Bilingual and Monolingual Infants' Attention Capture and Maintenance to Faces

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Abstract

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline. Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines. One sentence clearly stating the **general problem** being addressed by this particular study. One sentence summarizing the main result (with the words "**here we show**" or their equivalent). Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge. One or two sentences to put the results into a more **general context**. Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

Keywords: keywords

Word count: X

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Introduction

Face preference in infancy is important for gathering social information. Infants preferentially orient to face-like stimuli in the first days of life (Farroni et al., 2005; Johnson, 1990). Indeed, the "face pop-out" effect, infants' preference for faces over objects, persists throughout development (Frank, Vul, & Johnson, 2009; Gliga, Elsabbagh, Andravizou, & Johnson, 2009). The original "face pop-out" task was designed by Gliga et al. (2009), who showed that 6-month-olds make a higher number of and longer duration of fixations to faces over competing stimuli (also see Di Giorgio, Turati, Altoè, & Simion, 2012). Elsabbagh et al. (2013) replicate this effect, revealing significant face over object preference in 7- to 14-month-olds. Babies were presented with static arrays of a face and four non-social stimuli, including a "noise" stimulus created from the same face within the array (Elsabbagh et al., 2013). The proportion of trials with infants' first looks to the human face was significantly above chance at both 7-month and 14-month time-points (Elsabbagh et al., 2013). Using the same face pop-out task, Mercure et al. (2018) show that bilingual infants are faster than monolinguals at orienting to faces. This finding suggests that bilingual infants may be more sensitive than monolingual infants to face versus non-face stimuli. Put another way, bilingual infants' may show a stronger effect of "attention capture" to faces than do monolingual infants. In the same study, bilingual infants directed more fixations to the face over the non-face stimuli than do monolingual infants (Mercure et al., 2018). Bilingual infants may show stronger "attention maintenance" (i.e., more fixations) to face over non-face stimuli compared to monolingual infants. It could be that bilinguals' increase in attention capture and maintenance to faces is because bilingual infants rely on facial cues, such as lip patterns, to disambiguate their two native languages. This would lead bilingual infants to orient faster to faces and to scan them more extensively than do monolingual infants, even in the case of still faces, in anticipation of useful mouth movements. This study investigates whether reported bilingual effects for attention capture and maintenance to faces (Mercure et al., 2018) persist past the age of 10 months. We predict that attention capture (i.e., total face fixation latency) and attention maintence (i.e., total face fixation count) will differ by language group (monolingual vs bilingual). Specifically, we predict that bilingual infants will demonstrate faster fixation latency, calculated as the time from trial onset to first fixation to the face AOI. We also predict that bilingual infants will show significantly higher attention maintenance to the face than monolingual infants. Both predictions are based on Mercure et al. (2018), who show this pattern of effects among younger monolingual and bilingual infants (7 to 10 months of age). We expect to see a main effect of stimulus category on both fixation latency and fixation count. All babies regardless of language experience should orient more quickly to faces than to objects and return to faces more frequently than to objects. My main hypothesis predicts a Stimulus x Group interaction for both fixation latency and fixation count. For face fixation latency, we expect this significant interaction to be driven by bilingual infants' shorter face AOI latencies than monolinguals. This result would support the notion that bilingual infants orient faster to faces (over objects) compared to monolingual infants. For face fixation count, we predict the significant interaction to be driven by bilingual infants' higher number of visits to the face AOI than monolingual infants. Such a pattern would support the hypothesis that bilingual infants maintain more attention to faces (over objects) compared to monolingual infants.

Methods

Participants

A total of 18 monolingual (9 girls, mean age = 516.39 days, 16.98 months) and 18 bilingual infants (4 girls, mean age = 507 days, 16.67 months) between 15 and 18 months old contributed data. Monolingual infants were exposed to English (> 95% exposure) and bilingual infants were exposed to English and one non-English language (> 20% exposure).

