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Assessing the Boundary Conditions of the Own-Age and Own-Race Perceptual Bias for Faces

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Assessing the Boundary Conditions of the Own-Age and Own-Race Perceptual Bias for Faces

by
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ABSTRACT OF THE THESIS

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Our interactions with other people rely on our ability to perceive and distinguish faces based on snap decisions about their features. Past research has revealed that facial recognition is consistently better when the observer shares the same race as the person being identified or is roughly in the same age category (Meissner & Brigham, 2001; Rhodes & Anastasi, 2012). Although a misidentification can be irritating in daily life, high discriminability is especially important in situations where a misidentification could have drastic consequences, such as in eye witness testimony or during security checkpoints conducted by law enforcement. Although much research has been conducted to try to explain the cause of bias in favor of own-race and own-age faces, little is understood about the precise circumstances that give rise to these biases and when they begin to affect our perception or memory. I investigated the own-age bias (OAB) in younger and older adults and the own-race bias (ORB) in Caucasian and African American adults in a perceptual recognition task; the participant was shown a unique target face and immediately asked to respond to an array of faces and indicate if the target was present or absent before moving on to the next trial. The aim was to determine the factors that are influential in producing

an in-group bias without a large memory load. I was interested in how set size, retention interval, and intervening distractor faces impact the OAB and the ORB. I looked at discriminability *(d')* because it is a better measure of sensitivity than the hit rate alone and I also measured response latency. Another goal of this study was to ascertain that any observable perceptual biases result from processing facial features and not from any other characteristic of the photographs or differences in photograph quality across facial categories. To ensure that participants relied solely on facial features rather than hair cues, the facial stimuli used in this study were carefully selected and all hair was removed by cropping the faces into an oval shape. I found that Caucasian individuals had higher discriminability, but not faster reaction times, for Caucasian faces compared to African American faces; however, African American individuals did not show an ORB. I failed to find any evidence of the OAB in either young or older adults. Larger test set size, longer retention interval, and the addition of intervening distractor faces had a general negative effect on recognition and reaction times but did not exacerbate the ORB or OAB.

Introduction

People tend to better remember faces that share their own race, age, and even gender (Meissner & Brigham, 2001; Rhodes & Anastasi, 2012; Wright & Sladden, 2003; Loven, Herlitz, & Rehnman, 2011). In the past fifty years, this phenomenon has elicited substantial interest and research in the field of psychology. Especially in forensic psychology, the implications of a perceptual or memory bias in facial recognition when it comes to eyewitness testimony are great. In high stakes situations, such as police lineups, a high false alarm rate is of utmost concern. For example, the Innocence Project, which has helped exonerate hundreds of innocent incarcerated people, has found that the most common reason for wrongful convictions is erroneous eyewitness testimony (Scheck, Neufeld, & Dwyer, 2011). In a general survey of police lineups, it was found that witnesses chose a face belonging to a person known to be innocent about 20% of the time (Wright & McDaid, 1996)- indicating that people are highly motivated to identify someone even when they cannot properly identify the culprit. Although misidentification has little impact on the lives of eyewitnesses, it could potentially have dire consequences for the victims of misidentification. Taking into account that people are better at recognizing faces that are more similar to themselves, the possibility of a misidentification becomes even more likely when witnesses must identify individuals of a different age or race.

In-Group Facial Bias for Own Race and Own Age

The own race bias (ORB) is the finding that faces of the same race as the observer are remembered better compared to faces of another race. A stream of studies beginning in the 1970's established the robustness and reliability of the ORB across racial groups and memory tasks (Brigham & Barkowitz, 1978; Brigham & Malpass, 1985; Kassin, Ellsworth, & Smith, 1989; Chance & Goldstein, 1996). Meissner and Brigham's (2001) review and meta-analysis of

30 years of research on the ORB concluded that own race faces consistently resulted in a higher proportion of hits and a lower proportion of false alarms compared to other race faces across participants of different racial and ethnic backgrounds. Although not every possible combination of race of observer and facial stimuli has been investigated, recently, research on the ORB has confirmed the presence of the effect in diverse populations around the globe. The ORB has been found in white Americans, white South Africans, black South Africans, Chinese individuals, Egyptians, African Americans, Israeli individuals, and Hispanic individuals living in the U.S., to name a few (Chiroro, Tredoux, Radaelli, and Meissner, 2008; Weise, 2012; Marcon, Meissner, Frueh, Susa, & Maclin, 2010; Zhao & Bentin, 2008; Megreya, White, & Burton, 2011; Meissner & Brigham, 2001).

In addition to the own race bias, numerous studies have been published showing a bias in favor of own age faces. Rhodes and Anastasi (2012), in their meta-analytical review, found that own age faces compared to other age faces resulted in a higher proportion of hits and a lower proportion of false alarms indicative of an own age bias (OAB). This effect was present in children, younger adults, and older adults. A study by Wright and Stroud (2002) had young and older adults watch a video featuring either a young or older suspect. The authors found that people were better at identifying culprits from their own age group. There is also evidence of an own sex bias, however, quite a few of these studies have only been able to demonstrate this effect in females (Ellis, Shepherd, & Bruce, 1973; Loven et al., 2011; Lewin & Herlitz, 2002).

A Brief Overview of Past Research Exploring In-Group Facial Bias

Psychologists have been largely concerned with defining the factors that lead to bias in the first place. Many theories have been proposed in an attempt to explain the ORB and the OAB, a few of which will be briefly discussed in the following paragraphs.

Initially, it was thought that attitudes or prejudice toward other groups of people could explain the ORB (Brigham & Barkowitz, 1978). It seems intuitive to assume that people may be more motivated to differentiate faces that are held in higher regard while dismissing faces that belong to another race or age, for instance. However, this theory has been largely rejected by current psychologists and no relationship has been found between attitudes and facial recognition (Swope, 1994; Slone, Brigham, & Meissner, 2000; Meissner & Brigham, 2001). There is even some evidence that suggests that prejudiced individuals are more concerned than less prejudiced individuals with making accurate race categorizations when presented with racially ambiguous targets (Blascovich, Wyer, Swart, & Kibler, 1997). This finding supports an early study that determined that prejudiced individuals were more accurate at categorizing faces as 'other race' than individuals who did not hold such negative attitudes (Allport & Kramer, 1946). It is important to note that a categorization task, which requires only that judgments based on race or other characteristics (e.g. age or gender) be made, is very different from a recognition task which requires additional perceptual processes that enable the differentiation of individuals within the same group. Still, prejudice may be associated with the amount of contact or experience with members of another group, which has become a popular explanation for the ORB and the OAB (Harrison & Hole, 2009; Chiroro & Valentine, 1995).

