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Neural Correlates of Infant Attention During Initial Exposure to Own- and Other-Race Faces

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Past research has shown that infants raised in a racially homogenous environment demonstrate an advantage for processing own-race faces at the individual level in comparison to other-race faces (Lewkowicz, 2014; Mauer & Werker, 2014; Quinn, Lee, & Pascalis, 2018). This advantage for processing own-race faces develops across infancy and has been referred to as the own-race bias (e.g., Anzures, Quinn, Pascalis, Slater, Tanaka, & Lee, 2013). The processes that lead to development of the own-race bias are complex and not fully understood. Recent work suggests that by 10 months of age, differences in own- and other-race face processing may be related to attentional processes (Roth & Reynolds, 2022). The current study utilized event-related potentials (ERP) to examine neural correlates of infant attention during initial exposure to own- or other-race faces. Level of attentional engagement was also compared across early to late trials to determine whether infants demonstrated increased or decreased attention to a face with repeated exposure depending on race. Twenty-three infants were tested at 10 months of age. Only infants raised in a racially homogenous environment (based on parental report) were included in the dataset. Participants were familiarized with 20 repeated 1000 ms presentations of a single exemplar of either an own-race face ($n = 13$) or an other-race face ($n = 10$). Following familiarization, presentations of the familiar face were interspersed with presentations of novel faces until the infant was off task. EEG was recorded throughout testing using the EGI Geodesic EEG System (GES 400) 128-channel system with a 1000 Hz sampling rate. An offline bandpass filter was applied from 0.10 to 30.00 Hz. The analysis of the EEG focused on the Nc ERP component associated with level of attentional engagement in infancy (Reynolds & Richards, 2005). Mean amplitude of the Nc component was analyzed at midline-frontal electrodes from 345-650 ms following stimulus onset using a 200 ms prestimulus baseline period. Participants contributed a minimum of 8 artifact-free trials per condition to the ERP averages. Infants familiarized with an other-race face demonstrated greater amplitude Nc in comparison to infants familiarized

with an own-race face ($F(1,21) = 4.65$, $p = 0.037$, $\eta_p^2 = .191$). Interestingly, infants showed increased Nc amplitude to other-race faces following familiarization and decreased Nc amplitude to own-race faces following familiarization. These findings indicate that 10-month-old infants demonstrate greater attentional engagement during initial exposure to other-race faces than during initial exposure to own-race faces. This greater amplitude Nc could reflect a novelty effect for other-race faces for infants raised in racially homogeneous environments. The increase in Nc amplitude following familiarization with an other-race face may be indicative of continued attentional engagement due to incomplete processing of the face. Given the potential for early developing perceptual biases to contribute to subsequent development of social biases and prejudice (Xiao et al., 2018, 2019), these findings provide important insight into potential mechanisms associated with the own-race bias in face processing in infancy.

Introduction

Perceptual narrowing is a developmental phenomenon that results from experience in daily life. Perceptual narrowing tunes an infant's initial sensitivity to a broad range of stimuli to a more narrow and specialized focus on stimuli commonly encountered in the native environment. Facial processing is affected by perceptual narrowing during the early stages of development. For example, from 6–9 months of age, infants maintain perceptual sensitivity for own-species faces and lose sensitivity for other-species faces (Pascalis et al., 2002).

A similar process occurs in processing own- and other-race faces for infants raised in a racially homogenous environment, but not in infants who experience regular exposure to multiple race faces (Bar-Haim et al., 2006). Daily experience in a racially homogenous environment leads to an increased sensitivity to own-race faces and a decreased sensitivity to other-race faces, which results in an advantage for processing own-race faces at an individual level in comparison to other-race faces by 9 months of age (Kelly et al., 2005, 2007; Mauer & Werker, 2014; Quinn, Lee, & Pascalis, 2018). This advantage for processing own-race faces has been referred to as the own-race advantage.

1.1 Attentional biases in development of perceptual narrowing

Attention may serve as a mechanism behind the development of processing advantages for stimuli regularly encountered in the native environment, such as own-race faces (Reynolds & Roth, 2018; Simpson et al., 2014). Biases in attention create a likeliness to direct and maintain attention to certain stimuli over others or to certain properties of a stimulus over other properties. It has been proposed that learned attention may serve as a mechanism behind perceptual narrowing and the development of the own-race advantage (Simpson, Jakobsen, Fragaszy, Okada, & Frick, 2014).

