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Bilingualism Modulates Infants' Selective Attention to the Mouth of a Talking Face

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Abstract
Infants growing up in bilingual environments succeed at learning two languages. What adaptive processes enable them to master the more complex nature of bilingual input? One possibility is that bilingual infants take greater advantage of the redundancy of the audiovisual speech that they usually experience during social interactions. Thus, we investigated whether bilingual infants' need to keep languages apart increases their attention to the mouth as a source of redundant and reliable speech cues. We measured selective attention to talking faces in 4-, 8-, and 12-month-old Catalan and Spanish monolingual and bilingual infants. Monolinguals looked more at the eyes than the mouth at 4 months and more at the mouth than the eyes at 8 months in response to both native and nonnative speech, but they looked more at the mouth than the eyes at 12 months only in response to nonnative speech. In contrast, bilinguals looked equally at the eyes and mouth at 4 months, more at the mouth than the eyes at 8 months, and more at the mouth than the eyes at 12 months, and these patterns of responses were found for both native and nonnative speech at all ages. Thus, to support their dual-language acquisition processes, bilingual infants exploit the greater perceptual salience of redundant audiovisual speech cues at an earlier age and for a longer time than monolingual infants.

Keywords
bilingualism, human infants, language development, audiovisual speech, multisensory perception, selective attention

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Infants growing up in bilingual environments appear to acquire two first languages as easily as monolingual infants acquire a single language. This is remarkable because the bilingual infants' task is far more difficult. Nonetheless, they learn the basic properties of their two input languages rapidly and manage to functionally separate their linguistic systems. What mechanisms enable bilingual infants to acquire two languages?

Existing data provide insights into some of these mechanisms. Some evidence indicates that monolingual and bilingual infants (a) acquire canonical babbling skills at the same time (Oller, Eilers, Urbano, & Cobo-Lewis, 1997), (b) can distinguish between different languages at birth (Byers-Heinlein, Burns, & Werker, 2010), (c) can differentiate phonologically close languages (Bosch & Sebastián-Gallés, 2001b; Molnar, Gervain, & Carreiras, 2014), and (d) can discriminate consonantal phonetic contrasts (Burns, Yoshida, Hill, & Werker, 2007; Sundara, Polka, & Molnar, 2008). In contrast, other evidence suggests that bilingual infants develop some adaptive processes that permit them to deal with the more complex nature of dual-language input (Byers-Heinlein & Fennell, 2014). For example, bilingual infants maintain their sensitivity to lexical stress (Bijeljac-Babic, Serres, Höhle, & Nazzi, 2012) and differ from monolingual infants in the time-course of building some specific contrastive phonetic categories (Bosch & Sebastián-Gallés, 2003; Garcia-Sierra et al., 2011; Sebastián-Gallés & Bosch, 2009). Moreover, at an age when monolingual infants no longer do so, bilingual infants can distinguish between a native and a nonnative language or between two nonnative languages on the basis of visual attributes alone (Sebastián-Gallés, Albareda-Castellot, Weikum, & Werker, 2012; Weikum et al., 2007).

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Although research exploring infants' ability to process language has been done mostly in the auditory domain, typical social interactions involve exposure to audiovisual speech. Moreover, infants become interested in audiovisual speech as they grow and acquire experience (Lewkowicz & Hansen-Tift, 2012; Tenenbaum, Shah, Sobel, Malle, & Morgan, 2013). For example, at 4 months of age, American English monolingual infants attend to a talker's eyes, but by 8 months of age, they shift their attention to the talker's mouth (Lewkowicz & Hansen-Tift, 2012). This attentional shift gives infants access to highly salient redundant audiovisual speech cues just as they begin to babble and is likely to facilitate acquisition of speech perception and production.