The contact hypothesis proposes that the amount of interaction people have with individuals of another group (i.e. other race individuals) impacts the ORB because there are more opportunities to learn about critical differentiating features in that group. Several studies have found that the amount of interracial experience is correlated with the magnitude of the ORB (Byatt & Rhodes, 1998; Swope, 1994; Chiroro & Valentine, 1995; Li, Dunning, & Malpass, 1998). Chiroro and Valentine (1995) found that white and black individuals in South Africa who

had high interracial contact showed a significantly smaller ORB than black individuals in South Africa and white individuals in Britain who had little contact with others outside of their own race. Li et al. (1998) took a novel approach, defining interracial contact by whether white participants were basketball fans or novices because, presumably, basketball fans would have had more experience differentiating black faces because a large proportion of basketball players are black. Li et al. found that basketball fans were better at recognizing black faces than basketball novices. However, there is inconsistent support for the contact hypothesis and many studies have found a very small reduction in the ORB in high contact individuals or have found no evidence at all that the amount of interracial contact influences the ability to differentiate and recognize other race faces (Burgess, 1997; Ng & Lindsay, 1994; Brigham & Barkowitz, 1978). Even so, it is likely that contact plays some role in the ORB.

Although greater experience with other race faces, measured by the amount of interracial contact, is appropriate to at least partially explain the ORB, it cannot be as readily applied to the OAB or the own gender bias. Although race is a construct that cannot always be easily defined, individuals' group membership in any racial category is immutable; for instance, white children never grow up to become black adults. For this reason, it is possible that some individuals can maintain a low level of contact with people of other races. Unlike race, age is a characteristic that changes with time as children become young adults and young adults join the ranks of older adults. It could be argued that perhaps younger adults have limited experience with older adults and have not yet developed expertise for older faces which would explain the OAB. However, older adults are also known to exhibit a bias for faces of their own age and because older adults were once younger adults, it is unreasonable to assume that they did not have sufficient opportunity to develop expertise with younger adult faces.

Another compelling theory related to the contact hypothesis is the idea that it is only recent, extensive experiences with members of another group that affect recognition ability (Hills & Lewis, 2011; Harrison & Hole, 2009; Rhodes & Anastasi, 2011). Recent experiences are thought to affect current ability to recognize faces, which would explain why older adults have more trouble remembering young adult faces despite their own previous experience as young adults. Harrison and Hole (2009) investigated whether recent, meaningful experiences with other age groups diminished the OAB. They found that trainee teachers and undergraduates did not differ in their ability to accurately recognize faces that were similar to their own age but only trainee teachers, who had more experience with children's faces, showed a recognition advantage for children's faces relative to their peers who did not have experience working with children.

Sporer (2001) and several other researchers (Bernstein, Young, & Hugenberg, 2007; Chiroro et al. 2008; Wiese, 2012; Levin, 1996) have suggested that facial memory biases may best be understood and studied as an in-group face recognition advantage. For example, the categorization of faces as in-group (belonging to one's own race or age group) or out-group (other race/age) may impact the ORB and OAB. Indeed, Bernstein et al. (2007) showed that merely classifying faces as in-group or out-group produced a bias in favor of in-group faces comparable to the ORB. Faces that were labeled as having the same university affiliation as the observer compared to faces labeled as attending a rivalry school were remembered better regardless of race. It is not well understood why identifying faces as part of an out-group has an effect on later recognition.

Levin (1996, 2000) proposed the feature-selection model which makes the argument that, with other race faces, more attention is focused on making a categorical judgment while the individuating features of the face are deemphasized. This processing 'strategy' is applicable to

any situation in which a face is deemed to be part of an out-group. If out-group features are salient, it is possible that category-level information will be emphasized rather than individuating characteristics that facilitate later recognition.

Perceptual Identification

Theories normally assume that differential perceptual processing of in-group and out-group faces can explain the ORB and the OAB. For instance, the contact hypothesis posits that an advantage for in-group faces occurs because greater experience with those groups of faces leads to perceptual learning of features specific to own-age and own-race faces. Nevertheless, most studies looking at the ORB or OAB rely on long-term recognition memory tasks rather than perceptual tasks which makes it difficult to pinpoint the boundary conditions of facial biases. Levin's feature-selection model and other similar theories emphasizing group-categorization argue that observers' attention during the encoding phase is directed either to individuating features or to characteristics that are more useful for classifying the face by race or age (Levin, 1996; Levin, 2000; Sporer, 2001; Bernstein et al., 2007; Chiroro et al., 2008; Wiese, 2012).

For example, for own-race faces, participants focus more on individuating features, but for other-race faces, more attention is allocated to features that emphasize the race of the individual. Support for this theory has come from memory tasks in which group membership of facial stimuli is emphasized (Levin, 1996; Zhao & Bentin, 2008) rather than from evidence of differential perceptual processing when unique faces must be recognized. Levin (2000) conducted a visual search task, which required participants to classify faces by race, and found that participants were faster to classify other-race faces than own-race faces presumably because attention was directed to individuating features for own-race faces and to racial features for other-race faces. Although it was a perceptual task, the objective was to classify faces by race

rather than to recognize unique individuals. It should be noted that a single composite face was used to represent each race throughout the entire experiment. Unlike perceptual classification studies examining the ORB and the OAB, the aim of the current study was to investigate facial bias in a perceptual task that requires the individuation of faces using a large set of unique faces.

Some researchers in favor of the experience or contact-based hypothesis maintain that in-group faces are processed more holistically than out-group faces (Michel, Rossion, Han, Chung, Caldara, 2006; Kueffner, Cassia, Picozzi, Bricolo, 2008). In addition to the ORB, Michel et al. (2008) found that the face inversion effect was greater for upright, own-race faces whereas performance was similar for other-race faces, indicating that own-race faces were processed more holistically. Other theorists argue that motivation while attending to faces results in differential levels of effort for perception of in-group and out-group faces, which reflects individuals' experience of social rewards associated with different groups of people (Hugenberg, Young, Bernstein, & Sacco, 2010). There is also some evidence that in-group and out-group faces are scanned differently and that directing gaze to critical features decreases memory bias (Hills & Pake, 2013). Some researchers argue that the features most important for differentiating faces could vary between racial groups. It is also possible that differences in scanning behavior are due to cultural differences, such as avoiding eye contact.

