

# Exploring the Face Inversion Effect as an Indicator of Age Bias: The Impact of External Facial Features

Guangtong Wang (gw505@exeter.ac.uk)

Department of Psychology, Faculty of Health & Life Sciences,  
University of Exeter, UK

Ciro Civile (c.civile@exeter.ac.uk)

Department of Psychology, Faculty of Health & Life Sciences,  
University of Exeter, UK

## Abstract

We report here two behavioural experiments that investigated the Own Age Bias (OAB), better recognition performance of own-age vs. other-age faces, measured by the Face Inversion Effect (FIE). Both experiments employed an old/new recognition task where upright and inverted own (young adults) and other (older adults) were presented intermixed. Experiment 1 ( $n=48$ ), used real-life faces, and revealed a robust OAB, where a significantly larger FIE (higher recognition for upright vs. inverted faces) was found for own vs. other age faces due to a reduced performance for upright other age faces. Experiment 2 ( $n=48$ ) used standardised faces and revealed no effect of OAB, and no difference between upright own vs. other age faces. We interpret our results in the context of the perceptual learning and faces recognition literature.

**Keywords:** Face Recognition; External Facial Features, Face Inversion Effect; Perceptual Learning

## Introduction

Numerous studies in the face recognition literature have demonstrated that individuals exhibit enhanced recognition for faces within their own age group compared to those from different age groups, a phenomenon known as the own age bias (OAB) (see Rhodes & Anastasi, 2012; Wiese et al., 2013, for comprehensive reviews). For instance, in a seminal study by Fulton and Bartlett (1991), both younger and older adults were asked to study faces of younger and older individuals. The results from a subsequent recognition test revealed that younger adults displayed significantly better recognition for faces of their own age group, while older adults did not show a marked difference in recognition based on face age.

Similarly, Backman (1991) found that younger adults had superior memory for faces of younger individuals compared to those of older individuals. Interestingly, younger older adults (aged 63–70) demonstrated enhanced memory for older faces as opposed to younger ones. However, two groups of older older adults (with mean ages of 76 and 85, respectively) exhibited no OAB, indicating that the effect may be diminished or absent in advanced age.

An early investigation involving children by Goldstein and Chance (1964) produced mixed findings regarding

the prevalence of OAB. Nonetheless, subsequent studies have suggested that children may indeed exhibit an OAB (e.g., Anastasi & Rhodes, 2005; Hills & Lewis, 2011). Importantly, Rhodes and Anastasi (2012) noted that factors such as the type of test administered, the nature of the photographs used, and the length of the retention interval could significantly influence the emergence of the OAB.

Additionally, external facial features—including color, hairstyle, and other distinguishing traits—may also affect the OAB. Notably, studies that reported a significant OAB in young adults commonly utilized real-life face stimuli that encompassed these external features (Bryce & Dodson, 2013; Rhodes, Castel, & Jacoby, 2008; Bartlett & Leslie, 1986). In contrast, investigations employing standardized face stimuli (e.g., grayscale images, cropped hairstyles) frequently failed to identify a significant OAB among young adults (Mondloch, Maurer, & Ahola, 2006; Crookes & McKone, 2009; Melinder et al., 2010).

A recent review on the OAB has suggested that facial aging features, such as the presence of wrinkles, may correlate with changes in facial characteristics. Specifically, older faces tend to become less attractive yet more distinctive than younger faces, which could influence the modulation of the OAB (Wiese, Komes, & Schweinberger, 2013). Alterations in external facial features—such as the removal of color and hair—directly impact these facial characteristics. It is plausible that these external features modulate the OAB by altering how facial characteristics are perceived. Consequently, a crucial area of investigation concerning the OAB is the specific type of stimuli employed in studying this phenomenon.