The combination of languages varied between infants. Exposure to each language was estimated with an English adaptation (Byers-Heinlein, 2009) of the language exposure questionnaire designed by Bosch and Sebastian-Gallés (1997). Age did not differ between group ($F(1, 34) = 0.80$, $MSE = 991.36$, $p = .377$, $\hat{\eta}^2_G = .023$). A further 13 participated in the study but were excluded due to fussiness. Infants' parents were contacted from the Birkbeck Babylab database of primarily London-based volunteers recruited from advertisements and mum-and-baby groups, parenting websites, and publications. Parents reported no hearing problems or vision problems, and no serious mental or physical conditions. Travel expenses were reimbursed, and a young scientist t-shirt and certificate of participation were offered to families. This study was carried out in accordance with the UCL and Birkbeck Research Ethics Committees and conforms with the General Data Protection Regulation (2018). All parents gave written informed consent prior to participation.

Procedure

Infants participated in a large study on language experiences which began with five eye-tracking tasks: attention to faces (reported here), as well as tasks for foreign language perception, visual attention, dynamic face processing, and cognitive control. After eye-tracking, participants completed behavioural measures (Mullen Scales of Early Learning and videoed parent-child interaction) and language questionnaires. The protocol required between 1.5 - 2.5 hours per infant including breaks. Only data from the "attention to faces" task are reported in the present article. During the "attention to faces" task, infants sat on their parent's lap in a dimly lit room about 60 cm away from a Tobii TX300 eye-tracker. Infant gaze position was calibrated with colourful animations using a five-point routine. Each infant's gaze and behaviour was monitored throughout the study via webcam. The experimenter occasionally shook a rattle behind the screen to attract the infant's attention.

Stimuli

Eight different slides were presented for 10s each (Elsabbagh et al., 2013; Gliga et al., 2009; Mercure et al., 2018).

Figure 1. Example of a stimulus silde with five object categories.

In each slide, five colour images belonging to five object categories: faces, phase-scrambled ("noise") faces, birds, cars, and phones (see Figure 1). Each slide were be presented once and position of stimulus categories were randomised. Images were all of comparable size and presented at an equal distance from the centre of the screen. Differences in colour and luminosity were minimised. Faces all had a direct gaze and happy expression. There were 5 female faces and 3 male faces of different ethnicities. Scrambled faces were created from each face by randomising the phase spectra while maintaining the original outer face contour, with the amplitude and colour spectra remaining constant. For more details about the stimuli, see Elsabbagh et al. (2013). These "attention to faces" slides were interleaved with blocks from other studies.

Analysis Pipeline

We used R (Version 3.6.2; R Core Team, 2019) and the R-packages *broom* (Version 0.5.3.9000; Robinson & Hayes, 2019), *coda* (Version 0.19.3; Plummer, Best, Cowles, & Vines, 2006), *cowplot* (Version 1.0.0; Wilke, 2019), *dplyr* (Version 0.8.4; Wickham et al., 2019), *e1071* (Version 1.7.3; Meyer, Dimitriadou, Hornik, Weingessel, & Leisch, 2019), *extrafont* (Version 0.17; Winston Chang, 2014), *forcats* (Version 0.4.0; Wickham, 2019a), *ggplot2* (Version 3.2.1; Wickham, 2016), *ggpubr* (Version 0.2.4; Kassambara, 2019), *gridExtra* (Version 2.3; Auguie, 2017), *kableExtra* (Version 1.1.0; Zhu, 2019), *knitr* (Version 1.28; Xie, 2015), *lme4* (Version 1.1.21; Bates, Mächler, Bolker, & Walker, 2015), *lmerTest* (Version 3.1.1; Kuznetsova, Brockhoff, & Christensen, 2017), *magrittr* (Version 1.5; Bache & Wickham, 2014), *Matrix* (Version 1.2.18; Bates & Maechler, 2019), *MCMCvis* (Version 0.13.5; Youngflesh, 2018), *naniar* (Version 0.4.2; Tierney, Cook, McBain, & Fay, 2019), *papaja* (Version 0.1.0.9942; Aust & Barth, 2018), *plotly* (Version 4.9.1; Sievert, 2018), *praise* (Version 1.0.0; Csardi & Sorhus, 2015), *purrr* (Version 0.3.3; Henry & Wickham, 2019), *readr* (Version 1.3.1; Wickham, Hester, & Francois, 2018), *readxl* (Version 1.3.1; Wickham & Bryan, 2019), *reshape2* (Version 1.4.3; Wickham, 2007), *showtext* (Version 0.7.1; Qiu & See file AUTHORS for details., 2020, 2017), *showtextdb* (Version 2.0; Qiu & See file AUTHORS for details., 2017), *stringr* (Version 1.4.0; Wickham, 2019b), *sysfonts* (Version 0.8; Qiu & See file AUTHORS for details., 2018), *tibble* (Version 2.1.3; Müller & Wickham, 2019), *tidyr* (Version 1.0.2; Wickham & Henry, 2019), and *tidyverse* (Version 1.3.0; Wickham, 2017) for all our analyses. Simulated data, pre-processing scripts, and the pre-registered analysis script can be found on the GitHub repository (Mousley, 2019).