Despite all the attention to in-group face biases, there has been less focus on defining the boundary conditions of the OAB and ORB, such as the effects of varying retention interval durations, test set sizes, or the presence of presenting distracting faces as a form of interference during the retention interval. Although most theories assume differential processing of in-group and out-group faces, there have been very few studies which test in-group face bias in a perceptual identification task. Valentine and Endo (1992) used a classification task and asked

participants to quickly make judgments of race for British and Japanese faces. They found that other-race faces were classified faster than own-race faces.

Levin (1996, 2000) posited that with other-race faces, race is coded as a feature-present condition whereas with own race faces, which presumably represent the norm, race is coded as a feature-absent condition. This reasoning follows work in visual perception which has found that it is easier to find a feature-positive target, such as a tilted line, in a field of distractor, feature-negative objects (e.g. straight lines) because feature-positive objects will stand out. However, finding a feature-negative target in a field of feature-positive objects is much more difficult because feature-negative objects will be lost in the noise of a feature-positive distractor field (Triesman & Gormican, 1988). Levin applied this search asymmetry effect to own-race and other-race faces and found that other-race faces, in a visual search task, were identified more quickly than own-race faces were (Levin, 1996; Levin, 2000). The search asymmetry effect confirmed in own-race and other-race faces can be useful in explaining the perceptual encoding of in-group and out-group faces. However, these classification and visual search tasks did not require recognition of individual faces and even emphasized attention to the race of the faces by asking participants to classify faces by race or search for a target race in an array. It is still not clear whether there exists a bias favoring individuation of in-group faces in a perceptual identification task and what factors may affect these biases.

A more recent study by Megreya et al. (2011) had participants match the target face to its corresponding face in an array using different photographs of the same face; hair cues were not removed from the faces. They found a significant ORB, which suggests that the ORB is not dependent on memory and that it must involve perceptual processes as well. Unlike the present experiments, in Megreya et al.'s study, the target face remained present while participants

searched for the other photograph of the individual. For the present study, I ensured that participants would rely only on facial features for recognition, rather than hair cues or other details, by cropping each face to remove clothing and hair. In another perceptual study by Walker and Tanaka (2003), participants were asked to discriminate between a parent face and a morph face. Parent faces were either East Asian or Caucasian and the morph face had a 50-90% contribution from the parent face and from a face of the other race. They found that participants had an own-race advantage when they were asked to distinguish between a target face and a morphed face, which is further evidence of the presence of the ORB in a perceptual task. The current study did not artificially enhance the similarity between target faces and foils through the use of morph faces; instead, the current experiments relied on a more naturalistic set of unique faces from different racial and age groups. Unlike Walker and Tanaka, I utilized a visual search task, requiring participants to recognize a unique target face in an array of distractor faces.

Another study by Marcon et al. (2010) assessed the effects of encoding duration, retention interval, and test set size in a perceptual identification task using own-race and other-race faces. Marcon et al. (2010) were unable to test for crossover interactions in participants because all of their participants were Hispanic but their results suggest that retention interval and set size impact the ORB. These factors are known to affect facial recognition in general and may also impact the magnitude of the ORB in long-term recognition tasks (Palmer, Brewer, Weber, & Nagesh, 2013; Ratcliff, Sheu, & Gronlund, 1992; Penrod, 2008; Meissner & Brigham, 2001).

Generally, in facial recognition tasks, decreased exposure to target faces and longer retention intervals lead to reduced recognition accuracy (Shapiro & Penrod, 1986; Penrod, 2008). Other studies have also found a relationship between accuracy and exposure time, retention interval, and the role of attention (Palmer et al., 2013; Jacoby, Woloshyn, & Kelly, 1989, Ratcliff

et al.,1992). However, not all studies have confirmed that these factors impact the ORB. For example, Maclin, Maclin, and Malpass (2001) concluded that reducing exposure time did not have a differential effect on in-group and out-group faces and it is yet unclear how these factors affect performance on a perceptual identification task. It is possible that only specific combinations of exposure duration and retention interval affect the ORB or that reducing exposure time has an effect but only for time intervals within a certain range. Knowing these boundary limits can advance our understanding of the perceptual processes behind the ORB and the OAB.

Very few studies have examined the ORB or OAB using perceptual tasks. The perceptual boundary conditions of the ORB and the OAB are not yet established and it is unknown whether factors normally affecting facial perception, such as retention intervals, exposure duration, and set size, impact the ORB and OAB similarly or at all. Furthermore, research on the OAB has rarely studied older adult performance using perceptual identification tasks. Firm evidence of declining facial processing ability in older adults is lacking. Many studies have found that older adults tend to be less accurate and produce more false alarms on facial recognition tasks that have a large memory component but few have focused on assessing facial recognition without relying substantially on memory tasks (Shapiro & Penrod, 1986; Ferris, Crook, Clark, McCarthy, & Rae, 1980; Crook & Larrabee, 1992; Fulton & Bartlett, 1991). Interestingly, Lamont, Williams, and Pod (2005), using a standard facial recognition memory task, found that recognition performance in older adults was affected by recognition load, the amount of stimuli present in the recognition phase, which is related to the number of target faces to be remembered. Additionally, eyewitness studies comparing younger and older adults regularly use stimuli featuring only younger adults. For instance, Bartlett, Memon, and Swanson (2001) concluded

that older adults in an eyewitness scenario were less accurate than younger adults but did not take into account the possibility of a bias for own age faces.

The significance of understanding out-group facial recognition was highlighted earlier by its applicability to eyewitness scenarios. However, the presence of the ORB in a perceptual task without a prominent memory component can have implications for situations where individuals must present identification, such as airport security personnel who must ensure a match between a passport photo and the individual in front of them. Hair style changes, accessories, and other disguises are known to impact recognition and it is likely that cosmetic or style alterations may have a greater effect when processing out-group faces (Meissner, Susa, & Ross, 2013). People may also rely disproportionately on hair cues rather than attending to facial features and it is likely that reliance on these cues could be emphasized more when processing other-race faces than when processing own-race faces (Rhodes, 2006; Sporer & Horry, 2011). For this reason, it is important for researchers to ensure that participants are relying on facial features for recognition rather than on extraneous cues when processing faces.

The Current Study

The current study assessed the OAB in older and younger adults and the ORB in Caucasian and African American adults in a series of perceptual tasks conducted online and in the laboratory. The aim was to determine whether factors that are thought to exacerbate the OAB and ORB, such as larger set sizes and longer retention intervals, also have an impact when a perceptual task is employed. By employing identical tasks to assess the OAB and the ORB, it facilitates comparison of the OAB and the ORB and the circumstances that give rise to these biases.

