Language familiarity influences own-race face recognition in 9-and 12-month-old infants

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Introduction

The development of face processing and speech perception show intriguing commonalities, suggesting that the two cognitive systems interact during development (Maurer & Werker, 2014; Pascalis et al., 2014). One of the most interesting similarities is that the maturation of both systems undergoes a phenomenon often referred to as *perceptual narrowing* or *perceptual attunement*. This phenomenon describes the fact that infants are born with the ability to discriminate a wide range of stimuli (regardless of their frequency in their perceptual environment) based on low-level properties of the sensory input. However, at the end of their first year, they have become experts in recognizing the stimuli that are the most frequent in their perceptual environment, while they have lost the ability to recognize contrasts that are uncommon or absent in their daily life. For language learning, seminal work by Werker & Tees (1984) showed that 3- to 9-month-old infants are able to discriminate native as well as non-native phonetic contrasts. At 12 months however, infants are, as adults, only able to discriminate phonetic contrasts that belong to their native language (see also, Weikum et al., 2007; Pons et al., 2009). For face recognition, Kelly et al. (2007) evidenced a similar phenomenon: while both 3- and 6-month-olds are able to recognize own- as well as other-race faces, 9-month-olds are, as

adults, only able to recognize faces of their own race, the Other Race Effect (ORE, Rossion & Michel, 2011, for a review). These two phenomena have been studied separately, and the nature of the interaction between language and face systems remains understudied. However, this interaction could have important implications for current models of both face, and language perception.The goal of the present study is to directly explore the influence of language learning (and more specifically, language familiarity) on the development of face recognition in infancy.

Language has also been found to influence face processing in adults. Baus, Bas, Calabria & Costa (2017) investigated how language familiarity (native vs. non-native) affects own-race face recognition in adults. Their participants learned faces accompanied by voices speaking either in their native or non-native language, and had to recognize them in a subsequent test. Results showed that they remembered more accurately the faces previously paired with their native language than the other faces, showing that language familiarity somewhat improves the recognition of individuals (Baus et al, 2017). In the same line of arguments, Kandel et al. (2016) have shown that early language experience impacts on face processing abilities in adulthood. They found that bilingual adults did not exhibit the classic Other-Race Effect, as opposed to monolingual with the same level of experience with other race faces. Hence, early exposure to more than one language shapes perceptual organization beyond language processing, notably extending to face processing (see also Zhang et al. (2013)).

Taken together, these pieces of converging evidence suggest that language familiarity influences face processing in adults. Is there a similar influence of language on face processing during infancy? Do language and face processing systems develop independently from each other or do they interact early on, at stages when the representation for faces and speech are not mature yet? This question is important as it could radically improve our understanding of how infants adapt so quickly to their social environment, but also of the mechanism at play for face and language processing.

Some recent studies suggest that language and face processing systems interact during the first year (Krasotkina, Götz, Höhle & Schwarzer, 2018; Xiao et al., 2018, see also Pascalis et al., 2014, for a review). Using a within-participant design, Xiao et al. (2018) measured 3-, 6-, 9-, and 12-month-old infants' perceptual discrimination for language (native vs. non-native phonetic contrasts) and individual face recognition (own vs. other-race faces). While no correlation was found for face recognition and language discrimination scores at 3 and 6 months of age, their results showed significant relationships between these two scores at 9 and 12 months of age. At 9 months, they found a negative correlation between the extent of perceptual narrowing in the face domain and that in the language domain, suggesting that at this age, systems might somewhat compete with each other as they vie for attentional capacity as a limited resource. Conversely, at 12 months, a positive correlation was found, suggesting that these two systems no longer compete with each other but rather improve each other's functioning. The goal of the present study is to explore the role of language familiarity on infant face recognition.

Regarding this question, pioneering work by Kinzler, Dupoux and Spelke (2007) investigated the influence of language familiarity on infant's initial preference for a social partner. They demonstrated that when 6-month-old monolingual English-learning infants are presented with two faces side by side, they prefer looking at the face that has previously spoken to them in their native language rather than at the face who spoke in a non-native language (i.e., in Spanish). In another study, Uttley et al. (2013) investigated whether 6-month-old infants associate faces (own-race, other-race) with language (native, non-native). Caucasian monolingual English-learning infants were presented with pictures of faces that were either from their own race (Caucasian), or another race (Chinese). For the infants in the matching condition, the Caucasian faces were systematically presented with a voice speaking in the infants' native language (English) while the Chinese faces were always accompanied by a non-native language soundtrack (Mandarin). Infants in the mismatching condition perceived the opposite pairings. Results showed that 6-month-olds in the matching condition looked longer at the face-voice pairings than infants in the non-matching condition. This early "matching preference" suggests that 6-month-olds have already developed a multisensory expectation of how face race and language are associated in their environment.

