2008). Despite facial features being the most distinguishable component of the self, evidence from the EI demonstrates that the manipulation of body awareness through the use of sensory illusions seems to be effective not only with limbs, but also with the most representative component of self-identity, that is the face (Tajadura-Jimenez et al., 2012b).

The exploration of multisensory processing in the context of body stimuli (i.e. body-related information) with infants has demonstrated that they can detect multisensory stimuli that originate from the body, suggesting the presence of early implicit body perception simply based on the spatiotemporal matching between visual and tactile stimuli alone (Zmyj et al., 2011; Filippetti et al., 2013). Together, these results support the hypothesis that processing of visual and tactile inputs related to the body may be fundamental for the perception of one's own body, and may constitute relevant precursors from the earliest stages of postnatal development.

Despite these compelling findings, the use of different experimental paradigms across studies such as our own (Filippetti et al., 2013; 2014; 2015) and those of Zmyj and colleagues (Zmyj et al., 2011) restricts us from drawing conclusions about factors involved and possible developmental trajectories. In order to provide a unified paradigm across developmental age points, in the following experiment we maintained the focus of attention on the perception of synchrony in faces, as in our previous studies (Filippetti et al., 2013; 2014; 2015).

With this experiment we addressed the question of discrimination of multisensory processing by investigating 5-month-old infants' visual preference for visual-tactile temporal synchrony, in the absence of self-generated motor signals. In line with Zmyj et al. (2011), which showed visual preference for visual-tactile synchronous stroking of legs in 10-month-old infants, we hypothesized that infants in our Experiment would be able to discriminate visual-tactile synchrony using facial stimuli, by showing a visual preference for perfect temporal synchronous stroking.

Method

Participants

Infants were recruited from a database of parents who had agreed to participate in child development studies. Fourteen 5-month-old infants (8 girls, 6 boys; *M* = 4 months and 17 days, *SD* = 5.72 days) took part in the present study. Four additional infants participated but were excluded for lack of behavioural data due to fussiness (N=2) or tiredness (N=2). The local Ethics Committee approved the study protocol.

Stimuli and Procedure

Infants were tested in a dimly lit room and sat on their parent's lap. The distance between the screen and the infant's head was approximately 90 cm. Stimuli were displayed on a 69 cm monitor. Parents were asked to refrain from talking and interacting with the infant during the stimuli presentation and no information about the main aim of the study was provided prior to the testing session.

Using a preferential looking procedure, we presented two identical videos side-by-side for approximately 2 min. These stimuli consisted of a previously recorded video of a 5-month-old infant face being touched on the cheek with a paintbrush every 6 s. The two videos differed only in that one was time delayed relative to the other by 3 s. In other words, while one video displayed the first touch on the cheek after 3 s, in the other video the same first brush event occurred after 6 s. To ensure infants' attention was maintained throughout the experimental session, a 5 s baseline (flashing light followed by blank screen) appeared after approximately 60 s of the paired video presentation. While watching the paired videos, the infant participants' face was stroked on their corresponding cheek. This stroking was synchronous with one video display and asynchronous with the other. In order to ensure an asynchrony that could be detected between the seen and felt strokes, the asynchronous video was delayed with regard to the brush stroke applied on the participant's face by 3 s (Gergely & Watson 1999; Zmyj et al. 2009). The touch was always applied to the infant on the relevant cheek to be spatially congruent for both videos. Therefore, if in both videos the left cheek was stroked, then the infant's right cheek was touched, and vice versa. The side of the stroke (right or left cheek) and the position of the videos (right or left sides of the screen) were counterbalanced between infants.

Stroking of the infant's cheek was manually delivered by the experimenter using a soft medium size paintbrush (width=25 mm). Each stroke lasted for approximately 1 s; a total of 9 strokes were displayed and delivered in each of the two blocks of paired videos**.**

Data analysis

Based on the video recordings, an observer coded how long each infant looked at each of the two side-by-side videos. For the analysis of looking behaviour, the proportion of looking time to each video was used (see Table 1, where mean of total looking time to each side of the screen is also included).

Synchronous preference scores (percentages) for the synchronous video over the asynchronous video were calculated. Each infant's mean looking time for the synchronous video was divided by the sum of looking time to the synchronous and asynchronous video and converted into percentage scores (Turati et al., 2005). Paired sample t-tests (two-tailed) were conducted, unless otherwise stated. Reliability analysis was performed for 20% of the sample of looking time and revealed a score of Cohen's $k = 0.78$ and Pearson's $r = 0.89$.