Data pre-processing. We excluded trials where participants looked at the pre-defined AOIs for less than one cumulative second. Participants were included for analyses if they completed at least five valid trials (Mercure et al., 2018). These criteria are identical to teh ones used by Elsabbagh et al. (2013) and Mercure et al. (2018). Five AOIs corresponding to the five stimulus categoires (i.e., faces, scrambled faces, birds, phones, and cars) were defined in MATLAB. After excluding trials and participants according to the exclusion criteria, fixation latency and fixation count were averaged across all participants' valid trials to normalise for number of completed trials. Fixation latency was defined as the time difference between the trial onset and the first saccade to the face AOI. Fixation count was defined as the number of fixations within each area of interest. Total fixation duration was defined as the total time spent fixating within each area of interest during the trial period of 10s. As we did not have any specific hypotheses regarding group differences in attention to birds, cars, phones, or scrambled faces, these categories were averaged to create a "non-face" stimulus category. However, any significant face vs non-face effect was followed by planned comparisons for individual contrasts between the face and each object AOI to clarify the stability of the effect across control conditions. For further details, see "Analysis_Study2" (Mousley, 2019).

Results

Fixation Latency

The latency between the beginning of each trial and the beginning of the first fixation to face and non-face stimuli was analysed with a 2 (stim: face vs non-face) x 2 (group: monolingual x bilingual) ANOVA. There was a significant effect of stimulus category ($F(1, 68) = 49.59$, $MSE = 0.82$, $p < .001$), a trend toward a significant effect of group ($F(1, 68) = 2.73$, $MSE = 0.82$, $p = .103$), and a significant interaction of variable x group ($F(1, 68) = 10.83$, $MSE = 0.82$, $p = .002$) (see Figure 2).