Experiments 1 and 3 were conducted online and assessed whether increasing test set size would lead to a greater OAB in older and younger adults and a greater ORB in Caucasian and African American adults, respectively. Additionally, I was interested in determining whether test set size would have a differential impact on the OAB in younger and older participants. Experiments 2 and 4 were conducted in the laboratory and assessed whether a longer retention interval impacted the OAB in young adults and the ORB in Caucasian adults, respectively. The laboratory experiments also included a distractor condition in which distractor faces were presented during the retention interval to determine whether viewing additional faces between the presentation of the target and the test affects the magnitude of the OAB and the ORB.

Past research on the OAB and the ORB has not been concerned with the quality of facial stimuli; it is generally assumed that the materials used are adequate and similar across facial categories. Meissner & Brigham (2001) duly noted that greater attention should be given to the standardization of facial stimuli across race of face if test-retest reliability is to be improved. For all the present experiments, great care was taken in the selection of faces to reduce the possibility that there would be differences in quality across categories of faces. To ensure that participants relied solely on facial features for recognition, all faces were cropped in an oval shape to remove hair cues. Every face was transformed into grayscale and, for each photograph, the brightness and contrast were adjusted manually, if necessary, to control for differences in luminance and vibrancy in the photographs.

Experiment 1

Method

Participants

Fifty participants were recruited online through the Amazon Mechanical Turk website for this study. All participants indicated they were currently residing in the United States. There were 25 younger adults (18 females; *M* age = 23.8, *SD* = 3.1) and 25 older adults (15 females; *M* age = 64.5 years, *SD* = 4.0). All participants completed a visual search task which took about 30 minutes and they were paid $0.45 for their time.

Materials

All participants completed the task online using their personal computers.

Facial Stimuli. Four hundred and eight unique faces were transformed into grayscale, the brightness and contrast were adjusted manually, if necessary, to ensure that no photograph stood out from the others, and then each face was cropped into an oval shape to remove hair and other extraneous features using Adobe Photoshop. Refer to Figure 1 for an example. The images were collected by the experimenters from various online sources, the Chicago Face Database, the Minear and Park Database, as well as photographs taken by the experimenters. All of the faces appear in a frontal pose with a neutral expression. There were 102 unique faces each of Caucasian young males, Caucasian young females, Caucasian older males, and Caucasian older females. One hundred and forty four faces were chosen to be used as target faces, 36 faces from each face category. This left 66 faces from each category to be used as distractors in the test arrays. Each distractor face was used a maximum of three times.

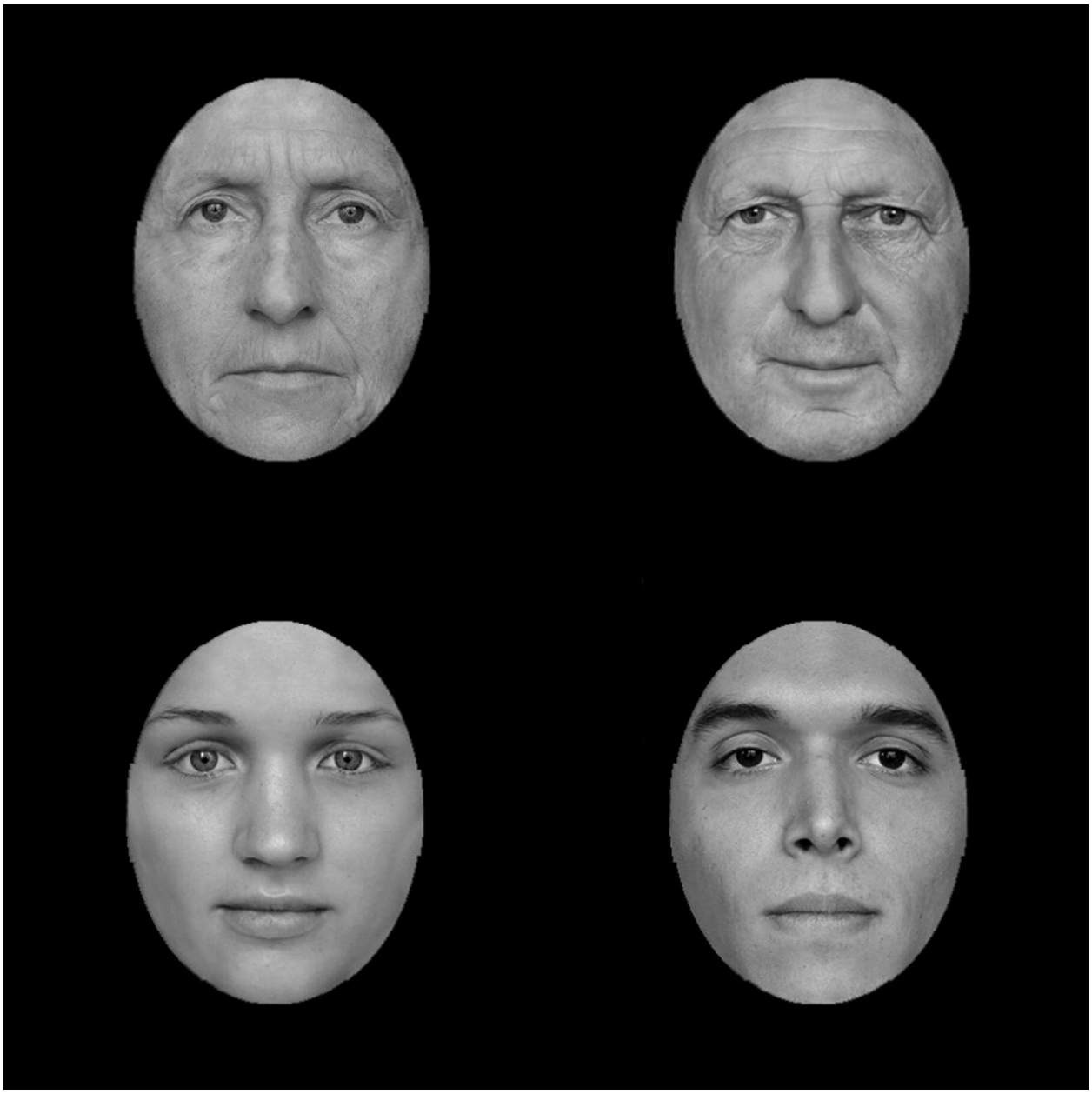

Figure 1. Sample stimuli of young and older adult faces. Top left: older female; top right: older male; bottom left: young female; bottom right: young male.