To profit from the greater salience of redundant audiovisual speech, infants must be able to integrate multisensory information. Indeed, studies show that this general ability emerges in infancy (Kuhl & Meltzoff, 1982; Lewkowicz, 2010; Lewkowicz & Ghazanfar, 2006; Lewkowicz & Pons, 2013; Patterson & Werker, 1999; Pons, Lewkowicz, Soto-Faraco, & Sebastián-Gallés, 2009; Rosenblum, Schmuckler, & Johnson, 1997; Teinonen, Aslin, Alku, & Csibra, 2008). Studies also show that once reliance on redundant multisensory input begins in infancy, it becomes the default mode of perceptual functioning (Rosenblum, 2008; Stein, 2012). For example, congenitally deaf children who are fitted with cochlear implants exhibit greater sentence comprehension scores for audiovisual speech than for auditory or visual speech (Bergeson, Pisoni, & Davis, 2005), people who are deprived of vision during infancy because of congenital cataracts exhibit deficits in audiovisual speech integration as adults (Putzar, Goerendt, Lange, Rösler, & Röder, 2007), and adults comprehend audiovisual speech better than auditory speech (Sumby & Pollack, 1954).

If selective attention to redundant audiovisual speech cues facilitates acquisition of speech in monolingual infants, might such attention be even greater in bilingual infants? Studies have found that 4.5- and 6-month-old bilingual infants learning two rhythmically similar languages can distinguish between such languages in an auditory-only task (Bosch & Sebastián-Gallés, 2001b); however, when they have to discriminate one of their two familiar languages from a nonfamiliar language in such a task, it takes them longer than monolingual infants to orient to native-language utterances (Bosch & Sebastián-Gallés, 1997, 2001a; Costa & Sebastián-Gallés, 2014). This suggests that bilingual infants' recognition of their native languages can be challenging in the absence of concurrent and redundant visual speech cues. Because bilingual infants need to unequivocally recognize both of their native languages and simultaneously keep them apart, they may exploit audiovisual speech cues more than do monolingual infants. Specifically, bilingual infants may attend to a talker's mouth at earlier ages and more frequently during the initial stage of dual-language acquisition to learn the specific properties of each language. Moreover, bilingual infants may continue to take greater advantage of the redundancy of audiovisual speech cues available in a talker's mouth given that 8-month-old bilingual infants can discriminate two nonnative languages on the basis of visual cues alone (Sebastián-Gallés et al., 2012).

We tested our predictions by examining, in monolingual infants (learning Catalan or Spanish; Experiment 1) and bilingual infants (learning Catalan and Spanish; Experiment 2), selective attention to the eyes and mouth of a talker producing native (or dominant) or nonnative audiovisual speech. This enabled us to determine whether the previous results from monolingual infants learning American English can be generalized to a different monolingual population and whether bilingual infants take greater advantage of audiovisual redundancy.

Experiment 1

Previous studies have found developmental changes in monolingual infants' relative deployment of selective attention to the eyes and mouth of a talker (Lewkowicz & Hansen-Tift, 2012). In this experiment, we attempted to corroborate and extend these findings to infants from a different cultural background who were learning a different language (i.e., either Catalan or Spanish rather than English).

Method

Participants. Sixty infants, consisting of separate groups of 4-, 8-, and 12-month-old infants, were tested. All infants were raised in a monolingual environment and were exposed to Catalan or Spanish at least 90% of the time. The linguistic status of the infants' environment was carefully assessed by a language questionnaire (Bosch & Sebastián-Gallés, 2001b). The first age group consisted of 20 monolingual 4-month-old infants (mean age = 4 months, age range = 3 months 28 days–4 months 7 days; 10 boys); 8 were from Catalan-speaking families and 12 were from Spanish-speaking families (mean daily exposure to native language = 95.3%, *SD* = 3.9). The second group consisted of 20 monolingual 8-month-old infants (mean age = 8 months, age range = 7 months 29 days–8 months 15 days; 12 boys); 9 were from Catalan-speaking families and 11 were from Spanish-speaking families (mean daily exposure to native language = 95%, *SD* = 4.4). The third age group consisted of 20 monolingual 12-month-old infants (mean age = 12 months, age range = 11 months 24 days–12 months 14 days; 12 boys); 11 were from Catalan-speaking families and 9 were from Spanish-speaking families (mean daily exposure to native language = 95.3%, *SD* = 3.9).

Thirty-one additional infants were tested, but we were unable to use their data because they were fussing or crying ($n = 7$), the eye tracker could not be calibrated properly because either the infant was uncooperative or the eye tracker could not find the pupil ($n = 22$), the parents interfered ($n = 1$), or there was an experimental error ($n = 1$). The sample size in this study was consistent with the typical sample sizes used in other research on infant development; thus, the point at which we stopped collecting data was based on common practices in the infant development field.