However, there is no study directly investigating the impact of language familiarity on how infants learn and recognize own-race faces. Indeed, beyond initial preferences, it is crucial to understand whether language influences how infants perceptually encode the faces of the people that surround them. In the present study, we tackled this question by testing how language familiarity impacts 9- and 12-month-old infants' ability to recognize faces from their own race. We chose to test these abilities at a period when both age groups have become experts in categorizing their own-race faces (Kelly et al., 2007) but language learning is still under way. Indeed, although infants can recognize their native language from birth (Moon et al. 1993), their first year is devoted to tuning to the specific phonological system of that language, with perceptual attunement to native vowels at around 6 months (Kuhl, 2000), and to native consonants at around 10-12 months of age (Werker & Tees, 1984). Regarding lexical development, infants start learning word-object associations at around 6 months (Bergelson & Swingley, 2012), but they will only start using such associations as communicative tools at around 12 months (Bates et al, 1995). Therefore, 9 and 12 months are two age periods when infants will process native vs. non-native language very differently. Moreover, infants between 9 and 12 months of age also undergo brain and attentional maturation (see De Diego-Balaguer, Martinez-Alvarez & Pons, 2016, for a review). As we will discuss later on, all of these factors could presumably be of importance as they influence how infants selectively attend to (Lewkowicz & Hansen-Tift, 2012) and potentially recognize the faces of others.

To test the effect of language familiarity, we selected two phonetically and rhythmically distant languages, that are supposed to be easily discriminable from one another: French and German. Notably, German and French belong to different rhythmic classes that neonates can already

discriminate solely on the basis of the low-pass filtered acoustic speech signal (Mehler et al., 1988; Nazzi et al., 1998; Ramus et al., 1999).

In Experiment 1, we tested the influence of language familiarity on face recognition by familiarizing 9- and 12-month-old French-learning infants with audiovisual clips of a Caucasian native bilingual French-German speaker, talking to half of them in their native language (French) and to the other half in a non-native language (German). In the test phase, the still picture of the speaker's face was presented side by side with a picture of a novel face. We used greater looking time to the novel face relative to the familiarized face at test to index face recognition. That is, if infants had recognized the face of the speaker from the familiarization phase, they were expected to show a novelty effect, namely a visual preference for the novel over the familiar face (the speaker's face they had been familiarized with). If language familiarity influences face recognition, we expected to observe, in line with previous findings, better face recognition performance for the infants familiarized to the speaker talking in their native language. We also expected this effect of language familiarity on face recognition to be stronger in the 12-month-olds than in the 9-month-olds, due to more mature language and/or selective attention skills.

Experiment 1

Method

Participants

The present study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the CERGA IRB00010290-2018-02-06-39 at the University Grenoble Alpes.

Seventy-two infants participated in Experiment 1. Thirty-six were 9-month-olds (M age = 287 days, SD age = 4.4 days, 16 females, 20 males), and the 36 others were 12-month-olds (M age = 376 days, SD age = 4.2 days, 15 females, 21 males). For each age group, half of the infants (N=18) were assigned to the Native Language condition, while the other half was assigned to the Non-native condition. Infants were healthy, full-term participants, recruited from the maternity ward of the Centre Hospitalier Universitaire Grenoble Alpes in France. They were all Caucasians and growing in a monolingual French-speaking environment (according to parental report infants were exposed to French more than 95% of the time). Eight additional infants (two 12-month-olds) were tested, but excluded from the analyses because they did not complete the procedure due to crying or fussiness. According to parental reports, the infants had had no direct exposure to German prior to their participation.

Stimuli

Familiarization stimuli were four video clips of two bilingual female speakers, native of both French and German reciting a nursery rhyme, an adapted French or German version of "Goldilocks and the three bears". Both speakers were recorded against a blue background, looking directly at the camera with a neutral expression. All videos were matched in image size and time duration. Each 30-second video showed a full-face image of the speaker and measured 20.6 cm x 18 cm when displayed on the monitor. Sound was presented at conversational sound pressure level. In the test phase, still pictures extracted from the video were presented. They all displayed one speaker's face in a neutral position with the mouth closed. All individual pictures were mounted on a uniform dark blue background. All stimuli were resized identically to ensure uniformity. One speaker was used for familiarization and the second one as a novel face during the test. The face presented during the familiarization was counterbalanced between the participants.