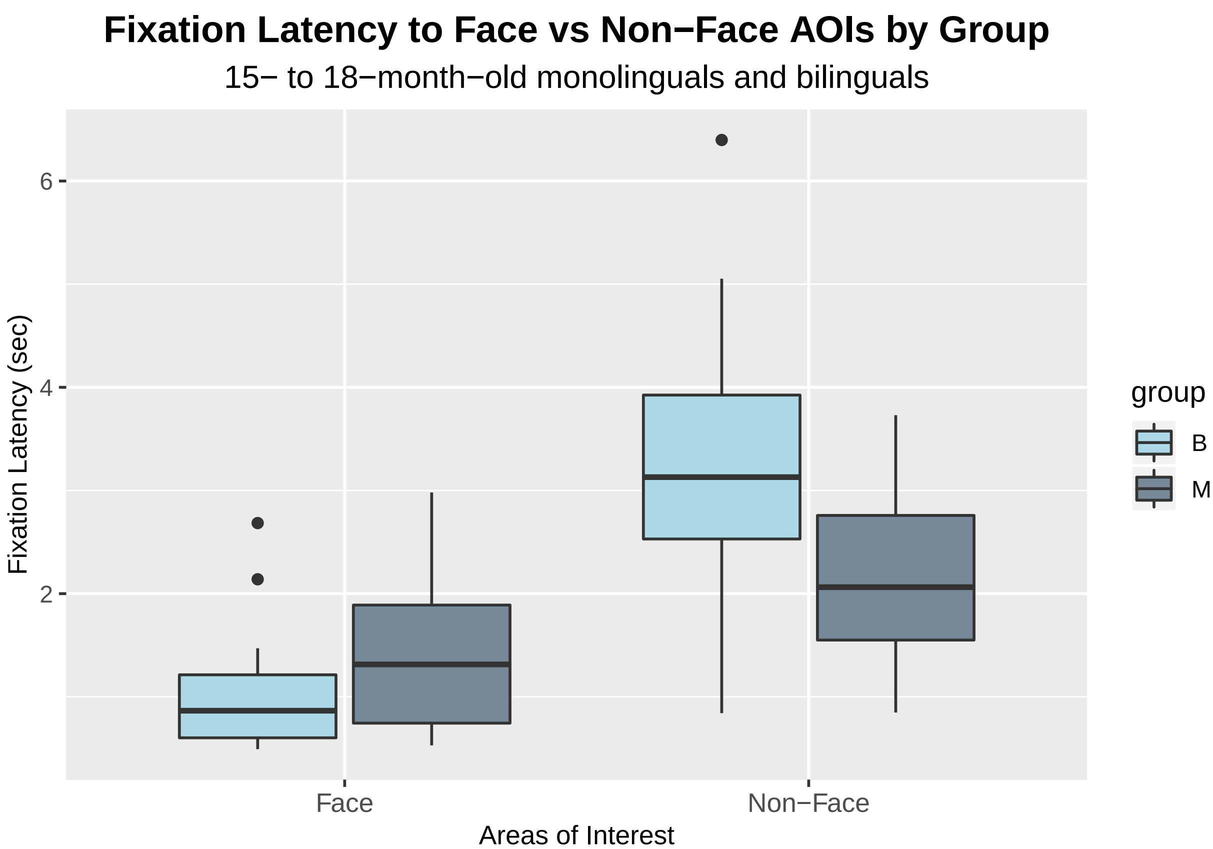

Figure 2. Fixation latency to face vs non-face AOIs by group.

Planned latency comparisons of face AOI to each object AOI revealed highly significant effects: car ($t(54.59) = -6.52$, $p < .001$), phone ($t(57.59) = -8.99$, $p < .001$), scrambled face ($t(67.79) = -6.66$, $p < .001$), and bird ($t(59.12) = -5.36$, $p < .001$) (see Figure 3).