To determine the infants' level of linguistic achievement, we administered the initial mean babbling levels questionnaire (as described by Morris, 2010) to the parents of 8-month-old infants to measure the phonological diversity in babbling and the MacArthur Communicative Development Inventory (MCDI) of receptive and productive vocabularies (Fenson et al., 1993) to the parents of 12-month-olds.

Apparatus and stimuli. Infants were seated in an infant seat in a sound-attenuated and dimly illuminated room, approximately 60 cm in front of 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. One of the actors (a highly proficient Catalan-Spanish bilingual) recited a Spanish or a Catalan version of the monologue, whereas the other actor (a native speaker of American English) recited an English version of the monologue. Each infant watched two videos, one in his or her native language and the other in a nonnative language. The order of the videos was counterbalanced across infants. To ensure maximal attention, the actors recited the monologues in an infant-directed manner (Fernald, 1985).

Procedure. 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 the two videos to each infant. While the infants watched the videos, we monitored their gaze at two areas of interest (AOI) with the eye tracker. One AOI was the area around the talker's eyes, and the other was the area around the talker's mouth.

Results

To determine the relative amount of time infants attended to the talker's eyes and mouth, we computed the proportion of total looking time (PTLT) for each AOI by dividing the total amount of time infants looked at each AOI by the time they spent looking at any part of the face. Then, we analyzed the PTLT scores with a mixed, repeated measures analysis of variance (ANOVA), with AOI (eyes or mouth) and language (native or nonnative) as within-subjects factors and language presentation order (native first or second), age (4, 8, or 12 months), and linguistic background (Catalan, Spanish) as between-subjects factors. The analysis yielded a significant AOI × Age interaction, $F(2, 54) = 13.58$, $p < .01$, $\eta^2 = .339$, which indicates that time spent looking at the two areas of the face differed as a function of age. The analysis also yielded a significant AOI × Language interaction, $F(1, 54) = 8.88$, $p < .01$, $\eta^2 = .125$, indicating that time spent looking at the two areas of the face differed as a function of the language spoken in the video. Finally, the analysis yielded an AOI × Language × Age interaction, $F(2, 54) = 3.04$, $p = .05$, $\eta^2 = .108$, indicating that attention to the two areas of the talking face varied as a function of age and the language spoken in the video. Figure 1 shows the three-way interaction in the form of mean PTLT difference scores. These scores were derived by subtracting the mouth PTLT score from the eye PTLT score for each participant and then computing the average of those individual PTLT difference scores at each age (a score above 0 signifies more time spent looking at the eyes, whereas a score below 0 signifies more time spent looking at the mouth).

To determine the source of the AOI × Language × Age interaction, we conducted planned comparison tests of time spent looking at the two AOIs at each age. The first such test examined responsiveness to the native language. It revealed that the 4-month-old infants looked longer at the eyes, $F(1, 19) = 5.93$, $p < .05$, $\eta^2 = .229$; the 8-month-old infants looked longer at the mouth, $F(1, 19) = 4.88$, $p < .05$, $\eta^2 = .196$; and the 12-month-old infants looked equally at the eyes and the mouth, $F(1, 19) = 1.55$, n.s., $\eta^2 = .067$. The second planned comparison test examined responsiveness to the nonnative language. This comparison revealed that the 4-month-old infants looked longer at the eyes, $F(1, 19) = 7.41$, $p < .01$, $\eta^2 = .272$, that the 8-month-old infants looked longer at the mouth $F(1, 19) = 25.88$, $p < .01$, $\eta^2 = .576$, and that the 12-month-old infants looked longer at the mouth, $F(1, 19) = 32.47$, $p < .01$, $\eta^2 = .630$.