Apparatus and Procedure

Infants were seated on their parent's laps, in a dimly illuminated room, ~ 60 cm away from a 22-inch computer screen. Parents were asked not to intervene, interact, nor speak with their infant during the experiment. Stimuli were presented using the E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA, USA). Two loudspeakers (Dell A225) placed behind the screen, on the left and right side, transmitted the audio soundtracks. A low-light video camera, located above the monitor, was used to record infants' looking behavior. The video recordings were subsequently digitized and analyzed with a frame-by-frame offline coding procedure. All parents signed a written consent form for their infant prior to the experiment.

The experimental procedure was divided into two phases: familiarization and test.

Familiarization trial

Infants were presented with a video clip of the face of one of the two female speakers, talking in German or in French, displayed at the center of the screen. Both the language spoken by the speaker (French/German) and the speaker identity were counterbalanced across participants. Before each trial an attention getter was presented until the infant looked at the middle of the screen. Each trial ended after the video (total duration: 30 seconds). In other words, the familiarization duration was not infant controlled.

Test trials

We used a preferential looking technique to test face recognition. Immediately after the familiarization, the face of the speaker presented in the familiarization phase and a novel face (the speaker the infant was not familiarized to) were displayed side-by-side on the monitor, separated by a 12 cm gap. They were presented for two test trials, lasting five seconds each. The trial started when the infant looked at one of the two stimuli and ended after 5 seconds had elapsed. The side (left/right) where the novel face appeared was counterbalanced across participants and trials. An attention getter screen was presented before each trial until the infant looked at the middle of the screen.

Eye movements were recorded throughout and the recording digitized to be analyzed frame-by-frame by two independent observers on a computer using homemade software. The observers were blind as to which stimulus was presented on each side. Inter-observer agreement was computed on 33% of the participants from the final sample collapsed across age. It showed a high reliability score (Pearson r = .96). Importantly, none of the participants were excluded because of side bias during testing (> 95% looking time to one side).

Results

Familiarization

The time infants spent looking at the speaker during the familiarization phase did not vary according to age group, language familiarity (*M* = 27.75s, *SD* = 2.7 for German and *M* =27.13s, *SD* = 3.4 for French) nor speaker identity (all $p > .05$). All data for the familiarization and Test phase of Experiment 1 and 2 can be downloaded here:
https://osf.io/g7wsv/?view_only=10675c79c945474da8cd9dc1551fe96c

Preference Test Trials

To test infants' face recognition, we computed the proportion of looking time toward the novel face by dividing the time infants spent looking at the novel stimulus by the total time they spent looking at both the novel and the familiar face during the test phase (cf. Figure 1, first column). If these scores were significantly above 50%, this would indicate a novelty preference. We then performed an arcsine transformation of these scores for each participant in each condition, to avoid potential ceiling or floor effects (Winer, 1970). To handle missing data and to be able to consider that the effect of fixed factors could vary among participants, we used a mixed-effects models and analyzed the data with R (R Core Team, 2012) using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Participants and Trial number (first, second) were random factors, while Age (9 vs. 12 months) and Language Familiarity (Native vs. Non-Native) were between-participants fixed factors and Face Familiarity (Familiar Face vs. Novel Face) a within-participant fixed factor. The Familiar Face condition was treated as baseline and parameters were estimated for the Novel Face condition. Results averaged across trials are presented in Figure 1, first and second columns. Statistical analyses did not yield any significant effect nor interaction between factors (all $t < 1$)[1]. The effect of Face Familiarity was only significant for the 12-month-olds in the Native language condition (Estimate = .10, SE = .03, $t = 3.3$, $p < .005$), but failed to reach significance for the three other group of infants (12-month-olds, Non-Native language: $t < 1$; 9-month-olds, Native language: $\beta = .07$, SE = .04, $t = 1.6$, $p = .12$, Non-Native language: $\beta = .07$, SE = .04, $t = 1.4$, $p = .17$). We further discuss those results in the next section.