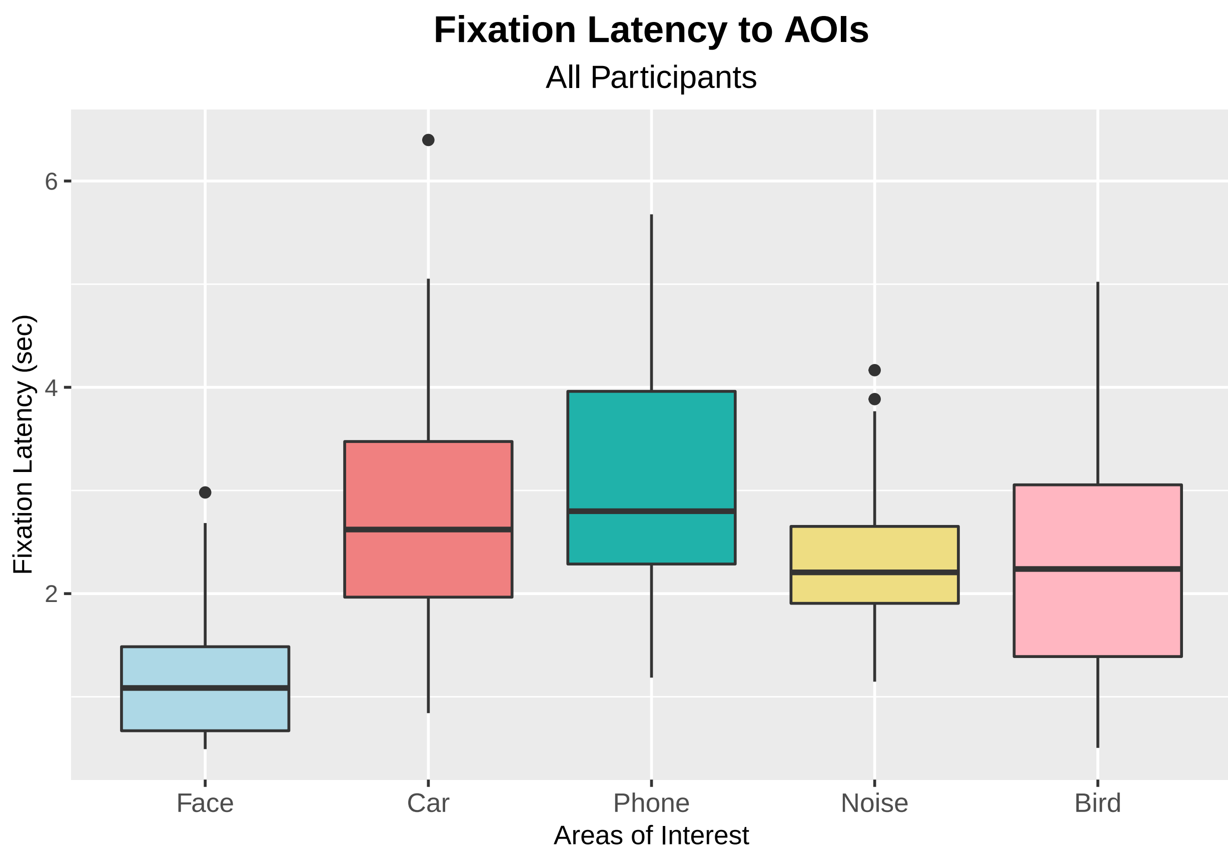

Figure 3. Fixation Latency to Each AOI.

Fixation Count

The number of fixations that infants directed to faces and non-faces was analysed in a 2 (stimulus: face vs non-face) x 2 (group: monolingual x bilingual) ANOVA. A significant effect of stimulus was found [$F(1, 68) = 16.44$, $MSE = 0.94$, $p < .001$, $\hat{\eta}^2_G = .195$], as was a trend towards an effect of group [$F(1, 68) = 2.73$, $MSE = 0.94$, $p = .103$, $\hat{\eta}^2_G = .039$] (see Figure 4). The interaction of group x variable was non-significant. Planned latency comparisons of face AOI to each object AOI revealed highly significant effects: car ($t(66.26) = 4.03$, $p < .001$), phone ($t(58.82) = 9.49$, $p < .001$), scrambled face ($t(62.58) = 6.89$, $p < .001$), and bird ($t(69.45) = 4.35$, $p < .001$) (see Figure 5).

Figure 4. Fixation Count to Face vs Non-Face Stimuli.