Discussion

We found that 4-month-old infants attended longer to the talker's eyes and that 8-month-old infants attended longer to the talker's mouth, regardless of the language she was speaking. In contrast, we found that 12-month-old infants

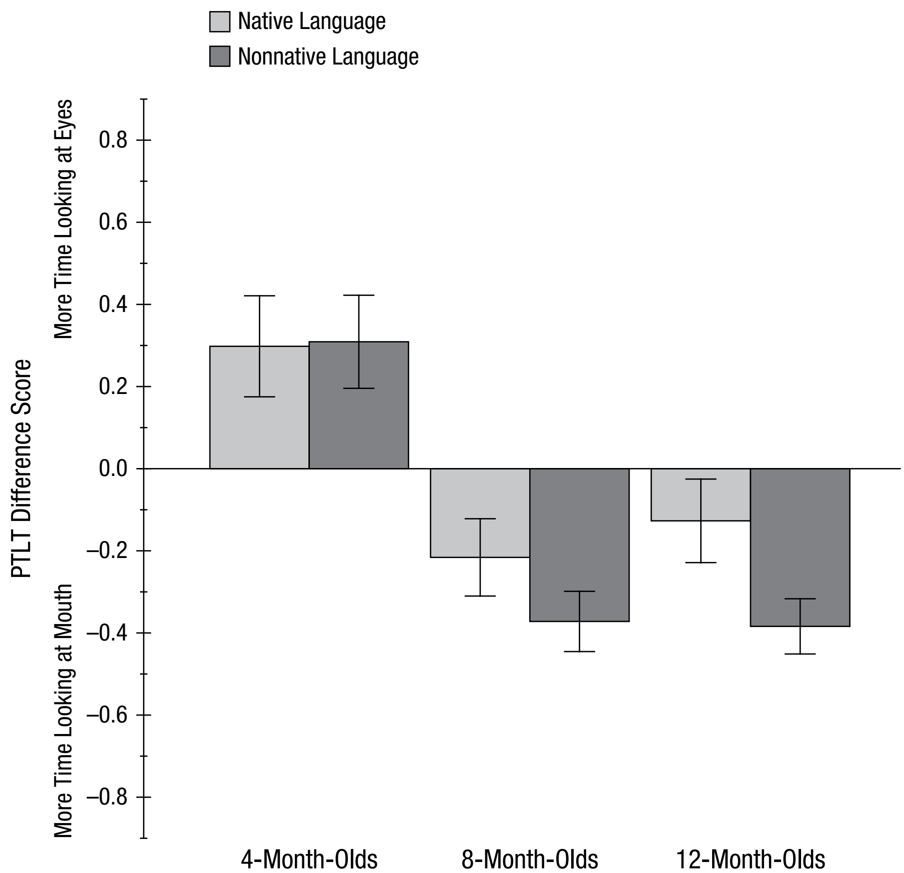

Fig. 1. Results from Experiment 1: difference scores for the proportion of total looking time (PTLT) directed at the eyes and mouth for monolingual infants as they watched a video of a monologue spoken in their native language (either Spanish or Catalan) and as they watched a video of a monologue spoken in a nonnative language (English). Results are shown separately for each of the three age groups. Error bars represent standard errors of the mean.

attended equally to the talker's eyes and mouth when she spoke in the native language and that they attended longer to the talker's mouth when she spoke in a nonnative language. These results replicate the findings from Lewkowicz and Hansen-Tift's (2012) study in which monolingual American infants learning American English were tested with native and nonnative (Spanish) audiovisual speech. Overall, our findings demonstrate that the developmental pattern of shifting attention generalizes to monolingual infants acquiring Catalan or Spanish in Spain.

Experiment 2

As previously suggested, bilingual infants may attend more to talkers' mouths than to their eyes earlier in development, and they may continue to do so throughout the first year of life to deal with the dual challenge of processing two languages and keeping them apart. To test this prediction, we examined the responses of 4-, 8-, and 12-month-old Spanish-Catalan bilingual infants to the same two videos presented in Experiment 1.

