Brief Report

Twelve-month-old infants' attention to the eyes of a talking face is associated with communication and social skills

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A R T I C L E   I N F O

A B S T R A C T

We investigated whether attention to a talker's eyes in 12 month-old infants is related to their communication and social abilities. We measured infant attention to a talker's eyes and mouth with a Tobii eye-tracker and examined the correlation between attention to the talker's eyes and scores on the Adaptive Behavior Questionnaire from the Bayley Scales of Infant and Toddler Development (BSID-III). Results indicated a positive relationship between eye gaze and scores on the Social and Communication subscales of the BSID-III.

Information from the talking face is key to the acquisition of communicative and social skills. Infant attention to a talker's lip movements, gaze direction, and facial expressions is crucial for the acquisition of speech, language, and social skills. Studies have shown that infants can perceive the perceptual and social cues inherent in talking faces and that they can perceive their multisensory coherence. With specific regard to the latter ability, studies have found that newborn infants can detect the temporal correspondence of auditory and visual communicative signals (Lewkowicz, Leo, & Simion, 2010), that older infants can perceive the equivalence of the auditory and visual attributes of different types of speech units (Kuhl & Meltzoff, 1982; Lewkowicz & Pons, 2013; Lewkowicz, 2010; Patterson & Werker, 1999, 2003; Pons, Lewkowicz, Soto-Faraco, & Sebastián-Gallés, 2009; Rosenblum, Schmuckler, & Johnson, 1997), and that 1-year-old infants can perceive the audiovisual coherence of fluent speech at the suprasegmental level (Lewkowicz, Minar, Tift, & Brandon, 2015).

The developmental improvement in infants' ability to perceive the multisensory attributes of speech and their multisensory coherence is accompanied by marked changes in infants' selective attention to the eyes and mouth of talking faces. Studies of monolingual infants have found that 4-month-old infants attend mostly to a talker's eyes, that 8–10 month-old infants attend more to a talker's mouth (Hillairet de Boisferon, Tift, Minar, & Lewkowicz, 2017; Lewkowicz & Hansen-Tift, 2012; Tenenbaum, Shah, Sobel, Malle, & Morgan, 2013) and that 12-month-old infants attend equally to the mouth and eyes of a talker speaking in the infant's native language. The attentional shift from a talker's eyes to the talker's mouth by 8–10 months of age coincides with the emergence of canonical babbling and a growing interest in speech and, thus, has been interpreted as reflecting speech processing. This interpretation is supported by two sets of findings. First, 12-month-old infants attend more to a talker's mouth speaking in an unfamiliar than a familiar language (Lewkowicz & Hansen-Tift, 2012), suggesting that infants take advantage of the audiovisual speech information available in the talker's mouth to disambiguate unfamiliar speech. Second, 4- and 12-month-old bilingual infants attend more to a talker's mouth than do monolingual infants (Pons, Bosch, & Lewkowicz, 2015), suggesting that bilingual infants rely on combined and, thus, more perceptually salient audiovisual speech cues to separate and consolidate the two languages that they are learning.

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Of course, in addition to conveying audiovisual speech cues, a talker's face conveys various social, referential, and deictic cues. These cues are available to infants whenever adults interact with them. Often, during such interactions, adults will turn their attention toward specific objects in a way that "leads" infants to attend to them (Bakeman & Adamson, 1984). Although infants exhibit some sensitivity to joint attention cues before their first birthday (Farroni, Massaccesi, Pividori, & Johnson, 2004), they only begin to exhibit a robust sensitivity to such cues around their first birthday (Carpenter, Nagell, & Tomasello, 1998; Flom, Deák, Phill, & Pick, 2004; Tomasello, Carpenter, Call, Behne, & Moll, 2005). This is illustrated by findings from a study by Brooks and Meltzoff (2005) showing that by 10 months of age infants selectively follow an adult's head movement to an object when the adult's eyes are open but not when the eyes are closed.

The studies that have investigated joint attention in infancy have found that establishing eye contact with adults is essential for initiating gaze following in a joint attention task. Once infants establish eye contact, they are in a position to establish communication with others, can learn about the objects that adults are referencing, and can learn to attach specific words to those objects. Indeed, studies have shown that gaze-following behavior at the end of the first year of life is strongly correlated with language scores at later ages (Brooks & Meltzoff, 2002; 2005; Tenenbaum et al., 2015; Young, Merin, Rogers, & Ozonoff, 2009). Studies also have shown that individuals with autism - who are known to have early language deficits - exhibit highly restricted gaze-following skills (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998). Thus, there is little doubt that attention to the social-referential cues conveyed by a talker's eyes is critical for the future mastery of a variety of linguistic and social skills (Butterworth, 1991; Scaife & Bruner, 1975).