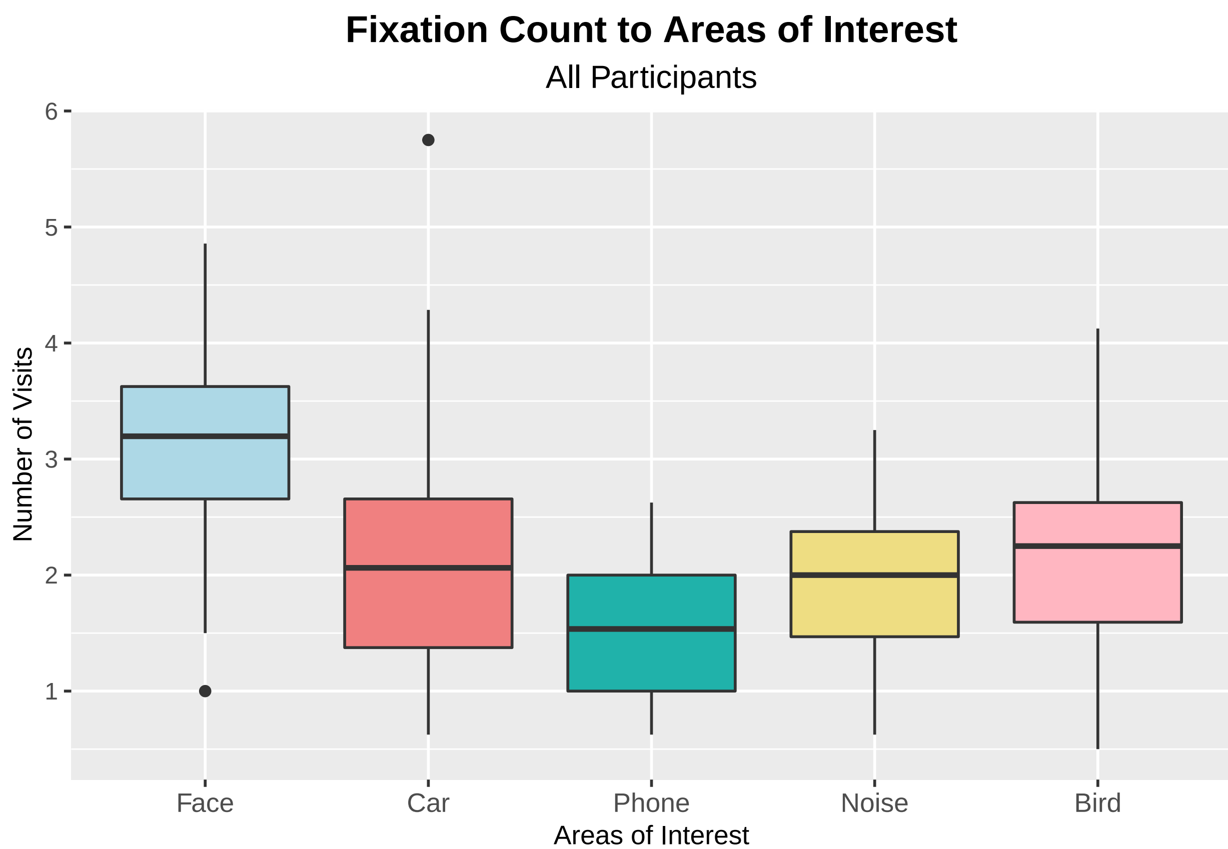

Figure 5. Fixation Count to All AOIs.

Fixation Duration

The total amount of time fixating to faces and non-faces over the whole trial was analysed in a 2 (stimulus: face vs non-face) x 2 (group: monolingual x bilingual) ANOVA. A significant effect of stimulus was found ($F(1, 68) = 3.93$, $MSE = 1.69$, $p = .051$, $\hat{\eta}^2_G = .055$), but no effect of group or interaction of variable x group (see Figure 6). Infants looked at faces for longer than any of the other object categories. Planned comparisons of face AOI to each object AOI revealed highly significant effects: phone ($t(43.35) = 7.60$, $p < .001$), car ($t(68.45) = 2.01$, $p = .049$), scrambled face ($t(49.62) = 6.47$, $p < .001$), and bird ($t(68.82) = 3.27$, $p = .002$) (see Figure 7).