Method

Participants. We tested 63 bilingual infants, consisting of separate groups of 4-, 8-, and 12-month-old infants. These infants were raised in a bilingual environment; in addition to being exposed to their native (dominant) language, they were exposed to another language for at least 25% of the time (i.e., either Spanish or Catalan). The Bosch and Sebastián-Gallés (2001b) language-exposure questionnaire was administered to establish each infant's language environment. The first group consisted of 21 bilingual 4-month-old infants (mean age = 4 months, age range = 3 months 29 days–4 months 9 days; 13 boys). Eight infants were Catalan dominant and 13 were Spanish dominant (mean daily exposure to dominant language = 62.7%, *SD* = 8.2). The second group consisted of 21 bilingual 8-month-old infants (mean age = 8 months, age range = 7 months 26 days–8 months 14 days). Seven were Catalan dominant and 14 were Spanish dominant (mean daily exposure to dominant language = 65.6%, *SD* = 6.4). The third age group consisted of 21 bilingual

12-month-old infants (mean age = 12 months, age range = 11 months 20 days–12 months 17 days; 10 boys). Nine were Catalan dominant and 12 were Spanish dominant (mean daily exposure to dominant language = 66.4%, *SD* = 8.0).

Twenty-four additional infants were tested, but we were unable to use their data because they were fussing or crying ($n = 4$), the eye tracker could not be calibrated properly because either the infant was uncooperative or the eye tracker could not find the pupil ($n = 19$), or there was an experimental error ($n = 1$). Once again, we used the initial babbling levels questionnaire at 8 months and the MCDI at 12 months to ensure that the bilingual infants and their monolingual peers had equivalent levels of linguistic achievement. The babbling scores indicated that the 8-month-old monolingual infants from Experiment 1 and the bilingual infants from the current experiment did not differ in their babbling activity (monolinguals: $M = 2.05$, $SD = 0.39$; bilinguals: $M = 1.90$, $SD = 0.44$). A Mann-Whitney test comparing these two scores indicated no difference, $z = 1.11$, n.s. For the monolingual infants, the MCDI vocabulary measures yielded comprehension-vocabulary scores that ranged from 15 to 268 words ($M = 83.3$, $SD = 68.3$), and the reported production-measures scores ranged from 0 to 19 words ($M = 6.8$, $SD = 6.2$).

To obtain comparable MCDI measures for the bilingual infants in the current experiment, we used the method of Bosch and Ramon-Casas (2014) to measure their total receptive and expressive vocabulary size (Spanish and Catalan, correcting for the presence of form-similar cross-language synonyms). These combined measures yielded comprehension-vocabulary scores that ranged from 9 to 155 words ($M = 65.4$, $SD = 46.1$), and the reported production-measures scores ranged from 0 to 16 words ($M = 6.0$, $SD = 4.2$). A comparison of these vocabulary measures by way of a Mann-Whitney test indicated that the two groups of infants did not differ in terms of their receptive lexicons, $z = 0.39$, n.s., or productive lexicons, $z = 0.81$, n.s. Thus, as can be seen from these measures, our samples of monolingual and bilingual infants did not differ in babbling and verbal abilities.

Apparatus, stimuli, and procedure. The apparatus, stimuli, and procedure were the same as those in Experiment 1. As in that experiment, we presented a native-language video and a non-native-language video; in this experiment, however, the native-language video was in the infants' dominant language.

Results

We used the same mixed, repeated measures ANOVA that we used in Experiment 1 to analyze the PTLT scores from this experiment, except that here the between-subjects factor was language dominance (Spanish dominant, Catalan dominant). Results indicated that there was a main effect of AOI, $F(1, 57) = 25.82$, $p < .01$, $\eta^2 = .312$, a significant AOI × Age interaction, $F(2, 57) = 6.12$, $p < .01$, $\eta^2 = .177$, and an AOI × Language × Age interaction, $F(2, 57) = 6.32$, $p < .01$, $\eta^2 = .182$. The AOI effect indicated that there was an overall preference for the mouth, whereas the AOI × Age interaction reflected differences in looking at the eyes and mouth as a function of age. Of course, the most interesting finding from the standpoint of our predictions was the AOI × Language × Age interaction. This interaction is depicted in Figure 2; as can be seen, time spent looking at the eyes and mouth varied as a function of age and language.