So far, the studies that have investigated infant response to talking faces have had two different objectives. Some studies have focused solely on infant attention to a talker's mouth, with the aim of determining whether this might predict future language development (e.g. Elsabbagh et al., 2014; Tenenbaum et al., 2013). Other studies have focused on infant gaze-following, with the aim of determining whether this might predict the future development of linguistic and social skills (e.g. Brooks & Meltzoff, 2002; 2005). Importantly, however, both types of studies have focused on the predictive value of infant attention either to the mouth or to the eyes of a speaker for subsequent language outcomes and social cognition skills, respectively. In contrast to these studies, two recent studies have asked whether there might also be a concurrent relation between visual scanning and linguistic skills. One of these studies found no association between infants' attention to a talker's mouth at 18 months of age and the number of words that they produced at that age (Hillairet de Boisferon, Tift, Minar, & Lewkowicz, 2018), whereas a second study found that attention to the mouth is associated with concurrent expressive language skills during the first year of life (Tsang, Atagi, & Johnson, 2018).

Given the mixed findings on the contemporaneous relationship between measures of selective attention to a social partner's eyes and mouth, we felt that it would be interesting to investigate whether there might be a contemporaneous connection between infant attention to a talker's eyes and social and communication skills. To do so, we examined whether attention in 12-month-old infants to the eyes and mouth of a talking face reciting a native and non-native speech monologue may be associated with their social and communication skills. We hypothesized that there is a likelihood that there is a contemporaneous connection between attentional responsiveness and social and communicative responsiveness at 12 months of age. If this is the case, then this will suggest that social and communicative needs contribute to a redirection of attention to the eyes and/or to the redistribution of attention to a talker's mouth and eyes at this age.

We tested 34 (20 females) full-term, 12-month-old, Catalan- or Spanish-learning, monolingual infants. The infants' average age was 12.2 months (range: 352–387 days). We tested seven additional infants but did not include them in the final sample because they cried (2), the eye tracker could not find the pupil (3), parents interfered with testing (1), or because of experimental error (1). Participants were initially recruited from the maternity unit of the Hospital Sant Joan de Déu, Barcelona, Spain. Parental consent was obtained before testing was carried out.

Prior to the start of the experiment, parents filled out the Adaptive Behavior Questionnaire from the Bayley Scales of Infant and Toddler Development (BSID, 3rd Edition) to determine the infants' level of social and communicative functioning. The original Questionnaire includes ten subscales of around 24 questions each related to skills in different areas: 1) Communication, 2) Community, 3) Functional pre-academics, 4) Home living, 5) Health and Safety, 6) Leisure, 7) Self-care, 8) Self-direction, 9) Social, and 10) Motor behavior. Questionnaire subscales 2 to 4 are not appropriate for toddlers younger than 12 months of age. Therefore, we did not use these subscales because the mean age of our sample was 12 months. From the remaining subscales, we were especially interested in the Communication and Social subscales. The Communication subscale includes items related to attention to faces when adults talk, laughing after the adult, forms of capturing attention through voice, gestures and cries, listening behavior, and expressive language produced either via imitation or spontaneously. Thus, this scale includes measures related not only to attention to the adults interacting with the infant but also measures related to expressive language and gestural behavior. The Social subscale includes items more directly related to interaction with the caretaker, desire to be in contact, differential responses to non-familiar people, imitation, willingness to share objects in interaction, and joint attention. Moreover, this subscale measures advances in social cognition related to infant learning from others. If we find an association between attention to the eyes in our task and the score in this specific subscale, this will support our hypothesis that selective attention to a talker's eyes is related to social responsiveness.

During the experiment, infants were seated in an infant seat in a sound-attenuated and dimly illuminated room, approximately 60 cm from a 17-in. computer monitor. Stimuli were presented on the computer monitor using Tobii Studio software (Tobii Technology AB, Danderyd, Sweden) and eye movements were recorded by a Tobii X120 stand-alone eye tracker at a sampling rate of 60 Hz. The stimuli consisted of 45 s multimedia movies in which one of two female actors recited a prepared monologue in an infant-directed manner. One was recited by the same bilingual speaker either in Spanish or Catalan, while the other was recited by a native speaker in English (Pons et al., 2015). Each infant watched two videos, one in her native language (Spanish or Catalan) and one in the non-native language (English). The order of the videos was counterbalanced across infants. We used the Tobii eye tracker's five-point

calibration routine to calibrate each infant's gaze behavior. As soon as the calibration routine was completed, we presented each of the two videos to each infant. While the infants watched the videos, we monitored their gaze with the eye tracker and recorded looking times to two areas of interest (AOIs), one around the talker's eyes and the other around the talker's mouth.