Facial Visual Search Task. For each category of faces, Caucasian young males, Caucasian young females, Caucasian older males, and Caucasian older females, there were 36 trials. The visual search task for the category of Caucasian young male faces consisted of a fixation cross for 500 *ms* followed by the presentation of a target Caucasian young male face in the center of the screen for a duration of 2000 *ms*, another fixation cross then appeared for 500 *ms* and was immediately followed by an array of either 4, 6, or 8 faces that belonged to the same category as the target face. The participant indicated whether the target face was present or absent in the test array by pressing either the '/' or 'z' key (counterbalanced) on their keyboard. Once the participant responded, or after 10 *s*, the program advanced to the next trial. Refer to Figure 2 for a sample trial. There were 12 trials each of set size 4, 6, and 8 and within each trial type, half of the test arrays contained the target face in an unpredictable position and half did not contain the target. The trials were presented in a randomized order until all 36 target Caucasian young male faces and their accompanying test arrays had been displayed. The same task was employed for the other three categories of faces. At the end of each block, participants had the option to take a short break and the program did not advance to the next block until participants indicated they were ready to begin by pressing a key on their keyboard. The face blocks were presented in a random order.

Design and Procedure

A 2 (age of face: young or old) x 2 (age of participant: young or older adult) x 3 (test set size: either four, six, or eight faces) mixed design was used with age of participant as the between subjects variable. Following the collection of age and gender, eligible participants, those aged 18-30 years or 60 years and above, were provided with a link to the online consent form and the facial visual search task.

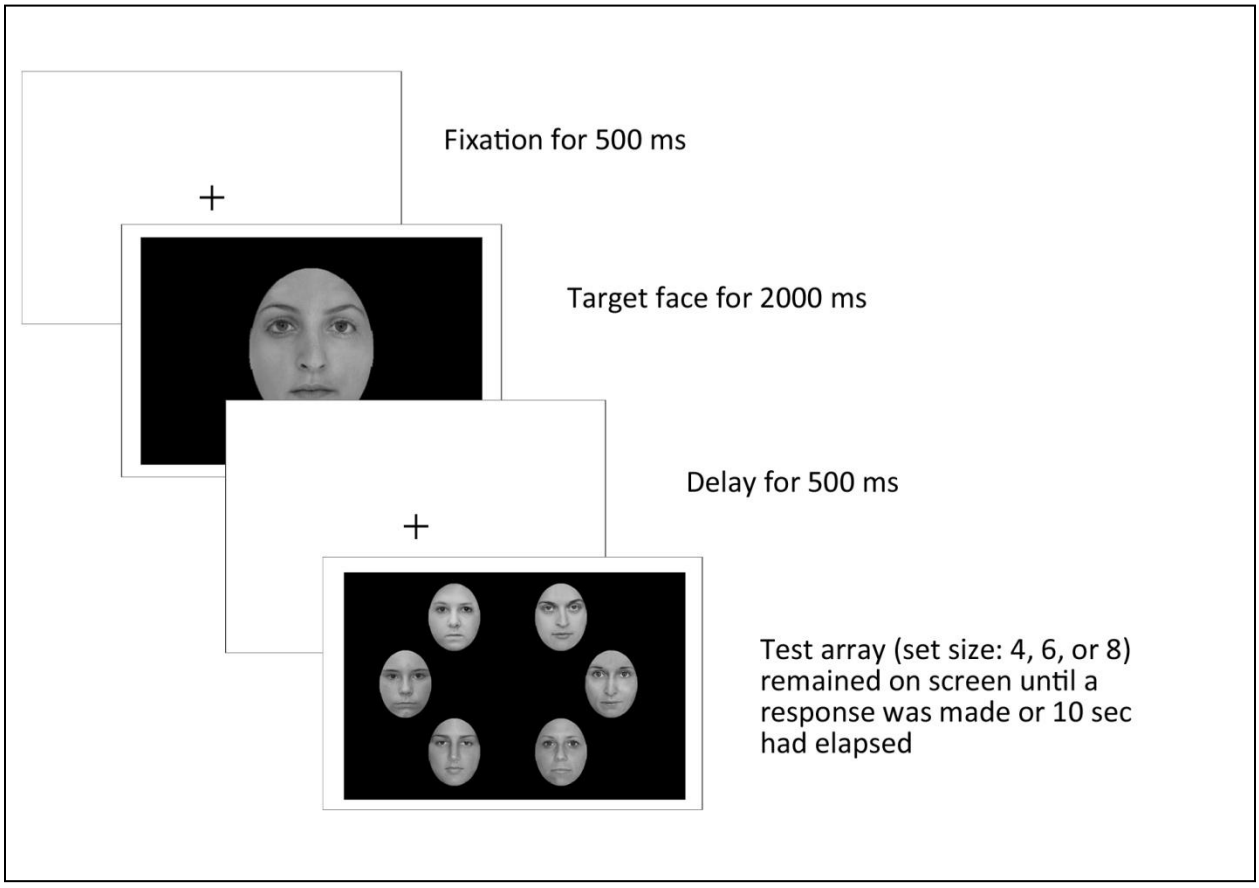

Figure 2. Sample target absent trial for Experiment 1.

Participants were given online written instructions and provided with practice trials. Participants were told they would briefly see a face which they should try to remember and to respond to the test array by indicating whether the face they had just observed was present or absent in the array. They were instructed to respond as quickly and as accurately as possible. The practice phase consisted of only three practice trials intended to familiarize participants with the three different types of trials; test arrays of set size 4, 6, and 8. Only Caucasian young adult faces were used for the three practice trials. Like in the actual task, participants were shown a target (practice) face for 2000 *ms*, then an asterisk appeared for 500 *ms* followed by the test array

which consisted of distractor faces from the same category as the target face. At the end of each practice trial, participants were given feedback and reminded of the instructions before advancing to the next trial. At the end of the practice phase, the program advanced to the first block when the participant indicated they were ready to begin by pressing a key on their keyboard. Block order was randomized by the program. Participant responses and reaction times were recorded.

Results

Two separate 2 (age of face: young vs. old) x 2 (age of participant: younger vs. older adults) x 3 (test set size: 4, 6, or 8) mixed ANOVAs were conducted, with age as the between subjects variable, on both reaction times and *d'*, which measures the distance between signal and noise means in the visual search task. An alpha level of 0.05 was used for all *F*-tests.

Sensitivity

For all trials, *d'* scores were calculated using the hit rate and false alarm rate because *d'* has been shown to be a better measure of discriminability than the hit rate alone or the hit rate minus the false alarm rate (Stanislaw & Todorov, 1999). The mean *d'* scores for all conditions are presented in Table 1.