Planned comparison tests of the triple interaction indicated that when viewing the video with the native-language monologue, the 4-month-old infants looked equally at the eyes and the mouth, $F(1, 20) = 0.69$, n.s., $\eta^2 = .034$, and the 8- and 12-month-old infants looked longer at the mouth than at the eyes, $F(1, 20) = 5.15$, $p < .05$, $\eta^2 = .205$, and $F(1, 20) = 30.37$, $p < .01$, $\eta^2 = .603$, respectively. The same developmental pattern held when the infants viewed the video with the nonnative-language monologue. That is, the 4-month-old infants looked equally at the eyes and the mouth, $F(1, 20) = 0.24$, n.s., $\eta^2 = .011$, whereas the 8- and 12-month-old infants looked longer at the mouth than at the eyes, $F(1, 20) = 11.24$, $p < .01$, $\eta^2 = .361$, and $F(1, 20) = 81.26$, $p < .01$, $\eta^2 = .802$, respectively.

Discussion

In this experiment, we found that (a) bilingual 4-month-olds looked equally at the eyes and mouth, regardless of the language spoken by the talker; (b) bilingual 8-month-olds looked longer at the mouth, regardless of the language spoken; and (c) bilingual 12-month-olds also looked longer at the mouth regardless of language spoken.

Results of a Monolingual-Bilingual Comparison

We compared the data from Experiments 1 and 2 to determine whether the changing patterns of selective attention differed as a function of language environment (i.e., monolingual or bilingual). For this comparison, we examined responsiveness to each test language separately, because responsiveness to native versus nonnative languages begins to differ early in infancy (Lewkowicz, 2014; Lewkowicz & Hansen-Tift, 2012; Pons et al., 2009; Werker & Tees, 2005).

For the analysis of responsiveness to native speech, we used a mixed, repeated measures ANOVA, with AOI (eyes or mouth) as a within-subjects factor and language

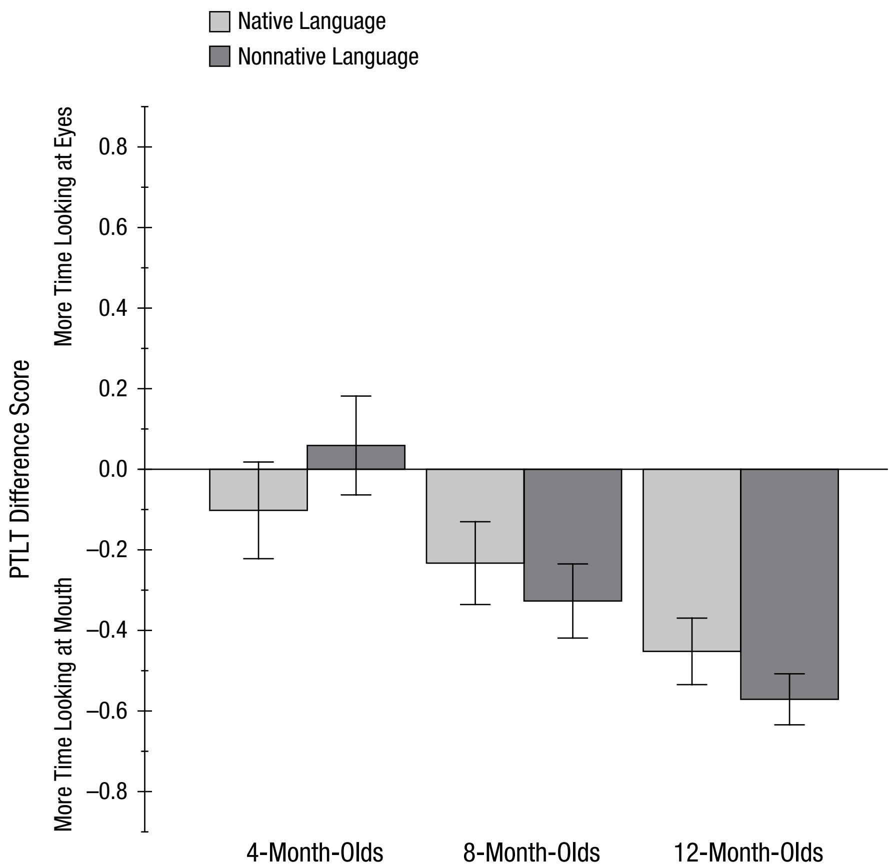

Fig. 2. Results from Experiment 2: difference scores for proportion of total looking time (PTLT) directed at the eyes and mouth for bilingual infants as they watched a video with a monologue spoken in their native (dominant) language (either Spanish or Catalan) and as they watched a video with a monologue spoken in a nonnative language (English). Results are shown separately for each of the three age groups. Error bars represent standard errors of the mean.