To be consistent with previous studies of infant selective attention to talking faces, we used the same measures as in those previous studies (Pons et al., 2015). Also, as in Pons, Sanz-Torrent, Ferinu, Birulés, and Andreu (2018), participants were only included if they looked at the face for at least 75% of the time (34 s). All the infants met this criterion. We computed the proportion of total looking time scores for each of the two AOIs for each participant by dividing the amount of time they looked at each AOI, respectively, by the total amount of time they looked at the face.

We analyzed the PTLT values with a repeated-measures analysis of variance, with AOI (eyes, mouth), and Language (native, non-native) as within-subjects factors, and Linguistic Background (Catalan or Spanish) as a between-subjects factor. Data from one participant were excluded because she exceeded the mean by more than 2 standard deviations. As in previous studies (Lewkowicz & Hansen-Tift, 2012; Pons et al., 2015), we found a significant main effect of AOI [$F(1,31) = 21.81$, $p < 0.01$] and an AOI x Language interaction [$F(1,31) = 6.21$; $p = 0.018$]. No other significant main effects or interactions were observed. The main effect was due to greater overall looking at the mouth while the interaction reflected the fact that the distribution of attention to the eyes and mouth differed as a function of the language spoken by the talking face. Also, as can be seen in Fig. 1 and, as in prior studies (Lewkowicz & Hansen-Tift, 2012), planned comparisons revealed that infants looked equally at the eyes and mouth when they were exposed to native-language audiovisual speech [$t(32) = 1.68$, *n.s.*] but that they looked more at the mouth when exposed to non-native (English) speech [$t(32) = 6.43$, $p < 0.01$].
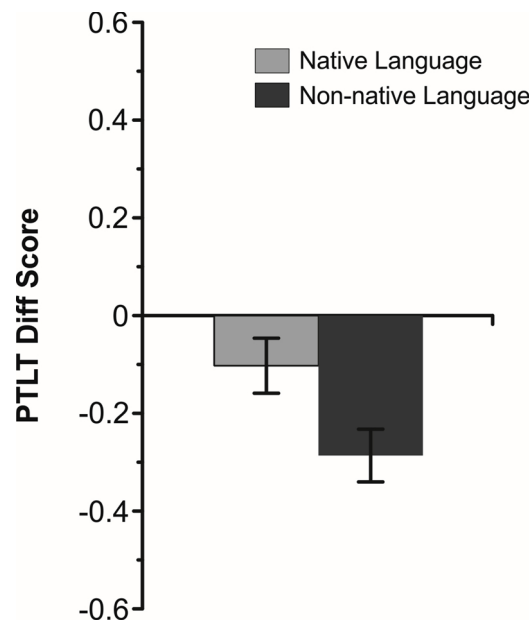
Fig. 1. Difference scores for the proportion of total looking time (PTLT) directed at the eyes and mouth for infants as they watched a video of a monologue spoken in their native language (either Spanish or Catalan) and as they watched a video of a monologue spoken in a nonnative language (English). Error bars represent standard errors of the mean. Note that even though we used separate PTLT scores for the eyes and mouth in the ANOVA, we depict the results graphically in terms of difference scores. A positive difference score indicates a preference for the eyes whereas a negative score indicates a preference for the mouth.