There was a main effect of set size, F (2, 96) = 25.84, $p < 0.001$, partial $\eta^2 = 0.350$. Post hoc pairwise comparisons using the Bonferroni correction revealed that *d'* in set size of 4 (M = 1.647, SD = 0.86) differed significantly from the set size of 6 (M = 1.227, SD = 0.82), $p < 0.001$, and from the set size of 8 (M = 1.091, SD = 0.89), $p < 0.001$. The difference between the set size 6 and the set size 8 condition was not significant, $p = .253$. There was no main effect for age of face, $F < 1$, and no main effect for age of participant, $F < 1$. Sensitivity in younger participants (M = 1.33, SD = 0.96) did not differ from older participant scores (M = 1.31, SD = 0.81), $p = .91$.

Table 1
Exp. 1: Discriminability (d')

Age Group	Young Faces	Older Faces
Young Adults		
Set Size 4	1.75 (.92)	1.57 (.89)
Set Size 6	1.22 (.89)	1.26 (.97)
Set Size 8	1.11 (.97)	1.08 (1.00)
Older Adults		
Set Size 4	1.59 (.93)	1.67 (.72)
Set Size 6	1.40 (.70)	1.02 (.69)
Set Size 8	1.10 (.88)	1.07 (.83)

Note. Standard deviations in parentheses.

All two-way interactions were not significant, all $Fs < 1$. The three-way interaction between participant age, age of face, and test set size was not statistically significant, $F(2, 96) = 2.74$, $p = .069$.

Reaction Times

Reaction times from accurate trials were analyzed. All reaction time data are presented in Table 2. The assumption of sphericity was violated for set size, as assessed by Mauchly's test of sphericity, $\chi^2(2) = 8.921$, $p = .012$. Therefore, a Greenhouse-Geisser correction was applied ($\varepsilon = 0.853$). There was a main effect of set size, F (1.705, 81.850) = 147.83, $p < 0.001$, partial $\eta^2 = 0.755$. Post hoc pairwise comparisons using the Bonferroni correction revealed that reaction times for trials with a test set size of 4 (M =2278.79, SD = 707.20) differed significantly from trials with a test set size of 6 (M = 2816.13, SD = 1009.57), $p < 0.001$, and from trials with a test

Table 2

Exp. 1: Response Latencies (in milliseconds)

Age Group	Young Faces	Older Faces
Young Adults		
Set Size 4	1954 (503)	1926 (508)
Set Size 6	2292 (541)	2333 (615)
Set Size 8	2690 (791)	2556 (717)
Older Adults		
Set Size 4	2689 (743)	2546 (702)
Set Size 6	3354 (1073)	3285 (1149)
Set Size 8	3862 (1180)	3747 (1211)

Note. Standard deviations in parentheses.

set size of 8 (M = 3213.84, SD = 1151.44), $p < 0.001$. The difference between set size 6 and set size 8 was also significant, $p < 0.001$. There was also a main effect of participant age, F (1, 48) = 18.09, $p < 0.001$, partial $\eta^2 = 0.274$, such that faster reaction times were observed in younger adults (M = 2292, SD = 676) than in older adults (M = 3247, SD = 1127). There was no main effect for age of face, F (1, 48) = 2.66, $p = 0.11$.

There was a statistically significant two-way interaction between set size and participant age depicted in Figure 3, $F(2, 96) = 11.02$, $p < .001$, partial $\eta^2 = 0.187$. Post hoc pairwise comparisons using the Bonferroni correction revealed that reaction times differed significantly between younger and older adults at all test set sizes, such that faster reaction times were observed in younger adults than in older adults, all $ps < 0.001$. The mean difference in reaction time between younger and older adults at set size 4 (M = -677, SD = 173) was smaller than the

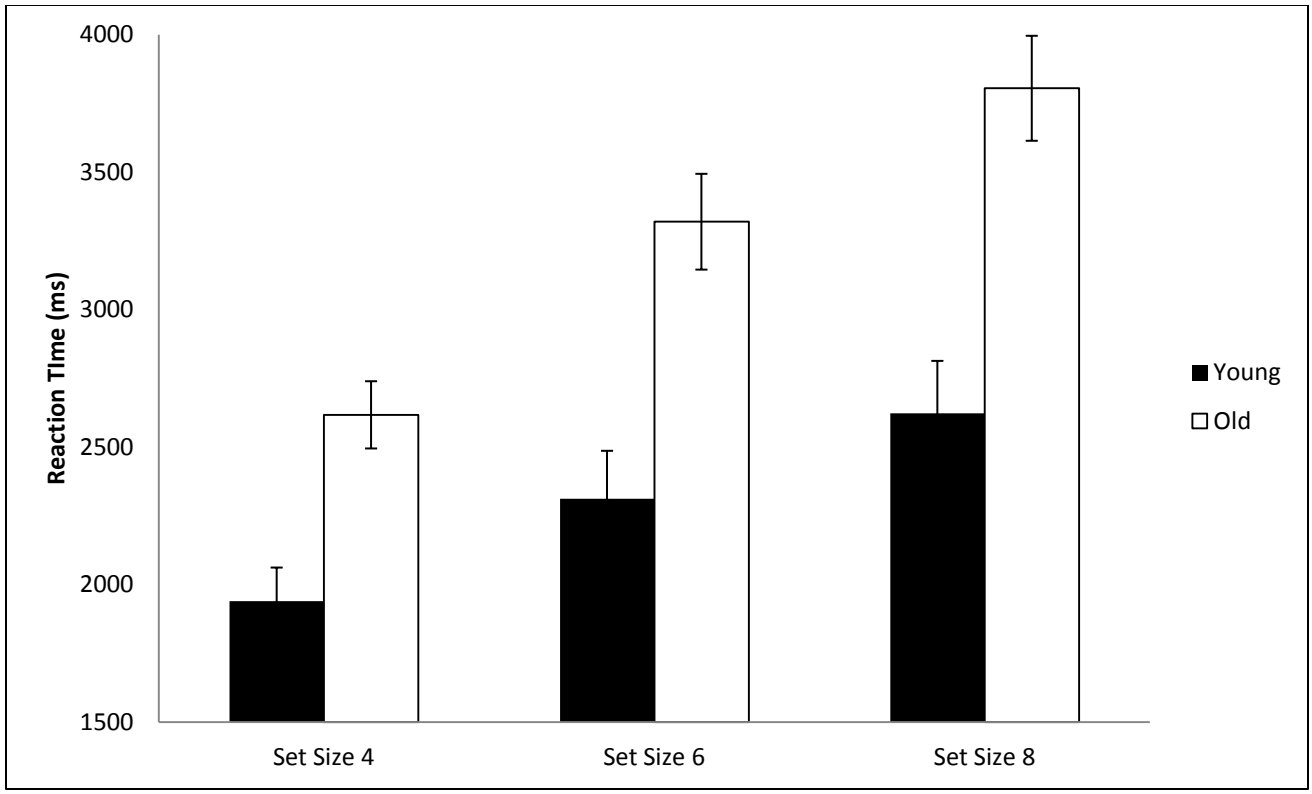

Figure 3. Response latencies in young and older adults as a function of test set size. Error bars represent the standard error of the mean.

mean difference at set size 6 (M = -1007, SD = 246) and the mean difference at set size 8 (M = -1182, SD = 270), suggesting that older adults' reaction times were affected by increasing set size more than younger adults. All other two-way interactions were not significant, all $Fs < 1$. The three-way interaction between participant age, age of face, and test set size was not statistically significant, $F < 1$.