environment (bilingual or monolingual) and age (4, 8, or 12 months) as between-subjects factors. This analysis yielded a main effect of AOI, $F(1, 117) = 9.04$, $p < .01$, $\eta^2 = .072$; an AOI × Age interaction, $F(2, 117) = 7.40$, $p < .01$, $\eta^2 = .112$; an AOI × Language Environment interaction, $F(1, 117) = 7.20$, $p < .025$, $\eta^2 = .057$; and a marginal AOI × Language Environment × Age interaction, $F(2, 117) = 2.48$, $p = .08$, $\eta^2 = .041$.

To determine the source of the interactions, we performed planned comparison analyses of time spent looking at the eyes and mouth, separately at each age, to determine whether monolingual and bilingual infants differed in their response profiles. These comparisons indicated that at 4 months of age, the bilingual infants looked equally at the eyes and mouth, $t(20) = 0.84$, n.s., but that the monolingual infants looked longer at the eyes, $t(19) = 2.41$, $p < .05$. Furthermore, a direct comparison of the data from the two groups of 4-month-olds indicated that the bilingual infants looked longer at the mouth than did the monolingual infants, $t(39) = 2.31$, $p < .05$. Both groups of 8-month-old infants looked longer at the mouth than at the eyes—bilinguals: $t(20) = 2.26$, $p < .05$; monolinguals: $t(19) = 2.28$, $p < .05$. A direct comparison of the two groups indicated that they did not differ in time spent looking at the mouth, $t(39) = 0.57$, n.s. Finally, at 12 months of age, the bilingual infants looked longer at the mouth, $t(20) = 5.51$, $p < .01$, whereas the monolingual infants did not, $t(19) = 1.25$, n.s. A direct comparison of the data from the two groups indicated that the bilingual infants looked longer at the mouth than did the monolingual infants, $t(39) = 2.50$, $p < .025$.

We used the same mixed, repeated measures ANOVA that we used for the analysis of responsiveness to native speech for the analysis of responsiveness to nonnative speech. This analysis yielded a main effect of AOI, $F(1, 117) = 28.15$, $p < .01$, $\eta^2 = .194$, and an AOI × Age interaction, $F(2, 117) = 26.78$, $p < .001$, $\eta^2 = .314$. The planned comparison tests indicated that at 4 months of age, bilingual infants looked equally at the eyes and mouth, $t(20) = 0.12$, n.s., whereas monolingual infants looked longer at the eyes than at the mouth, $t(19) = 2.70$, $p < .025$. A direct comparison of the two groups did not reveal a significant difference. Both groups of 8-month-old infants looked longer at the mouth than at the eyes—bilinguals: $t(20) = 3.35$, $p < .01$; monolinguals: $t(19) = 5.80$, $p < .01$. A direct comparison indicated that the two groups did not differ in time spent looking at the mouth, $t(39) = 1.26$, n.s. Finally, at 12 months of age, both groups looked longer at the mouth than at the eyes—bilinguals: $t(20) = 12.06$, $p < .01$; monolinguals: $t(19) = 5.69$, $p < .01$. Crucially, however, the bilingual infants looked more at the mouth than did the monolingual infants, $t(39) = 2.03$, $p < .05$.

Overall, we observed some similarities and some key differences between the bilingual and monolingual infants. First, at 4 months of age, monolingual infants looked longer at the eyes than at the mouth, whereas the bilingual infants looked equally at the eyes and mouth, regardless of the language spoken by the talker. Second, at 8 months of age, both monolingual and bilingual infants looked longer at the mouth than at the eyes, regardless of the language spoken. Finally, at 12 months of age, the monolingual infants looked equally at the eyes and mouth in response to native speech and longer at the mouth than at the eyes in response to nonnative speech, whereas the bilingual infants looked longer at the mouth than at the eyes in response to both native and nonnative speech.