A major debate surrounding the OAB pertains to the nature of this bias—whether it arises from social motivations or perceptual expertise. This discussion parallels the literature on the “own” bias in face recognition, with the most robustly studied phenomenon being the Own Race Bias (ORB). Early social scientific interpretations posited that this bias indicated a tendency among observers, particularly those with prejudiced racial attitudes, to lack motivation for distinguishing

among members of other races, resulting in poorer memory for other-race faces. Over the years, various motivational accounts linked to social categorization have been proposed to explain the ORB (Rodin, 1987; Wegner & Bargh, 1998).

Perhaps the most comprehensive explanation to emerge in recent years posits that the ORB reflects a tendency for individuals to think categorically about outgroup members, leading them to process facial features differently compared to ingroup faces (Levin, 2000). Ingroup faces (e.g., own-race) encourage perceivers to focus on distinguishing features among ingroup members, whereas outgroup faces (e.g., other-race) are often categorized based on prototypical features—such as race, sex, and age—that are common across all outgroup faces, complicating the task of differentiation (Young et al., 2012). Therefore, it is argued that distinct facial features guide the recognition of ingroup and outgroup members based on social categorizations, such as race, which can similarly apply to other social categories like sex and age, thereby elucidating the OAB.

Cognitive scientists have alternatively proposed that the ORB stems from a lack of visual experience with other-race individuals, resulting in diminished perceptual expertise for those faces. Research has shown that the magnitude of the ORB is influenced by the level of interracial contact individuals experience in their daily lives (Zhao et al., 2014).

A key paradigm employed in the face recognition literature to test the perceptual expertise hypothesis is the Face Inversion Effect (FIE) (Yin, 1969; Diamond & Carey, 1986; Valentine 1988; Civile et al., 2014; Civile et al., 2016; McCourt et al., 2023). The FIE represents a decline in recognition performance when individuals are tasked with recognizing faces that are turned upside down, or inverted. This paradigm is one of the most frequently utilized in the field and is often regarded as an index of perceptual expertise. Research suggests that inversion disrupts our ability to process configural and holistic information, as individuals lack expertise in recognizing faces presented in an upside-down orientation (Gauthier, 1997; McLaren, 1997; Maurer et al., 2002).

Consequently, the FIE has been employed to investigate the nature of the ORB. For example, Vizioli et al. (2010) demonstrated a diminished FIE for own versus other-race faces, attributing this reduction primarily to impaired performance on upright other-race faces. More recently, Civile and McLaren (2022) utilized a transcranial Direct Current Stimulation (tDCS) procedure, drawn from the perceptual learning and face recognition literature, to disrupt perceptual learning and investigate how the ORB could be fully attenuated by impairing the perceptual expertise associated with own-race faces.

In their study, Western Caucasian participants were randomly assigned to either an anodal or a sham/control condition prior to completing an old/new recognition task—commonly used in FIE research—featuring both

upright and inverted Western Caucasian and East Asian faces. Results from the sham/control group confirmed a robust ORB, as indicated by a reduced FIE for other-race faces compared to a pronounced FIE for own-race faces. This finding suggested that the disparity was primarily due to disrupted recognition performance for upright other-race faces. Crucially, under the anodal condition, the interaction index representing the ORB was entirely eliminated by the effects of tDCS, which reduced the FIE for own-race faces. This disruption brought the performance of upright own-race faces down to the same level as that of upright other-race faces. Thus, this study marks a significant advancement in the literature, providing direct evidence that the ORB, as indexed by the FIE, can be completely mitigated by disrupting perceptual expertise. This finding underscores the role of perceptual learning in shaping recognition outcomes for upright own-race faces (Civile & McLaren, 2022).