Discussion

Analyses of the sensitivity data revealed that younger and older adults did not differ in *d'* scores; there were no age differences in sensitivity. There was no main effect of age of the face which precludes the possibility that one group of faces was more distinctive than the others. I found that test set size had an effect on sensitivity, such that higher *d'* scores were observed in trials of set size 4 compared to larger set sizes but there was no statistically significant difference between a set size of 6 and a set size of 8. I found no evidence of the OAB because there was no interaction between participant age and the age of the face; neither younger adults nor older adults showed higher discriminability for own age faces than for other age faces. There were no other interactions. Increasing set size led to a decline in sensitivity overall but no OAB was observed in larger set sizes.

As expected, older adults were slower than younger adults. The difference between younger adults' reaction times and older adults' reaction times became more pronounced as set size increased. There was no observable OAB; reaction times for own and other age faces were similar in both younger and older adults and the OAB did not become apparent at larger set sizes.

Experiment 2

Method

Participants

Twenty four undergraduate students (18 females; *M* age = 19.5, *SD* = 1.2) from Washington University in St. Louis were recruited through the psychology department subject pool. All participants completed a visual search task which took about 35 minutes and participated for course credit.

Materials

All participants were tested individually in a private testing room. Participants completed the experiment using a computer with a 15-inch monitor, on which stimuli was presented, and responded using the computer keyboard. The experiment was presented using Superlab 4.5 software (Cedrus Corporation, San Pedro, CA).

Facial Stimuli. The same facial stimuli used in Experiment 1 were used in this experiment. Refer to Figure 1 for an example. As in Experiment 1, there were 102 unique faces each of Caucasian young males, Caucasian young females, Caucasian older males, and Caucasian older females. One hundred and forty four faces were chosen to be used as target faces, 36 faces from each face category. Sixty six faces from each category were used as distractors in the test arrays and each distractor face was used a maximum of three times.

Facial Visual Search Task. For each block of faces, Caucasian young males, Caucasian young females, Caucasian older males, and Caucasian older females, there were 36 trials. There were three different types of trials: immediate, delay, and distractor. See Figure 4 for an example. The visual search task for the immediate condition consisted of a fixation cross presented for 500 *ms* followed by a target face presented in the center of the screen for 2000 *ms*, then another

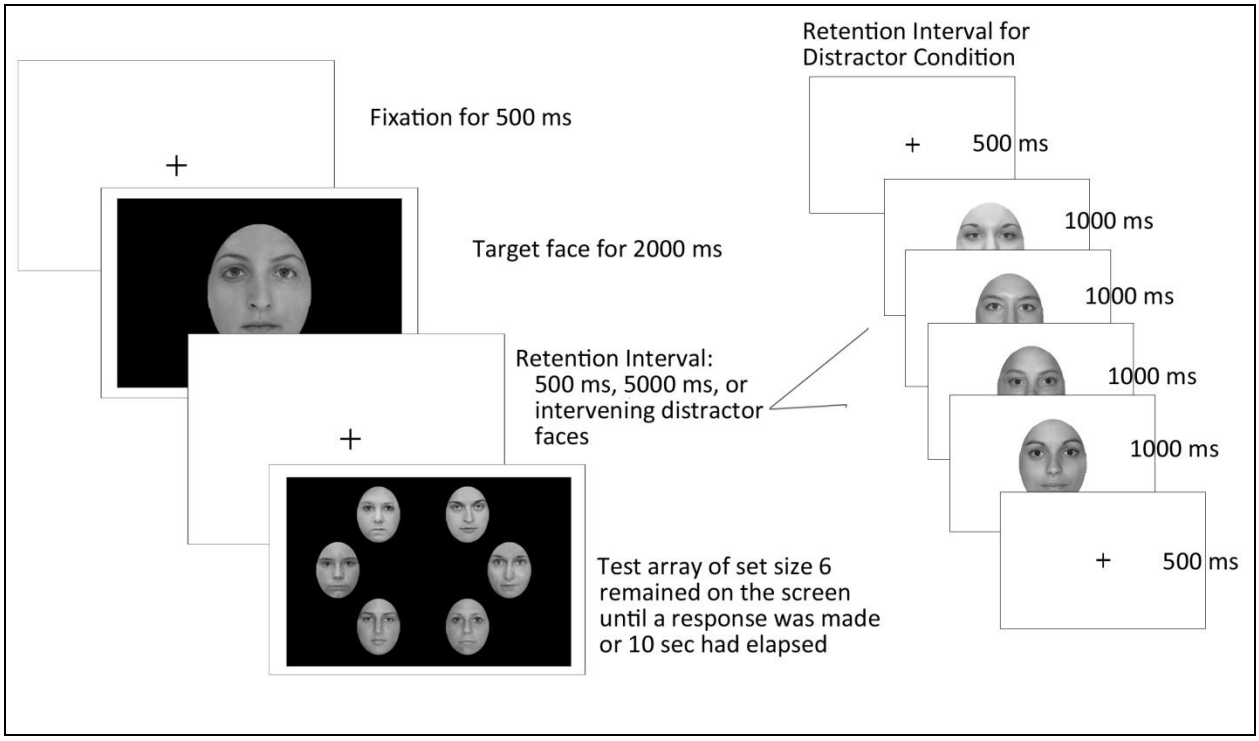

Figure 4. Sample target absent trial for Experiment 2.

fixation cross appeared for 500 *ms*, and, immediately after, a test array of six faces that belonged to the same category as the target face was presented. The delay condition was exactly the same as the immediate trials except that the retention interval lasted for 5000 *ms*; after the target face was presented, the screen was blank for 4500 *ms* and then an asterisk appeared for 500 *ms* before advancing to the test array. The third type of trial, the distractor condition, also consisted of a target face presented for 2000 *ms* and was followed by a fixation cross that appeared for 500 *ms*. Then, four distractor faces, from the same category as the target face, were presented one after the other for 1000 *ms* each and another fixation cross appeared on the screen for 500 *ms*.