1.2 Neural correlates of infant attention

This study analyzes event-related potentials (ERP), which are voltage oscillations in scalp-recorded electroencephalogram (EEG) to a stimulus or event. ERP is a non-invasive measurement of brain activity via electrical current on the scalp. The Negative central (Nc) ERP component provides an index of infant attention with greater Nc amplitude associated with greater attentional engagement (Courchese et al., 1981; Reynolds & Richards, 2005; Richards, 2003). The Nc peaks around 350 to 750 milliseconds after stimulus onset over frontal and midline electrodes. Recent work has suggested that by 10 months of age, differences in own- and other-race and own- and other-species face processing may be related to attentional processes (Dixon et al., 2019; Roth & Reynolds, 2022). These studies indicate that experience modulates the process of developing attentional biases in early infancy, which subsequently affect the development of sensitivity to the types of faces regularly encountered in daily life. Frequent exposure to a stimulus may lead to an attentional preference that fosters enhanced processing of familiar stimuli commonly encountered in daily life at finer levels of discrimination than unfamiliar stimuli (i.e., processing familiar faces within categories at the individual level as opposed to only processing unfamiliar faces at a categorical level). More efficient processing may require less attention, which could result in reduced amplitude Nc. Individuation allows the infant to recognize and distinguish unique features of an individual, whereas categorization groups individuals based on generalized characteristics, ignoring specific differences.

1.3 Current study

This study compared infant attentional engagement to own- and other-race faces during initial exposure (i.e., familiarization) and across early to late trials to determine whether infants demonstrated greater attention to own- or other-race faces and whether or not their attention to a face changed with repeated exposure based on race. This study utilized the Nc ERP component as a neural correlate of attention to determine if 10-month-old infants demonstrate differences in attention based on whether they are tested with an own- or other-race face. By 10 months of age, infants typically have had extensive exposure to own-race faces and therefore have likely begun to develop expertise in processing these familiar types of faces; however, infants have typically had minimal exposure to other-race faces and therefore should be inexperienced and less efficient at processing these unfamiliar types of faces. Due to the relative novelty of other-race faces and increased processing demands required for processing unfamiliar stimuli, it was predicted that 10-month-old infants would demonstrate a greater amplitude (i.e., more negative) Nc indicative of greater attention to other-race faces than own-race faces during the familiarization procedure. We were also interested in whether infants' attention increased or decreased with repeated exposure to either an own- or other-race face. It was predicted that infants tested with own-race faces would show a reduction in Nc amplitude from early familiarization trials to later test trials indicative of complete processing of the own-race face during familiarization. In contrast, for the group tested with other-race faces, it was predicted that Nc amplitude would increase from early familiarization trials to later test trials, which would reflect incomplete processing of the other-race face during familiarization. This would lead the infants in this group to continue to focus deeper levels of attention on the other-race face during testing trials.

Methods

2.1 Participants

All procedures involved in this study followed a protocol approved by the Institutional Review Board of the University of Tennessee, Knoxville. The final dataset included twenty-three 10-month-old infants. Participants were randomly assigned to one of the two familiarization conditions: own-race ($N = 10$) or other-race ($N = 13$). Participants were recruited without regard to race, ethnicity, or gender, but a majority infants were expected to be White due to the demographics of the local population. All infants were within 3 weeks of their 10-month birthdate, were born full-term without any major complications during pregnancy or birth and had no known visual difficulties or developmental issues.

2.2 Apparatus

Testing took place in a quiet, dark room. Participants were placed about 55 cm away from the monitor. Attention to the screen was monitored via video recording. The camera footage was synchronized with EEG data. The experimental face stimuli were displayed onscreen and synchronized to the stimulus events on the EEG and video data.

2.3. Visual stimuli

Figure. 1. Own (White) and other (Black) race facial stimuli

Stimuli for this experiment were taken from The Chicago Face Database. Neutral expressions and middle-aged women were chosen for this study to avoid gender interaction effects on perception of race (Tham et al., 2015; Tham et al., 2018) and to maximize infant attention, since infants better maintain attention to female faces (e.g., Quinn et al., 2002; Reynolds& Roth, 2018). A total of 40 faces (20 White and 20 Black) were included in the final dataset.

All the infants included in the final dataset were White, thus the "own-race" familiarization condition in the experiment repeatedly showed a picture of a White woman as the familiar stimulus, and the "other-race" familiarization condition showed a picture of a Black woman as the familiar stimulus.

2.4 Procedure

After informed consent, caregivers completed a demographic survey which consisted of family background and demographic information, along with the race of the infant, and the race, gender, and age of any other people in the household or commonly interacting with the infant. The majority of infant participants tested for this study had experienced nearly exclusive exposure to own-race individuals unless from an interracial family. Infants in a self-reported interracial family were excluded from the analysis.