Returning to the literature on the OAB, several studies have provided evidence for more efficient configural and holistic processing of own-age faces compared to those of other age groups, aligning with the perceptual expertise explanation. For instance, Kuefner et al. (2008) demonstrated that young adult participants exhibited enhanced recognition of upright adult faces relative to both newborn and child faces during a delayed matching task; however, this own-age advantage vanished when the faces were presented in an inverted orientation. In another experiment, Macchi et al. (2009) found a similar FIE for newborn and adult faces among nurses working in a maternity ward—individuals with substantial expertise at seeing newborn faces—while control participants (novices) did not show an FIE for newborn faces. Further research by Macchi et al. (2010) revealed that mothers without younger siblings, who gained extensive experience with infant faces only in adulthood, exhibited a robust FIE for own-age faces but not for other-age faces. This discrepancy was attributed to poorer performance on upright infant faces. Collectively, these studies suggest that the FIE is reduced for other-age faces when sufficient expertise has not been developed, with upright face performance serving as a primary factor influencing the modulation of the FIE, consistent with findings in the ORB literature.

However, it is important to note that some earlier studies utilizing the FIE as an index of the OAB have produced inconsistent results. For example, Mondloch et al. (2006) employed experimental paradigms primarily aimed at studying upright faces, such as blocked trials presentation instead of intermixed trials, where upright stimuli were presented first.

In this paper, we aim to advance the OAB literature indexed by the FIE by investigating this phenomenon in young adults aged 19-30 years when presented with both own-age faces and the faces of older adults (ages 69-80). Our objective is to build upon the work of Kuefner et al. (2008) and Macchi et al. (2009; 2010), with a specific focus on the OAB toward older individuals. Based on predictions from the ORB literature, we anticipate discovering a robust OAB, as indicated by a reduced FIE

for older/other age faces in contrast to the pronounced FIE for own-age faces. This difference is expected to stem primarily from disrupted performance for upright older faces compared to upright young faces, highlighting the significance of perceptual expertise for faces presented in their typical upright orientation.

Another aim of this study is to directly assess how real-life faces versus standardized faces modulate the OAB, addressing the relevance of external features in achieving the OAB. To minimize potential confounds related to the specific tasks employed in OAB research, both of our experiments will utilize an old/new recognition task—commonly employed in the FIE literature and previously used by Civile and McLaren (2022) to investigate the ORB indexed by the FIE.

## Experiment 1

### Subjects

A total of forty-eight Western Caucasian participants (24 female; aged 18-30 years) residing in Western countries were recruited via the Prolific platform. To mitigate the potential influence of the ORB (Rossion & Michel, 2011; Civile & McLaren, 2022), the sample was exclusively composed of Western Caucasians. All participants had normal or corrected-to-normal vision and were fluent in English. The study methods were conducted in accordance with the relevant ethical guidelines and regulations, as approved by the Psychology Research Ethics Committee at the University of Exeter. Informed consent was duly obtained from all participants prior to their involvement in the study.

### Materials

Both experiments utilized a set of Western Caucasian faces sourced from the FACES database (<https://faces.mpg.de/imeji/>), a well-established repository that encompasses specific demographic variables (age, race, sex) as well as various attributes (expressions, rated attractiveness, and distinctiveness) commonly employed in face recognition research (Ebner et al., 2010; Riediger et al., 2011; Ebner et al., 2018; Holland et al., 2019). In this database, ‘young’ faces are defined as those belonging to individuals aged 19-31 years, while ‘old’ faces correspond to individuals aged 69-80 years.

For Experiment 1, a set of 56 young and 56 older male and female targets was selected, all exhibiting neutral facial expressions and directing their gaze toward the camera. Participants were depicted wearing grey tops against a standard neutral grey wall background. These stimuli comprised real-life, colored images featuring the faces, hair, and shoulders of the participants, with dimensions of 24 cm × 30 cm. The inverted faces were generated by rotating the original images by 180 degrees. In total, 224 faces were employed in the study, consisting of 112 upright faces and 112 inverted faces (see Figure 1 for examples of the stimuli used).