[1] Fixed-effects estimates and standard errors along with *t* and *p* values were estimated using Satterthwaite's approximation for degrees of freedom.

Discussion

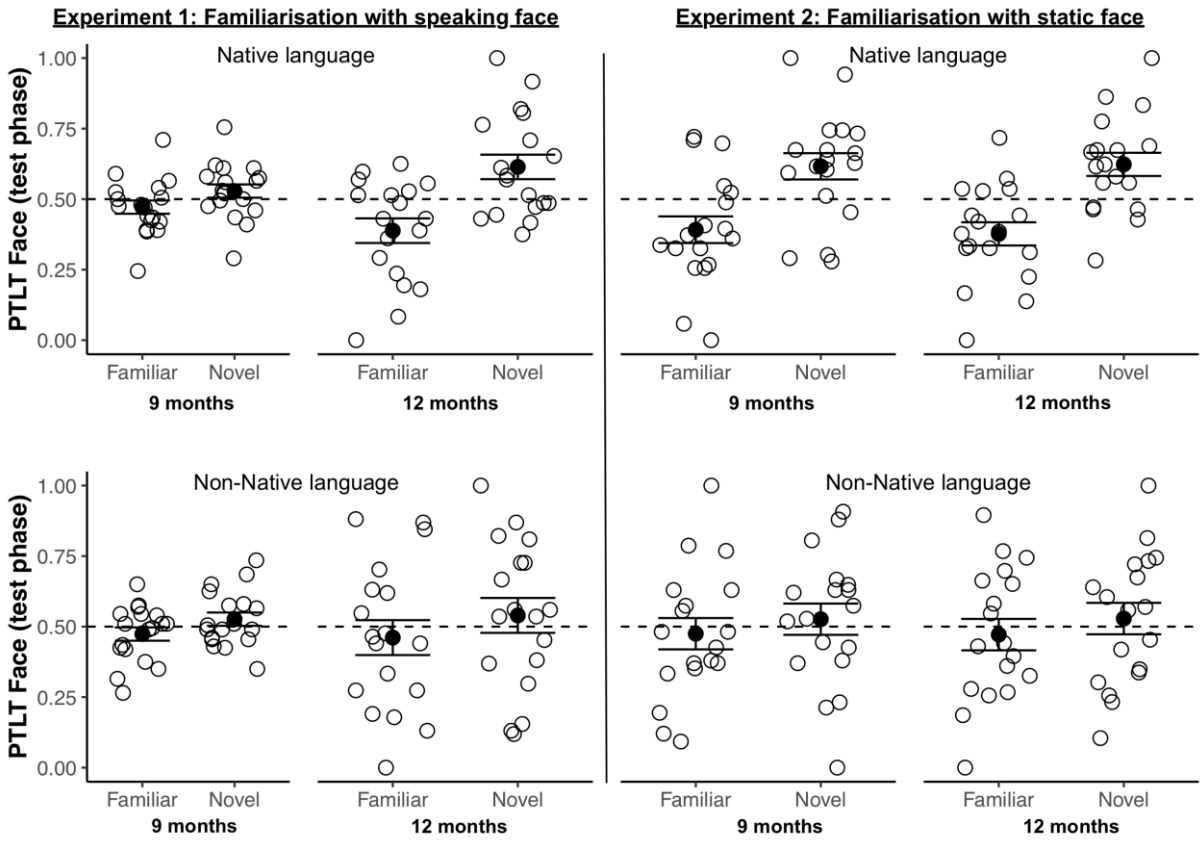
Our results suggest that 9-month-olds did not recognize the familiar face over the novel face, regardless of whether she spoke in their native languages or not. At 12 months, results are more difficult to interpret. Further analyses suggest that 12-month-old recognize the speaker's face, but only in the native language condition. However, no significant interaction was observed in the omnibus analysis, suggesting that this last effect was weak and has to be interpreted cautiously. Taken together, these results suggest that robust recognition for both age group is not found after a familiarization using videos of a face speaking non-native language.

When comparing these data with previous literature, our results are intriguing. Infants did not seem to robustly recognize a face they had been familiarized with for 30 seconds. By contrast, previous studies by Pascalis et al. (2002) evidence robust own-race face recognition from 9 months of age, using familiarization phases even shorter than ours (20s- vs 30s-long, respectively). Thus, it is unlikely that in the present study, the lack of clear evidence for face recognition could be due to immature face processing skills.