Next, to address our specific research question, we asked whether there was a relationship between infant attention to the talker's eyes and their social and communication abilities. To do so, we computed Pearson product-moment correlations between $PTLT_{eyes}$ values and the scores from the different subscales of the Adaptive Behavior Questionnaire from the BSID-III. Fig. 2 shows these correlations. As can be seen, attention to the eyes in the native-language condition was positively correlated with the Social subscale scores [$r = 0.437$, $p = 0.029$] and marginally correlated with the Communication subscale scores, [$r = 0.35$, $p = 0.07$]. No other significant correlations were found for the native-language condition. Attention to the eyes in non-native language condition was also positively correlated with the Social subscale scores [$r = 0.537$, $p < 0.01$] and also marginally correlated with the Communication subscale scores [$r = 0.377$, $p = 0.063$]. No other significant correlations were found for the non-native language condition.
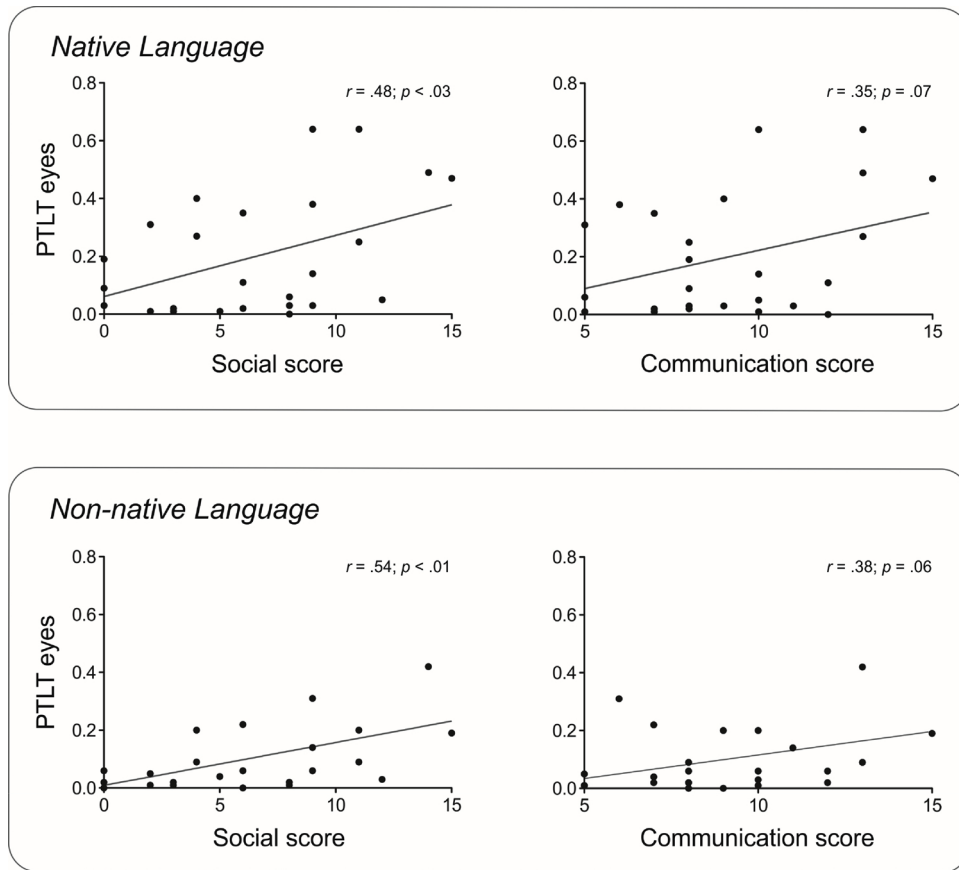
Fig. 2. Relation between PTLT scores to the eyes of a talker speaking in a native (Spanish or Catalan) or a non-native language (English) and Social and Communication scores.

The findings from the current study are notable for two reasons. First, they replicate earlier findings reported by Lewkowicz and Hansen-Tift (2012) and Pons et al. (2015). They show that 12-month-old infants deploy equal attention to the mouth and eyes when a talker speaks in the infants' native language but that they deploy more attention to a talker's mouth than eyes when they are exposed to a talker speaking in an unfamiliar language. Second, the current findings show that 12-month-olds' attention to a talker's eyes is positively correlated with the Social subscale of the BSID-III. This subscale measures skills crucial to social interaction and joint attention processes, both of which can enhance learning. This positive association between attention to the eyes and the Social score is interesting in the context of previous studies which have found that infants' gaze-following behavior (to an object referenced by the talker) predicts productive vocabulary at a later age (Brooks & Meltzoff, 2005). Interestingly, however, we only obtained marginal correlations between attention to the eyes and the Communication subscale score. One possible reason for this finding might be that the items included in this particular subscale include those related to gestural and expressive language abilities rather than purely social responsiveness abilities. In other words, the Communication score assesses behaviors that involve a clearer connection to oral language for which information is likely to be found in the talker's mouth rather than the eyes.

In conclusion, the current findings indicate (a) that 12-month-old infants deploy their selective attention to a talker's mouth differentially as a function of language familiarity, and (b) that 12-month-olds also take advantage of the social cues inherent in a talker's eyes in their own social responsiveness. The latter finding is novel when considered in the context of the former and, together, they provide new insights into the mechanisms underlying infant responsiveness to the various perceptual cues that are normally available in a talker's face during caregiver-infant interactions. They suggest that, by the time they reach their first birthday, infants start taking advantage of multiple perceptual cues during their social interactions with their interlocutors in the service of the acquisition of speech, language, and social skills. Future studies should further investigate the relationship between infant respon-siveness to different combinations of audiovisual speech and social cues and subsequent measures of receptive and productive vocabulary and other related linguistic capacities to obtain a complete developmental picture of the interrelations among these abilities. There is little doubt that such studies will yield a complex developmental picture.

Acknowledgements

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