### Procedure

After providing consent, participants performed an old/new recognition task which included a study/learning phase and a recognition task (Civile, McLaren et al., 2014; Civile, McLaren et al., 2016; McCourt et al., 2023). In the study phase participants completed 112 trials. Each trial began with a 1-second fixation cue displayed in the center of the screen, followed by the presentation of a face image for 3 seconds. The faces were evenly divided between young and older, male and female, with both upright and inverted orientations presented in a randomized and intermixed order. No response was required from the participants during the study phase; instead, they were instructed to memorize as many faces as possible. The recognition phase included 224 trials, with 50% consisting of stimuli from the study phase and the remaining 50% featuring novel stimuli, also evenly split between upright and inverted orientations, presented one at a time in random order. Each trial commenced with a 1-second fixation cue in the center of the screen, followed by the face stimulus displayed for a maximum of 4 seconds. Participants responded using the “X” and “.” keys to indicate whether they believed a given stimulus had been previously shown or was novel in the study phase. The designation of response keys was counterbalanced across participant groups. If no response was made within the 4-second window, the subject timed out, and the next trial began automatically.

At the end of the study, a supplemental questionnaire to control for the effects of facial distinctiveness and attractiveness of the stimuli was presented to the participants. Hence, participants rated the young faces as more attractive than the older ones ( $p < .001$ ), whereas no significant difference was found in distinctiveness ( $p = .31$ ). Importantly, attractiveness of the faces was not correlated with the OAB, lower FIE for other vs own age faces, ( $p = .74$ ) nor when considering only performance for upright young vs older faces, ( $p = .65$ ).

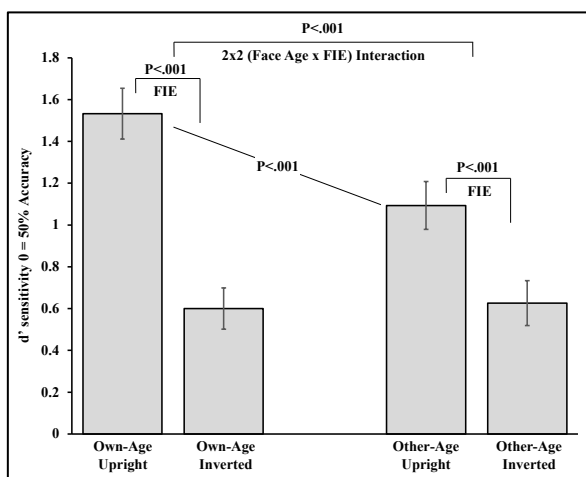
### Results

According to previous behavioral work on the FIE (Civile, McLaren et al., 2014; Civile, McLaren 2016; McCourt et al., 2023) our primary measure was accuracy in the recognition task. Accuracy for male and female faces was collapsed based on previous studies that found no differences between them. The data from all the subjects in each experimental condition was used to compute a  $d$ -prime ( $d'$ ) sensitivity measure for the recognition task where a  $d'$  of 0 indicates chance-level performance. We assessed performance against chance for upright and inverted own and other age faces showing that for all conditions we found  $p < .001$  for this analysis. Each  $p$ -value reported for the comparisons between conditions is two-tailed, and we also report the  $F$  or  $t$  value along with effect size ( $\eta^2p$ ).

We performed a 2 × 2 repeated-measures ANOVA to examine the two within-subjects factors *Face Age* (younger, older) and *FIE* (upright, inverted), which revealed a significant main effect of Face Age,  $F(1,47) =$

8.70,  $p = .005$ ,  $\eta_p^2 = .15$ , indicating that overall performance for own/young faces ( $M = 1.06$ ,  $SD = .68$ ) was significantly better than that for other/older faces ( $M = .86$ ,  $SD = .68$ ). A significant main effect of FIE was found,  $F(1,47) = 79.12$ ,  $p < .001$ ,  $\eta_p^2 = .62$ , indicating an overall robust inversion effect. Critically, we found a significant interaction between Face Age and FIE,  $F(1,47) = 13.66$ ,  $p < .001$ ,  $\eta_p^2 = .22$ , led by a larger inversion effect for own age faces ( $M = .93$ ,  $SD = .69$ ),  $t(47) = 9.26$ ,  $p < .001$ ,  $\eta_p^2 = .64$ , vs. that found for the other age faces ( $M = .46$ ,  $SD = .69$ ),  $t(47) = 4.63$ ,  $p < .001$ ,  $\eta_p^2 = .31$ .