We consider several explanations to account for our results. First, the lack of clear evidence for own-race face recognition in Experiment 1 could be due to a peculiarity of our stimuli. It could be that for some reasons, the faces we used were somewhat hard for infants to distinguish from each other. However, we used successfully those dynamic stimuli in another study (Kubicek et al., 2014) making this argument unlikely. Another possible explanation could come from the use of a complex dynamic/talking face, rather than the mere still picture of a face, in the familiarization phase. In previous studies on face recognition, such as Pascalis et al. (2002), infants were only familiarized with static pictures of faces. Using talking faces could have induced a supplementary cognitive load in 9- and 12-month-olds: they could have been distracted by the complexity of the dynamics of the talking face, preventing them to process the identity of the speaker. Similarly, they could have been overwhelmed by the language input. In line with this argument, two previous eye-tracking studies, using audiovisual talking faces, showed that at 8, 10 and 12 months of age, infants looked a large amount of time at the mouth region of a female speaker (Lewkowicz & Hansen-Tift, 2012; Pons, Bosch & Lewkowicz, 2015; Kubicek et al., 2014). Thus, 9- and 12-month-olds' failure to recognize an own-race face could be due to the fact that the face spoke during the familiarization, inducing greater looking time at the mouth region of the talking face than we should have observed if we had presented own-race static faces. This attentional shift to the mouth, could have lessened their ability to process the face identity, with insufficient attention to other internal features such as the eye region of the speaker. This selective attention to the mouth would impinge on face identity processing during familiarization.

To test these hypotheses, we conducted a second study. Instead of using talking faces in the familiarization phase, we only kept the auditory soundtrack of the nursery rhyme, accompanied by the

static picture of the speaker's face, getting closer to the classical paradigms used in infant face recognition literature. If the results of Experiment 1 were only due to a peculiarity of our face stimuli or to a lack of language maturation, we should observe the same results in Experiment 2. If the results of Experiment 1 were due to the presence of an audiovisual dynamic face attracting attention to the mouth region and preventing infants from memorizing facial identity, by using still pictures, we should circumvent this mouth attraction and observe a novelty effect in both age groups. If, as hypothesized in Experiment 1, language familiarity influences face recognition processes, we should observe a stronger novelty effect for infants familiarized with the Native rather than to the Non-Native language.



Experiment 2

Method

Participants

Seventy-two infants participated in Experiment 2. Thirty-six were 9-month-olds (M age = 284.75 days, SD age = 6.28 days, 23 females while the other 36 infants were 12-month-olds (M age = 382.3 days, SD age = 19.6 days, 20 females). For each age group, half of the infants (N=18) were assigned to the Native Language condition, while the other half was assigned to the Non-native condition. Infants were healthy, full-term participants, recruited from the maternity ward of the Centre Hospitalier

Universitaire Grenoble Alpes in France. They were all Caucasians and growing in a monolingual French-speaking environment (according to parental report infants were exposed to French more than 95% of the time). Ten additional infants (4 12-month-olds) were tested, but excluded from the analyses because they did not complete the procedure due to crying or fussiness. According to parental reports, these infants had no direct exposure to German prior to their participation.

Familiarization

The familiarization phase was identical to Experiment 1 except that instead of seeing the talking face of the speaker, infants were presented with a still picture of the speaker's face displayed at the center of the screen. It was accompanied by a 30s soundtrack of the nursery rhyme extracted from the video clips of Experiment 1.

Test trials

The test trials were exactly the same as in Experiment 1. As in Experiment 1, no participant was excluded because of side bias during testing (> 95% looking time to one side).

Results and Discussion

Familiarization Trials

The time infants spent looking at the speaker during the familiarization phase did not vary according to age group, language familiarity (M = 23.3s, SD = 4.2 for German and M =24.01s, SD = 4.1 for French) nor speaker identity (all $p > .05$).

Preference Test Trials.