The infant was seated on their caregiver's lap approximately 55 cm away from the monitor and an experimenter applied the EGI sensor net to their head. The familiarization (early) phase consisted of 20 repeated 1000 ms presentations of a single face. This resulted in 20 seconds total familiarization time for both familiarization conditions, which is based on previous studies that indicated this is adequate for infants to show a novelty preference at this age (Rose et al., 1982). During the familiarization trial, the attention-getter stimulus was played between each face to maintain fixation. Once the infant was fixated, the face image was displayed for 1000 ms. A 200 ms blank white screen preceded each face presentation and was used as a pre-stimulus ERP baseline. A blank white screen also followed each stimulus presentation and varied randomly in duration from 1000 to 1500 milliseconds. Immediately after the 20 familiarization trials (i.e., early trials) were complete, the test trials (i.e., late trials) began. Familiar or novel own- or other-race faces were shown in pseudo-random order with equal probability of each across a block of trials. Testing continued until the infant became tired or fussy.

2.5. EEG recording and analysis

EEG data were collected through the EGI Geodesic EEG 400 (GES 400) 128-channel system. Bandpass filters were set from 0.10 to 30.00 Hz with 20k amplification and a sampling rate of 1000 Hz. The recordings were reviewed for EEG artifacts; EEG segments with more than 10% of the channels deemed bad due to artifacts were excluded. For those included, bad channels were replaced using a spherical spline interpolation (Perrin et al., 1989). After review, only participants who contributed 7 or more ERP trials per trial type for stable ERP averages were included for analysis (Reynolds & Richards, 2019).

Results

A full-factorial ANOVA was conducted to compare results across familiarization conditions. The groups were separated based on trial condition (early or late) and race (own or other). A 2x2 mixed-design ANOVA with a between-subjects factor for group (own- or other-race) and a within-subjects factor for block (early or late) was used for these analyses. Follow-up planned comparisons were run within each condition using ANOVA or paired-sample *t*-tests (two-tailed). All significant tests are reported based on an alpha level of $p < .05$.

3.1 Nc component

3.1.1 Main effect for group factor

The Nc component showed a significant main effect for the race condition, $F(1,21) = 4.65$, $p = .037$, $\eta_p^2 = 0.191$. As shown in Figure 2, there was a greater amplitude Nc for the other-race familiarization condition ($M = -5.98$ mV, $SE = 1.59$) compared to the own-race familiarization condition ($M = -0.62$ mV, $SE = 1.81$).

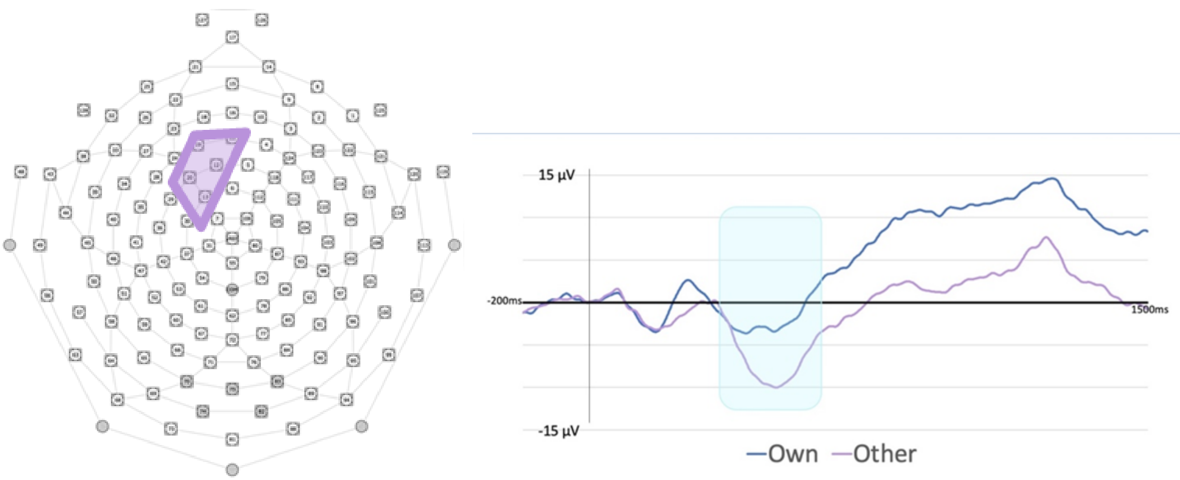

Figure 2: Nc by stimulus type at frontal-central electrodes by familiarization condition (own-race familiarization condition is represented with a blue line and other-race familiarization condition is represented with a purple line). Lines represent change in amplitude of the ERP potential from baseline (in mV*)*. The shaded box represents the time window for the analyses of the Nc component (345–650 ms).