We conducted a further paired-sample t-test comparing performance for upright faces, which revealed a significant better performance for own ( $M = 1.53$ ,  $SD = .84$ ) vs. other ( $M = 1.09$ ,  $SD = .79$ ) age faces,  $t(47) = 4.50$ ,  $p < .001$ ,  $\eta_p^2 = .30$ . The same analysis for the inverted faces, revealed no significant difference between own ( $M = .60$ ,  $SD = .68$ ) vs. other ( $M = .62$ ,  $SD = .74$ ) age faces,  $t(47) = .28$ ,  $p = .77$ ,  $\eta_p^2 < .01$  (Figure 1).



**Figure 1** reports the results from Experiment 1. A robust OAB was found indexed by a reduced FIE for other vs. own age faces. The x-axis shows the face conditions, the y-axis shows  $d'$ . Error bars represent s.e.m.

## Discussion

Experiment 1 yielded three primary findings. Firstly, a significant OAB was identified, as indicated by a reduced FIE for other-age faces compared to own-age faces. Secondly, consistent with the perceptual learning and face recognition literature, the diminished FIE for other-age faces was attributed to impaired performance on upright older faces. This effect parallels findings typically observed in the ORB literature, where participants exhibit a reduced FIE for other-race faces due to disrupted performance on upright other-race faces (Vizioli et al., 2010; Civile & McLaren, 2022).

Building on these findings, Experiment 2 sought to further investigate the OAB by manipulating the set of face stimuli to control for the influence of external features (e.g., hair color, hairstyle, eye color). In this experiment, the face stimuli were standardized by

cropping the hair, removing the shoulders, and converting the entire image to grayscale.

## Experiment 2

### Subjects

In agreement with Experiment 1, we recruited forty-eight naïve Western Caucasians (24 female; 18-30 years old) who lived in Western countries were recruited through the Prolific platform. They had a normal or corrected-to-normal vision and can fluently use English. All methods were conducted following the relevant guidelines and regulations, as approved by the Psychology Research Ethics Committee at the University of Exeter. Informed consent was obtained from all participants.

### Materials

The same set of young and older faces used Experiment 1 was also used in Experiment 2, however this time the faces were standardized by being grey-scaled, cropped in the hair and shoulders (see Figure 2 for examples of the stimuli used).

### Procedure

As for Experiment 1, an old/new recognition task procedure was used in Experiment 2, with the exception that standardised faces were this time employed. In this case as well, at the end of the study, a supplemental questionnaire to control for the effects of facial distinctiveness and attractiveness of the stimuli was presented to the participants. Hence, in agreement with Experiment 1, participants rated the young faces as more attractive than the older ones ( $p < .001$ ). Also, this time older faces were rated as more distinctive than young faces ( $p < .001$ ). Because Experiment 2 did not show a significant OAB, nor any significant difference between upright young vs. older faces, we did not analyse the relationship between facial characteristics.

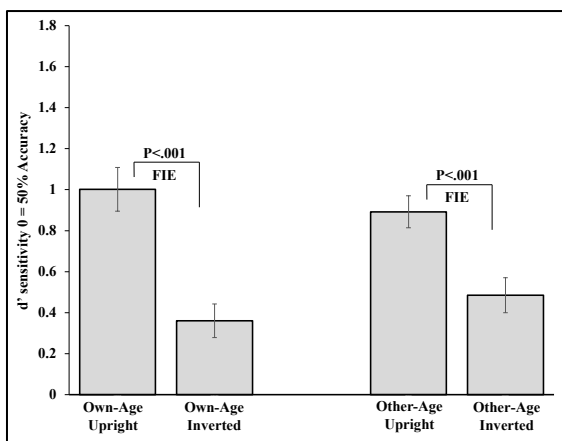
## Results

As in Experiment 1, the data from all the subjects in each experimental condition was used to compute a  $d'$ -prime ( $d'$ ) sensitivity measure for the recognition task where a  $d'$  of 0 indicates chance-level performance. We assessed performance against chance for upright and inverted own and other age faces showing that for all conditions we found  $p < .001$  for this analysis. Each p-value reported for the comparisons between conditions is two-tailed, and we also report the F or t value along with effect size ( $\eta^2p$ ).