Results from Experiment 2 averaged across trials are presented in Figure 1, second column. We conducted a mixed model analysis using Language Familiarity and Face Type as fixed factors on the arsine transformation of the preference scores from Experiment 2. Initially, Age (9 vs 12 months) was also declared as a fixed factor, but it did not significantly increase the variance accounted for and was thus excluded from the final model. In contrast with Experiment 1, results revealed a significant main effect of Face Familiarity (Estimate = .18, SE = .03, t = 6.03, p < .001) and Language Familiarity (Estimate = .08, SE = .03, t = 2.6, p < .05), as well as a significant interaction between both factors (Estimate = -.15, SE = .04, t = -3.6, p < .005). Nine-month-old (Estimate = .14, SE = .03, t = 4.1, p < .001) and 12-month-old (Estimate = .22, SE = .04, t = 5.6, p < .001) infants in the Native Language condition looked significantly longer at the novel face in the test phase, suggesting that they recognized the face they were familiarized with. However, neither 9- nor 12-month-olds (both t < 1) in the Non-Native condition looked significantly longer at the novel face in the test phase.

We then compared results from Experiment 1 and 2, conducting a mixed model analysis using Language Familiarity and Face Type as fixed factors on the arsine transformation of the preference scores from both experiments, adding Experiment (Experiment 1, Experiment 2) as a between-participant factor. Initially, Age (9 vs 12 months) was also declared as a fixed factor, but it did not significantly increase the variance accounted for and was thus excluded from the final model. While no main effect of Experiment was found (Estimate =.04, SE = .03, t = 1.2, p = .22), the interaction between Face Familiarity and Experiment was significant (Estimate = -.10, SE = .04, t = -2,4, $p < .05$) and the other between Face Familiarity, Experiment and Language Familiarity almost reached significance (Estimate =.12, SE = .06, t = 2,1, $p < .05$). Taken together, these analyses show that results in Experiment 2 statistically differ from those in Experiment 1.

Discussion

The second experiment was designed to determine if the results of Experiment 1 were a consequence of 1) a peculiarity of the face stimuli we used, 2) the influence of language maturation on face processing, or 3) the audiovisual dynamic stimuli used (videos instead of still pictures) in the familiarization phase. The results are more in line with the last hypothesis. In contrast with Experiment 1, 9- and 12-month-old infants in Experiment 2 seem to have learned the familiar face that had been presented with the native language. However, infants from the same age groups who had been familiarized with the face associated with the non-native language did not display evidence of recognition afterwards.

General discussion

The goal of the present study was to explore the effect of language familiarity on how infants recognize own-race faces. The first important finding is that when 9- and 12-month-old infants were familiarized with a video of a *dynamic* talking face, they did not seem to clearly recognize it later on (Experiment 1), regardless of language familiarity. As mentioned in the discussion of Experiment 1, these findings contrast with previous literature on own-race face recognition in infancy. One explanation for this pattern of results lies in the way infants distribute their visual attention when viewing dynamic talking faces. As mentioned in the discussion of Experiment 1, Lewkowicz & Hansen-Tift (2012)'s findings indicate that 8- to 12-month-olds spend a great amount of time focusing on the mouth region (rather than on the eyes region) of a talking face. It is thus possible that in Experiment 1, 9- and 12-month-olds spend a great amount of time focusing on the mouth region of the speaker. This mouth attraction may have prevented them from robustly encoding and remembering the whole face identity, since they would have allocated insufficient attention to other crucial facial features for face recognition (i.e., the eyes region). Following this rationale, one might consider studies exploring infants' eye gazes to when presented with dynamic and native language speaker. For instance, Hillairet de Boisferon, Tift, Minar & Lewkowicz (2015) found that in line with our present interpretation, 10-month-old infants looked less at the mouth region of a native speaker in an asynchronous condition– rather than in a synchronous condition. Additionally, another eye-tracking research by Xiao, Quinn, Liu, Ge, Pascalis & Lee (2015) showed that 9-month-old infants would spend more time looking at the eyes rather than at the mouth region of a static own-race face. Conversely, they shifted their pattern of attention favoring the mouth over the eyes region when looking at videos of dynamic silent faces. It is important to note that this interpretation remains completely speculative, as we did not measure infants' eye-gaze during the study. Further research should thus explore whether and how different attentional strategies to static and dynamic (talking vs. non-talking) faces impact face recognition.