No main effect was found for the block factor ($F(1,21) = 0.36$, $p = .555$, $\eta_p^2 = 0.017$). No differences were found between early trials (M = -2.58 mV, $SE = 1.25$) compared to the late trials ($M = -4.02$ mV, $SE = 2.06$) when collapsed across familiarization groups.

To examine the potential impact of learning on attention across early to late trials, planned comparisons were carried out analyzing change in Nc amplitude across blocks (early trials to late trials).

3.2 Own-race familiarization condition

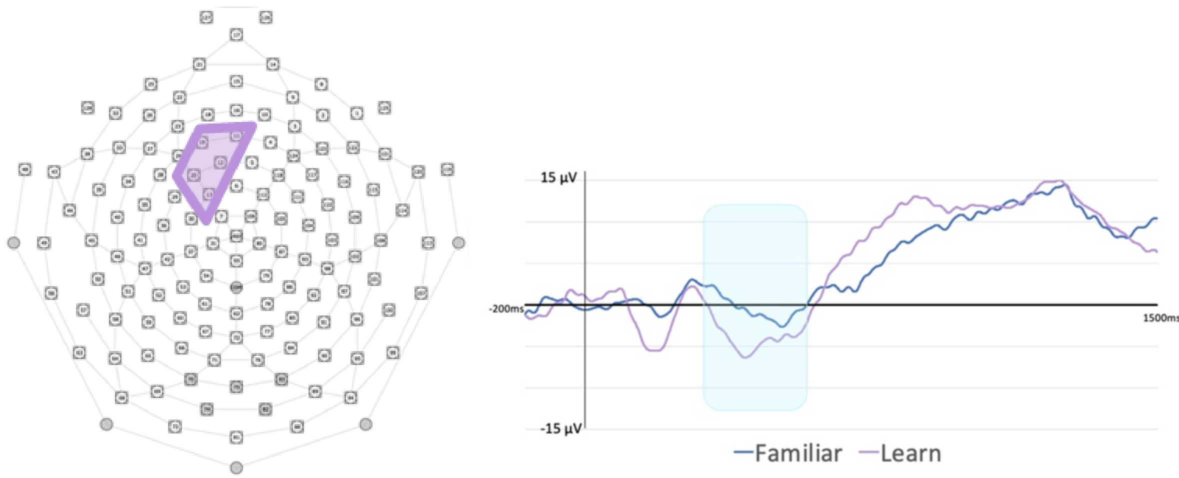

Fig.3. Nc by stimulus type at frontal-central electrodes for the own-race familiarization condition early and late trials (early/learn trials are represented with a purple line and late/familiar trials are represented with a blue line). Lines represent change in amplitude of the ERP potential from baseline (in *mV).* The shaded box represents the time window for the analyses of the Nc component (345–650 ms).

Within the own-race familiarization condition (see Figure 3), there were no differences in Nc amplitude across blocks, $t(9)$ -0.16, p = .88, for early (learning) trials (M = -0.97 *mV*, SE = 1.57) in comparison to familiar (late) trials (M = -0.27 *mV*, SE = 3.76).