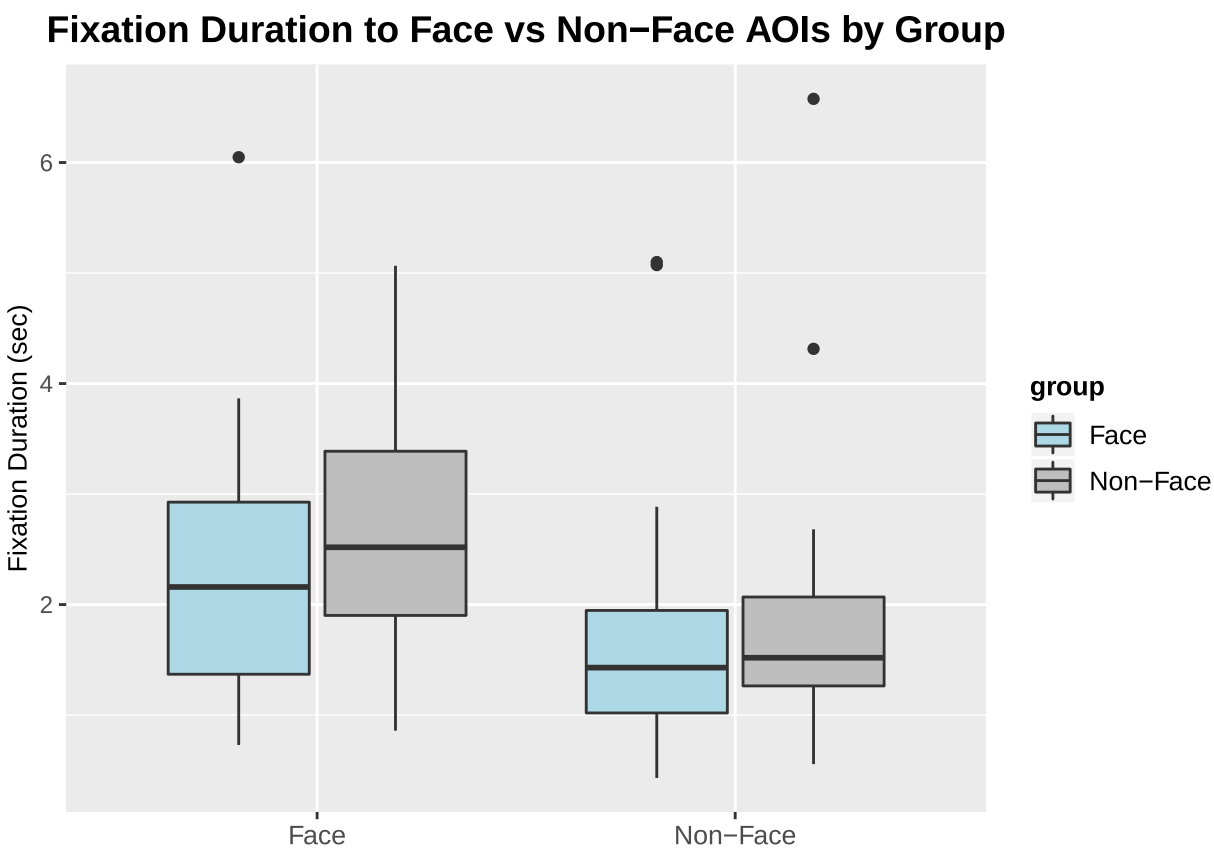

Figure 6. Fixation Duration to Face vs Non-Face AOIs by Group.

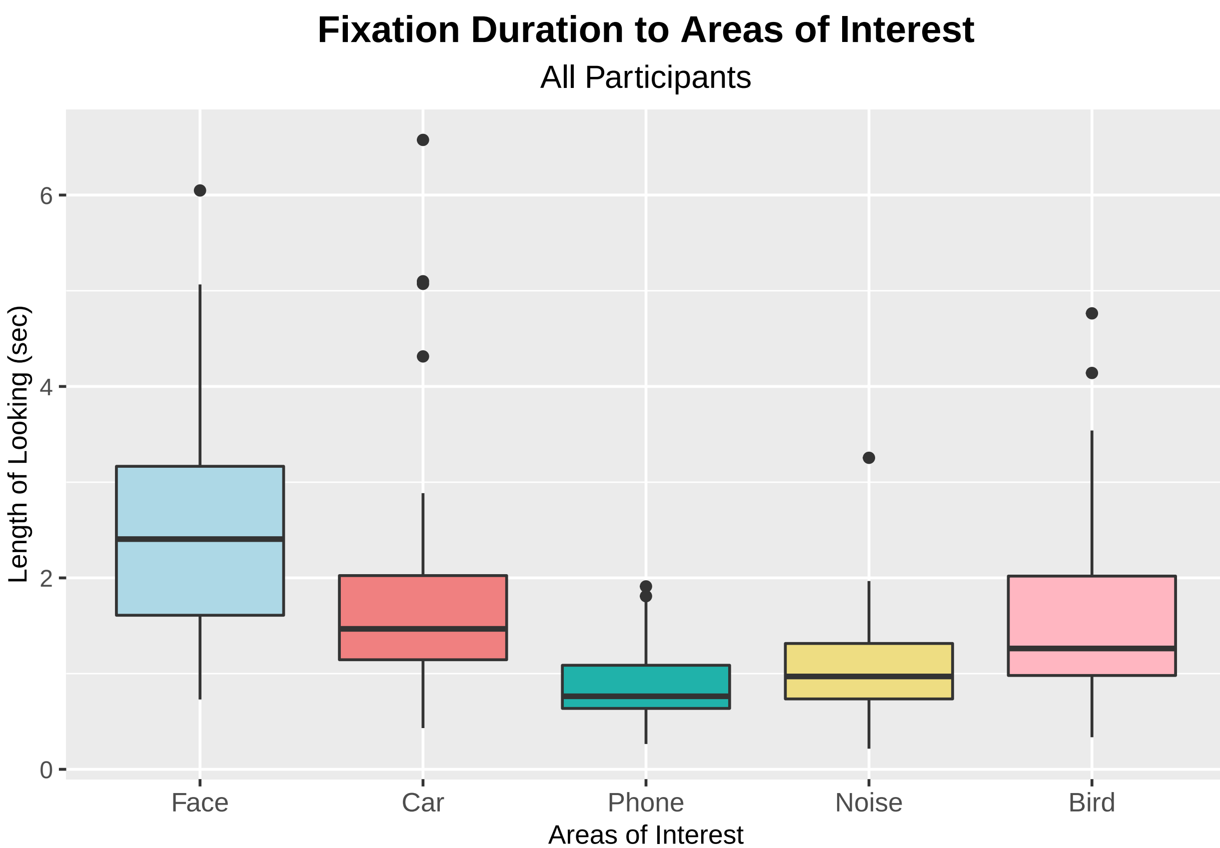

Figure 7. Fixation Duration to Areas of Interest.