Another compatible interpretation of the data is that visual still faces are easier to process than dynamic videos, facilitating the task in the younger infants. The ability of 9-month-old infants to recognize a face when it speaks their native language could be explained by a lesser cognitive load when processing a native sound, resulting in a better processing of the visual stimulus. When presented with a still image, the processing would be even easier than when presented with a dynamic succession of images (a video). To explore this hypothesis, we compared the amount of time infants spent looking at the face of the speaker during the familiarization phase between Experiment 1 and Experiment 2. We used a mixed-effects model on the proportion of total Looking time for the familiarization phase preference scores during the test phase, using Language Familiarity, Age and Experiment as fixed factors. The effect of Experiment was significant (Estimate = .12, SE = .03, t = 4,2, $p < .001$), indicating that infants who were familiarized to the Video of the talking face in Experiment 1 spent more time looking at the face than infants who were familiarized to the Static face

in Experiment 2. No other effect nor interaction was significant (all $p > .48$). This increased familiarization time could potentially reflect a greater cognitive load in Experiment 1, because infants needed more time to process the dynamic face rather than the static face of Experiment 2. While one has to remain cautious about this post-hoc interpretation, as a great cognitive load could also lead to decrease looking times, we believe that further research is needed to explore whether longer familiarization phases could promote how infants recognize more ecological dynamic faces.

Second, our results suggest that at 9 and 12 months of age, hearing a non-familiar language, as opposed to a familiar one, somewhat reduces infants' ability to learn a still face of their own-race that is associated with that language (Experiment 2). This result, brings a new perspective to the literature on infant cognition. Indeed, previous studies have shown that 9-month-old infants are able to recognize own-race faces even after a short presentation time (Pascalis et al., 2002). The present study suggests that this recognition ability can be modulated by language familiarity: at 9 and 12 months of age, hearing a non-native language somewhat reduces the efficiency of infants' own-race face recognition. Importantly, it cannot be explained by a simple a lack of exposure, as the looking time spent on the face during the familiarization phase did not differ between non-native and native language conditions (see the analysis on the looking times of the familiarization phase presented in the previous paragraph).

These results are broadly in line with adult data, which show that face processing is modulated by the context in which the face is learned (Baus et al., 2017). In this study adult participants were presented with faces while hearing a native language (i.e., Spanish) or a non-native second language (i.e., English). In a subsequent test, participants were better at recognizing the faces that had been paired with the native language. Nonetheless, adults in the non-native language condition still performed above chance. This indicates that listening to a language they were somewhat familiar with but did not fully master only partially impaired face recognition. These last results contrast with the present infant data. Indeed, the present results suggest that face recognition is prevented in the non-native language condition. This could be due to the fact that, as opposed to Baus et al., 2017, we used a language that French-learning infants had never been exposed to (German). Further research needs to be done to study whether, in infancy, the degree of familiarity with a given language gradually influences how faces are encoded or whether it is an all-or-none type of phenomenon.

Regarding the cognitive mechanisms that could account for the present results, one possible interpretation is that hearing a completely unknown language tampers with – at least partially- own-race faces recognition processes . From a social point of view, it could be that infants categorize faces presented with a unknown language as out-group, which would trigger, as opposed to faces presented with a native language, a broader encoding of the face in memory, limiting its later recognition. Alternatively, social categorization as in-group would enhance infants' attention and memory processes to encode fine-grained representations of the faces that speak their native language (see

Kinzler et al., 2007; 2009; Pietraszewski and Schwartz, 2014, for more discussion on the topic). A second and perhaps non-mutually exclusive hypothesis could be that another type of learning happens in that condition, derailing -at least temporarily- infants' ability to encode own-race faces. Hearing a novel foreign language could orient infants' attention away from face identity processes and lead them to solely focus on the novel auditory stream, at least partially tampering with visual face encoding and its subsequent recognition (see Wickens, 2008; Pickel and Staller, 2012 for such a hypothesis in adults). This interpretation fits well with few theoretical frameworks suggesting that the development of language and attention skills constrains visual perceptual narrowing for faces (see Markant & Scott, 2018, for a review).

It is however, important to note that the data provided by the present study could not be face specific. It is indeed possible that infants in Experiment 2 that the apparent association between faces and language might be a general outcome of conditions in which infants need to process a great deal of novel information (in the Non-Native language condition) versus less novelty (in the Native language condition). Further research is needed to investigate whether infants would see their recognition of non-social random objects influenced by the presence of native familiar versus non-native unfamiliar language, to see if the association is specific to the social interaction of faces and language.

From a more general perspective, this study also shows that auditory linguistic information as well as visual cues are at play when identifying conspecifics, as early as 9 months of age. At a neural level, this means that at least from this age mechanisms responsible for online face and language processing interact with each other. Further research should address the role of specific language and/or face experience where infants grow in an environment where bilingualism and/or multi-ethnic faces are the norm.

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