3.3 Other-race familiarization condition

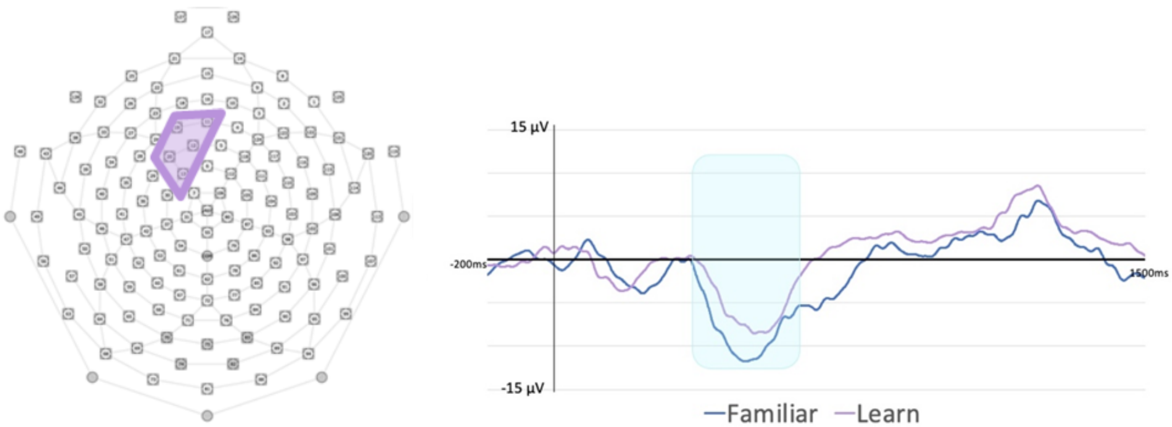

Fig.4. Nc by stimulus type at frontal-central electrodes for the other-race familiarization condition early and late trials (early/learn trials are represented with a purple line and late/familiar trials are represented with a blue line). Lines represent change in amplitude of the ERP potential from baseline (in *mV).* The shaded box represents the time window for the analyses of the Nc component (345–650 ms).

Within the other-race familiarization condition (see Figure 4), the difference in Nc amplitude across blocks approached significance, $t(12)$ 1.41, $p = .18$, for learning ($M = -4.18$ *mV*, $SE = 1.83$) in comparison to familiar trials ($M = -7.78$ *mV*, $SE = 2.17$).

Discussion

This study investigated infant attention during initial exposure to own- and other-race faces. To examine the overall attentional difference in own- and other-race facial processing, we collapsed across early and late trial types. The Nc component showed a significant main effect for the race condition; there was a greater amplitude Nc for the other-race familiarization condition compared to the own-race familiarization condition. This is consistent with our predictions and supports the hypothesis that infants would demonstrate greater attention during initial exposure to other-race faces due to novelty and lack of experience with these types of faces. Developing expertise based on regular exposure during daily life could lead infants to require less attention for adequate processing of own-race faces in comparison to other-race faces. This would explain why infants tested with other-race faces demonstrated greater amplitude Nc during familiarization in comparison to infants tested with own-race faces.

Because infants already demonstrate the own-race bias by 10 months of age, we predicted infants tested with other-race faces would show an increase in attention across early to late blocks indicative of incomplete processing of the novel face. In contrast to this, infants who were familiarized with an own-race face were predicted to show a decreased Nc amplitude in late trials compared to early trials indicative of successful processing of and reduced attention to the novel own-race face.

Although the direction of the findings was consistent with these predictions, the differences did not reach statistical significance in our analysis of the own-race group which could be due to a lack of statistical power based on the small sample size. Within the other-race familiarization condition the difference in Nc amplitude across blocks approached significance. Within own-race familiarization, the lack of differences across early to late trials may be because infants are already quite skilled in processing their own race faces, thus, not much attention is required for the familiarization process, and therefore there was little change from the early (learning) and late (familiar) trials.

4.1 Social implications of own- and other-race bias

By 9 to 10 months of age, infants may begin to individuate their own-race faces but categorize other-race faces. The categorization of other-race faces is indicative of an out-group view (Lee et al., 2017a; Lee et al., 2017b; Quinn, 2020; Quinn et al., 2016; Quinn et al., 2019) and can be linked to negative evaluations, such as implicit bias and negative attitudes (Dunham et al., 2013, Katz & Kofkin, 1997; Setoh et al., 2017). These views and the categorization of other-race faces as out-group faces may lead to prejudice later in life (Xiao et al., 2018, 2019). Understanding the development and malleability of this mechanism may be vital for combating inherent racial prejudice.

4.2 Limitations

Participation recruitment was limited due to a global pandemic (COVID-19) and time constraints, resulting in lower statistical power. This, combined with the location of the study (a majority-White population) resulted in a final dataset of only White infants. The homogeneity of the participants also meant that all other-race conditions were Black faces, and all own-race conditions were White faces. These two factors combined decrease the generalizability of these data.

Diversifying the age groups could also increase the applicability of the data. Perceptual narrowing develops across infancy. Testing other age groups or conducing a longitudinal study could provide greater insight into developmental trajectories in the development of own- and other-race face processing.

4.3 Conclusion

The current findings provide further insight into the development of the own-race bias in face processing. The results indicate that extensive experience with own-race faces in comparison to other-race faces leads to differential levels of attentional engagement during initial processing of faces. Future studies should examine how attention may contribute to further development of the own-race bias. Understanding how other-race faces are processed could help to ameliorate social prejudice later in life, as these perceptual biases have been linked to the subsequent development of social biases and prejudice (Xiao et al., 2018, 2019). Discovering the mechanisms underlying the reversal of these developments will also be vital in fighting systemic racial prejudice.

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