We performed a  $2 \times 2$  repeated-measures ANOVA to examine the two within-subjects factors *Face Age* (younger, older) and *FIE* (upright, inverted), which revealed a non-significant main effect of Face Age,  $F(1,47) = 8.70$ ,  $p = .006$ ,  $\eta_p^2 < .01$ , indicating that this time overall performance for own/young faces ( $M = .68$ ,

SD = .51) was similar to that for other/older faces (M = .68, SD = .46). A significant main effect of FIE was found,  $F(1,47) = 42.09, p < .001, \eta_p^2 = .47$ , indicating an overall robust inversion effect. Critically, this time the interaction was not significant,  $F(1,47) = 2.67, p = .109, \eta_p^2 = .05$ , despite a numerically larger inversion effect for own age faces (M = .64, SD = .82),  $t(47) = 5.39, p < .001, \eta_p^2 = .38$ , vs. that found for the other age faces (M = .40, SD = .66),  $t(47) = 4.24, p < .001, \eta_p^2 = .27$ .

We conducted a further paired-sample t-test comparing performance for upright faces, which this time did not show a significant difference between performance for own (M = 1, SD = .73) vs. other (M = .89, SD = .54) age faces,  $t(47) = .95, p = .34, \eta_p^2 = .02$ . The same analysis for the inverted faces, revealed no significant difference between own (M = .36, SD = .57) vs. other (M = .48, SD = .58) age faces,  $t(47) = 1.05, p = .29, \eta_p^2 = .02$  (Figure 2).



**Figure 2** reports the results from Experiment 2. This time no significant OAB was found. The x-axis shows the face conditions, the y-axis shows  $d'$ . Error bars represent s.e.m.

## Discussion

The results of Experiment 2 indicated that the OAB, as indexed by the FIE for other-age faces, was not significant when standardized faces were used. Consequently, both own-age and other-age faces demonstrated a significant FIE, with no differences observed between the recognition of upright faces. A numerical trend was noted for other-age faces reflecting a reduced FIE compared to that of own-age faces.

A closer examination of the results from Experiments 1 and 2 reveals a notable difference in overall performance; participants performed significantly better in Experiment 1 (M = .96, SD = .64) compared to Experiment 2 (M = .68, SD = .37),  $F(1, 46) = 7.08, p = .01, \eta_p^2 = .13$ . Importantly, when comparing performance for each face type directly across the two experiments, only upright own-age (young) faces displayed a significant difference. Participants in Experiment 2 (M = 1.23, SD = .73) recognized these faces significantly less well than those in Experiment 1 (M = 1.53, SD = .84),  $t(46) = 3.39, p = .001, \eta_p^2 = .19$ .

## General Discussion

In the two experiments reported here, we extended the investigation into the mechanisms underlying the OAB by examining how young adults recognize sets of own-age versus other-age (older) faces. We built upon previous findings from the ORB literature (Vizioli et al., 2010; Civile & McLaren, 2022) and the OAB literature (Kuefner et al., 2008; Macchi et al., 2009; 2010) by demonstrating that the FIE can serve as a measure of the OAB, thereby supporting the perceptual expertise account of this phenomenon.

Specifically, our findings from Experiment 1 revealed a robust OAB, characterized by a significantly reduced FIE for older-age faces, which was attributed to disrupted recognition performance for upright faces. This key finding aligns with previous research in both the ORB and OAB literature, reinforcing the idea that mechanisms of perceptual expertise can effectively explain the OAB. Consequently, the results from Experiment 1 make a significant contribution to the perceptual expertise literature, elucidating the nature of the 'own' bias in face recognition. The most recent explanation offered in this context was proposed by Civile and McLaren (2022) within the ORB framework.