General Discussion

Lewkowicz and Hansen-Tift (2012) found that American infants learning English exhibit two shifts in the relative amount of selective attention that they devote to the eyes and mouth of a talker during the first year of life. The first shift—from the eyes to the mouth—was found between 4 and 8 months of age. The second shift—away from the mouth—was found by 12 months. We replicated these findings in a sample of monolingual infants growing up in a different cultural milieu and learning languages that are rhythmically different from English. Moreover, and consistent with our hypothesis, we found that bilingual infants generally took greater advantage of the redundancy of audiovisual speech cues than did the monolingual infants.

The main difference between the bilingual and monolingual infants was at 4 and 12 months. At 4 months, monolingual infants looked more at the eyes than at the mouth, whereas the bilingual infants did not. This suggests an earlier attentional shift to the mouth in the bilingual infants. At 12 months, the monolingual infants looked equally at the eyes and mouth in response to native speech but more at the mouth than at the eyes in response to nonnative speech. In contrast, the bilingual infants looked longer at the mouth than at the eyes in response to familiar and unfamiliar speech and longer than monolingual infants in both cases. At 8 months, both monolingual and bilingual infants looked longer at the mouth than at the eyes. Overall, these findings support our prediction that bilingual infants are likely to maximally and efficiently exploit the highly salient audiovisual speech cues that are normally located in a talker's mouth.

Whether bilinguals continue to rely on audiovisual speech cues past 12 months of age is currently an open question. Given that the problem of language recognition and differentiation becomes less pronounced with extended linguistic exposure, bilingual infants' reliance on such cues may decline as they get older. Nonetheless, as our findings show, up to 12 months of age, bilingual infants do rely on the greater perceptual salience of audiovisual speech cues to build two distinct language systems. Presumably, this is because language differentiation in bilingual infants—especially in infants exposed to rhythmically or phonologically similar languages—is initially constrained by limited experience with linguistic input.

Our results provide the first evidence of a modulation of attention to the eyes and mouth of a talking face driven by differences in infants' linguistic background (i.e., single-language or dual-language exposure) and are consistent with findings showing that bilingual infants are sensitive to visual speech cues in a discriminative task (Sebastián-Gallés et al., 2012; Weikum et al., 2007). Of course, given that our bilingual infants were learning two rhythmically similar languages, it would be interesting to investigate whether bilingual infants learning more dissimilar languages also might take greater advantage of redundant audiovisual cues. One possible answer is that the rhythmical and phonological similarity of two specific languages may modulate the degree to which infants take advantage of redundant audiovisual cues.

How might greater attention to a talker's mouth facilitate language acquisition in bilingual infants? Like their monolingual counterparts, bilingual infants show language-general phonetic-discrimination abilities at 4 months of age (Bosch & Sebastián-Gallés, 2003), but unlike monolingual infants, they find it challenging to recognize one of the two native languages purely on the basis of auditory input (Bosch & Sebastián-Gallés, 1997, 2001a). Our finding that bilingual infants shift their attention to the redundant audiovisual speech cues earlier than monolinguals suggests that the greater perceptual salience of such cues probably helps bilingual infants identify distinct language-specific features that help them keep the languages apart. Continued attention to redundant audiovisual speech cues through 12 months of age suggests that audiovisual information is still useful at that age, not only for the acquisition of the perceptual attributes of the two languages but also for further gains in language acquisition.

Might redundant audiovisual speech continue to enhance language acquisition into later development, and might it continue to play a different role in bilinguals than in monolinguals? The answer to both questions is affirmative. For example, studies have shown that monolingual adults comprehend audiovisual speech better than auditory speech (Sumby & Pollack, 1954) and that adults rely on redundant visual speech cues when presented either with an ambiguous soundtrack (Lansing & McConkie, 2003) or with speech in noise (Vatikiotis-Bateson, Eigsti, Yano, & Munhall, 1998). Likewise, studies have found that bilingual adults find it easier to differentiate difficult-to-discriminate audible phonemes with the aid of concurrent visible articulations (Navarra & Soto-Faraco, 2007). Regardless of the ultimate answer to whether and to what extent redundant audiovisual speech cues play a role in early speech and language development, there is little doubt that the development of speech and language is a multisensory affair.

Author Contributions

F. Pons developed the study concept. D. J. Lewkowicz contributed to study design. F. Pons and L. Bosch collected the data. F. Pons performed data analyses. F. Pons, L. Bosch, and D. J. Lewkowicz wrote and approved the final manuscript.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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