Results

Table 1 shows the mean and standard error of total looking time and proportion of looking time for the two videos. Synchronous preference scores were significantly above chance level - 50% ($M = 59.6\%$, $SD = .15$), one sample t-test, $t(13) = 13.55$, $p < 0.001$, meaning that infants preferred to look at the synchronous video over the asynchronous video.

We did not find any effect of side of the stroking, $F(1,12) = 0.004$, $p = 0.95$, or side of video (synchronous or asynchronous), $F(1,12) = 0.25$, $p = 0.63$. We performed an additional analysis in order to test whether the visual preference for visual-tactile synchrony over asynchrony could be explained by a reward selective fixation effect (e.g. visual brushing appearing on each video, which matches the stroke applied on the infant's cheek). We measured the attraction to each video within 2 s prior and 2 s following each visual brushing. We performed a paired-sample t-test to assess this potential fixation learning confound, by comparing the attraction to the video 2 s after brush stroke (synchronous or asynchronous) between block1 and block 2. We found no significant difference in looking time between the two blocks, $t(27)= -1.18$, $p = 0.91$, suggesting that the attraction post stroke did not increase from block 1 to block 2, and thus ruling out any potential fixation effect.

Discussion

The present findings demonstrate that 5-month-old infants discriminate between synchronous and asynchronous visual-tactile displays, as revealed by their own looking behaviour. This result confirms our hypothesis, showing a visual preference for synchronous visual-tactile stimuli at this age, and further supports the importance of tactile experience, combined with its visual feedback, for the discrimination of multisensory stimuli in the context of body-related information. However, given the limited sample size, it is important that future research replicates the present findings.

Our investigation of visual-tactile body-related processing in newborns (Filippetti et al., 2013) demonstrated a similar direction of visual preference towards multisensory temporal synchrony. Taking these findings together, we speculate that during the first 5 months of life infants seek redundant multisensory information in order to specify the bodily-self. In contrast to previous behavioural studies in infancy, which have demonstrated a shift of visual preference from contingency to absence of contingency around this age (Bahrick & Watson, 1985; Watson, 1994; Schmuckler, 1996), the current data indicate that with this particular paradigm 5-month-old infants show greater looking towards the sensory redundant (synchronous) display. However, in the current study we used only visual-tactile information, and this could explain the difference in findings between studies. In support of this, Zmyj and colleagues (2011) have demonstrated a similar preference for synchronous events in 10-month-old infants (but not in 7-month-old infants), where higher looking time was observed for the visual-tactile synchronous leg-display. The difference in looking behaviour between the 7-month-old infants in Zmyj's study (2011) and our 5-month-olds could also be attributed to our use of facial stimuli. Possibly the combination of a visual facial stimulus together with the rather unfamiliar experience of visual-tactile stroking could explain the direction of preference observed here. Nevertheless, irrespective of the direction of looking behaviour, the current results demonstrate that 5-month-old infants are capable of discriminating between visual-tactile synchronous and asynchronous multisensory information.

In this experiment we used the face of a peer, thus ruling out the possibility that differences in visual appearance could influence the looking behaviour of infants. However, this use of a peer face also prevented us from systematically exploring the role of familiarity with own personal facial features in the discrimination between self and other (as in the enfacement illusion). Additionally, based on the current data, we don't know whether morphological features or changes in visual appearance can influence the elaboration of visual-tactile multisensory information (for example by contrasting face vs. non-face stimuli – see Filippetti et al., 2013). Another limitation of the present experiment concerns the investigation of multisensory spatial congruency alongside temporal synchrony. Based on the present findings, we cannot comment on whether synchronous touch applied to another bodily location would have caused a similar preference for synchrony. Further studies should investigate these issues.

Based on our previous findings, the current experiment highlights the possibility of a developmental trajectory from birth to 5 months in which infants discover body-related visual-tactile stimuli as self-specifying information (Rochat, 2009). However, in order to confirm this hypothesis, future research should directly investigate this possibility by exploring infants' visual discrimination of visual-tactile synchrony in a longitudinal design.

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Looking time (s)		Proportion of looking time (s)	
Synchrony	Asynchrony	Synchrony	Asynchrony
49.60 (5.02)	32.91 (3.56)	0.596 (0.04)	0.404 (0.04)

Table 1. Average and standard errors (in parentheses) of looking time for the synchronous and asynchronous displays. The left side of the table shows total looking time, whereas the right side displays proportion of looking time.