According to the McLaren, Kaye, and Mackintosh (MKM) model (McLaren et al., 1989; McLaren & Mackintosh, 2000; McLaren & Civile 2011; McLaren et al., 2012; Civile, McLaren et al., 2023), exposure to prototype-defined categories of stimuli facilitates perceptual learning. Initially, observers concentrate on the common features of category exemplars, which aids in associating these features with their respective category memberships. Once these common features are correctly linked to their categories, their salience diminishes, allowing the unique features of each exemplar to become more prominent. This modulation of feature salience enables perceptual learning, as observers can focus on the distinctive characteristics of each exemplar, improving their ability to discriminate between items within the same category and recognize them when presented upright. However, this advantage is lost upon inversion due to reduced expertise with inverted faces.

Various factors—including specific tDCS stimulation (Civile et al., 2018; Civile, Quaglia et al., 2021; Civile, Waguri et al., 2020; Civile, McLaren et al., 2020), the presentation of other-race faces (Vizioli et al., 2010; Civile & McLaren, 2022), labeling faces as 'autistic' (Civile et al., 2019), alterations of faces through techniques such as Thatcherization or scrambling (e.g., Civile, Elchlepp et al., 2012; Civile et al., 2014; Civile et al., 2016), and the use of other-age faces, as seen in Experiment 1—have all been shown to significantly reduce the FIE by disrupting recognition performance for upright faces, without affecting recognition of inverted faces.

This phenomenon can be explained by the fact that these manipulations alter salience modulation, such that common features retain high salience, highlighting the similarities among faces rather than their differences. As

a result, faces may appear more “similar,” which disrupts our ability to effectively discriminate between upright faces and leads to a reduction in the FIE. This explanation provides a theoretical framework that could account for findings across various domains, including the ‘own’ bias (Civile & McLaren, 2022), stigmatization (Civile et al., 2019), applications of tDCS (Civile, Quaglia et al., 2021), and perceptual processes in face recognition (Civile et al., 2014; 2016).

Experiment 2 did not demonstrate the OAB, and the performance for upright and inverted faces, when analyzed independently, did not show significant differences between own/young faces and other/older faces. This finding suggests that the standardization of face stimuli used in Experiment 2 may have resulted in a loss of critical information necessary for detecting the OAB. This loss of information appeared to disproportionately affect the recognition of own/young age faces, as evidenced by a substantial decline in performance compared to Experiment 1. Support for this observation can be found in the face recognition literature, particularly regarding the effects of manipulating face contours on the FIE. McCourt et al. (2023) found that removing or altering face contours can diminish performance for upright faces but not for inverted ones. Consequently, the manipulations applied in Experiment 2, such as cropping the hair, likely influenced the overall contour perception of the faces, adversely affecting recognition of the age group with which participants had the most experience—upright own/young age faces. Future research should investigate the performance of own-age faces across various manipulations within the same study to identify which specific types of information are critical for modulating the OAB. Additionally, it is worth noting that participants rated the other/older age faces in Experiment 2 as more distinctive than the young faces. Although this did not translate into any behavioral differences between Experiment 1 and Experiment 2—neither upright nor inverted older faces showed significant differences across the experiments—it may suggest that the standardization of faces led participants to recognize more individual features typical of older faces (e.g., wrinkles).

In summary, the results from our experiments demonstrate that the OAB can be observed in young adults when presented with both own/young age faces and other/older age faces. We recorded a robust FIE for own-age faces, while a significantly reduced FIE was found for other-age faces. Crucially, in alignment with the perceptual expertise literature, the reduction in the FIE for other-age faces is primarily attributable to disrupted performance on upright other-age faces (as seen in Experiment 1). Moreover, our findings indicate that the type of stimuli employed is essential for eliciting the OAB. Manipulations designed to standardize the faces—such as cropping the hair and converting images to grayscale—led to the disappearance of the significant OAB, particularly affecting the recognition of upright own-age faces.

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