Face Orientation Measure

A measure of "face orientation" was calculated with the following formula: non-face latency - face latency / non-face latency + face latency. A one-way ANOVA (group: monolingual x bilingual) was then conducted on face orientation measure (FOM). The result revealed a significant main effect of group [$F(1, 34) = 7.09$, $MSE = 0.08$, $p = .012$, $\hat{\eta}^2_G = .172$]. **Add explanation of adding age as a continuous factor once EM replies to email.

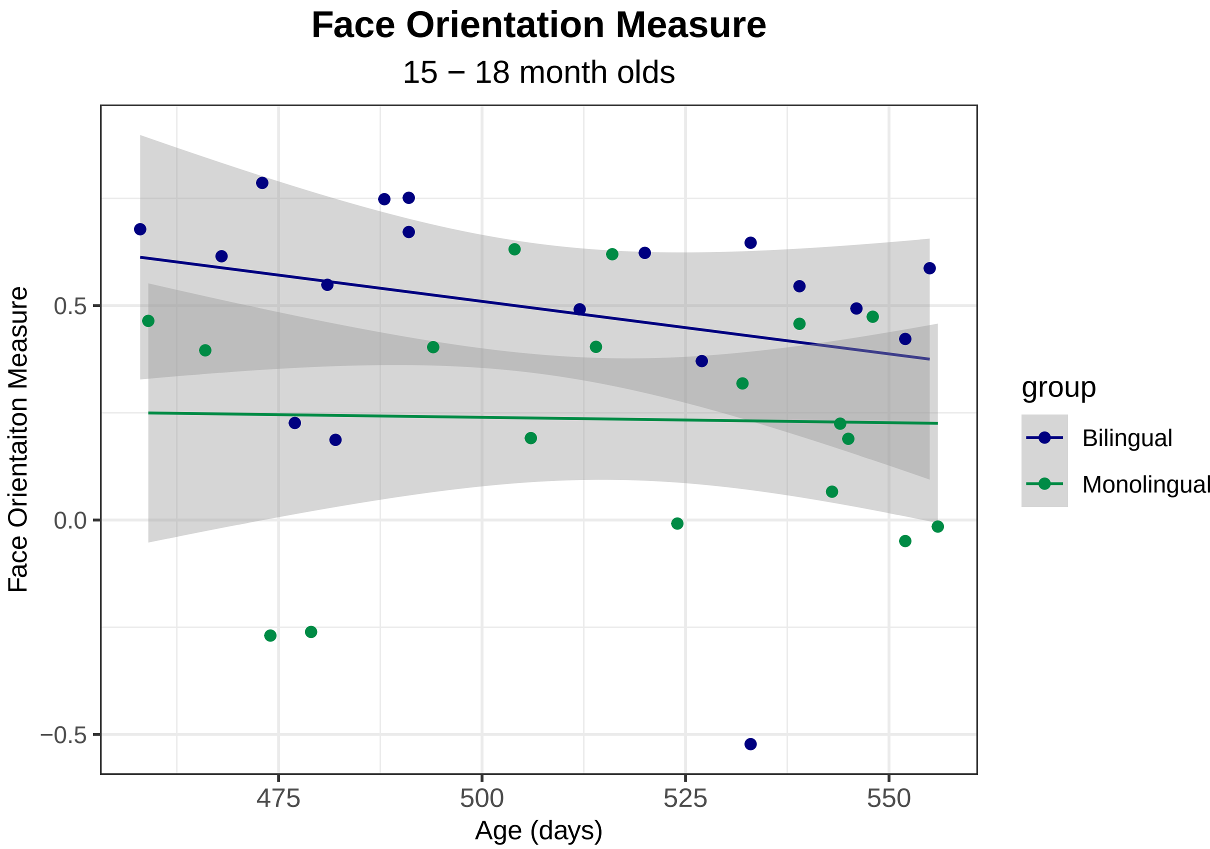

Figure 8. Face Orientation Measure by Group.

** Note to Evelyne: I can include FOM analyses on your face pop-out if you want, but I would need the data.

Discussion

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