In total, the amount of time between the presentation of the target face and the test array in the distractor condition was the same as in the delay condition, 5000 *ms*: after the target face, a fixation cross appeared for 500 *ms*, followed by four faces with a duration of 1000 *ms* each, and

then followed by another fixation cross that lasted 500 *ms* before the test array was presented. For distractor trials, participants were told to ignore the distractor faces and focus only on the target face. In all trials, participants indicated whether the target face was present or absent in the test array by pressing either the '/' or 'z' key on their keyboard. Once the participant responded, or after 10 *s*, the program advanced to the next trial. Each condition, immediate, delay, and distractor, consisted of 12 trials; within each condition, half of the test arrays contained the target face in an unpredictable position and half did not contain the target. For all trials, all of the test arrays had a set size of six faces. The trials were presented in a randomized order until all 36 target faces and their accompanying test arrays had been displayed. The same task was employed for all four blocks of faces. At the end of each block, the experimenter began the next block of trials which allowed the participant to take a short break between each block. The face blocks occurred in a random order.

Design and Procedure

A 2 (age of face: young or old) x 3 (trial type: immediate, delay, and distractor) within subjects design was used.

After participants consented to the study and demographic information was collected, the experimenter went over the instructions and practice trials with the participant. Participants were told they would briefly see a face which they should try to remember and to respond to the test array by indicating whether the face they had just observed was present or absent in the array. They were instructed to respond as quickly and as accurately as possible. The practice phase consisted of only three practice trials intended to familiarize participants with the three different types of trials; immediate, delay, and distractor trials. Only Caucasian young adult faces were used for the three practice trials. The practice trials were identical to the three types of trials in

the visual search task. After each practice trial, participants were given feedback and reminded of the instructions before advancing to the next trial. At the end of the practice phase, the experimenter began the first block of trials and the task began when the participant indicated they were ready to begin by pressing a key on the keyboard. The experimenter left the testing room after starting the block and returned once the participant had advanced through all 36 trials in order to begin the next block of trials. The blocks were presented in a random order. Participant responses and reaction times were recorded.

Results

Two separate 2 (age: young vs. old) x 3 (trial type: immediate, delay, or distractor) ANOVAs were conducted examining the effects of age of face (young vs. old) and trial type (immediate/delay/distractor) on both reaction times and *d'* scores. An alpha level of 0.05 was used for all *F*-tests.

Sensitivity

For all trials, *d'* scores were calculated using the hit rate and false alarm rate. The mean *d'* scores for Experiment 2 are presented in Table 3.

Table 3
Exp. 2: Discriminability (d')

Trial Type	Young Faces	Older Faces
Immediate	2.01 (.65)	2.16 (.89)
Delay	1.66 (.74)	1.63 (1.08)
Distractor	1.26 (.84)	1.10 (.79)

Note. Standard deviations in parentheses.

There was a main effect of trial type, F (2, 46) = 33.52, $p < 0.001$, partial $\eta^2 = 0.593$. Post hoc pairwise comparisons using the Bonferroni correction revealed that *d'* in the immediate condition (M = 2.09, SD = 0.77) differed significantly from the delay condition (M = 1.64, SD = 0.92), $p = 0.001$, and from the distractor condition (M = 1.177, SD = 0.81), $p < 0.001$. The difference between the delay condition and the distractor condition was also significant, $p = 0.004$. There was no main effect for age of face, $F < 1$. There was no interaction between the age of face and trial type, $F < 1$.

Reaction Times

Reaction times from accurate trials were analyzed. All mean reaction times are presented in Table 4. There was a main effect of trial type, F (2, 46) = 8.03, $p = 0.001$, partial $\eta^2 = 0.259$. Post hoc pairwise comparisons using the Bonferroni correction revealed that reaction times in the immediate condition (M =2520, SD = 308) differed significantly from the delay condition (M = 2752, SD = 431), $p = 0.006$, and from the distractor condition (M = 2754, SD = 482), $p = 0.023$. The difference between the delay condition and the distractor condition was not significant, $p =$

Table 4
Exp. 2: Response Latencies (in milliseconds)

Trial Type	Young Faces	Older Faces
Immediate	2516 (295)	2523 (328)
Delay	2794 (418)	2709 (448)
Distractor	2778 (423)	2730 (542)

Note. Standard deviations in parentheses.

1.0. There was no main effect for age of face, $F < 1$. There was also no interaction between age of face and trial type, $F < 1$.

Discussion

There was no evidence of the OAB in this younger adult sample, which confirms our findings from Experiment 1. Sensitivity did not differ between own age faces and other age faces. There was a main effect of trial type, such that sensitivity was higher in the immediate condition compared to the delay and distractor conditions. The immediate condition had a retention interval of 500 *ms* whereas both the delay and distractor conditions had a retention interval of 5000 *ms*, which indicates that longer retention intervals result in lower *d'* scores. The significant difference in *d'* scores between the distractor condition and the delay condition indicates that the presentation of faces between the target face and the test array also decreases sensitivity.

Analysis of reaction times did not reveal an OAB. The immediate condition resulted in faster reaction times than both the delay and distractor conditions but there was no difference between the delay and distractor conditions. There were no other significant main effects or interactions.

Experiment 3

Methods

Participants

Fifty two participants were recruited online through the Amazon Mechanical Turk website for this study. All participants indicated they were currently residing in the United States. There were 26 African American adults (19 females; *M* age = 32.5, *SD* = 10.5) and 26 Caucasian adults (18 females; *M* age = 35.2 years, *SD* = 10.1). All participants completed a visual search task which took about 30 minutes and they were paid $0.45 for their time.

Materials

All participants completed the task online using their personal computers.

Facial Stimuli. Four hundred and eight unique faces were transformed into grayscale, the brightness and contrast were adjusted manually, if necessary, to ensure that no photograph stood out from the others, and then each face was cropped into an oval shape to remove hair and other extraneous features using Adobe Photoshop. Refer to Figure 5 for an example. The images were collected by the experimenters from various online sources, the Chicago Face Database, the Minear and Park Database, as well as photographs taken by the experimenters. All of the faces appear in a frontal pose with a neutral expression. There were 102 unique faces each of African American young males, African American young females, Caucasian young males, and Caucasian young females. The set of Caucasian young males and Caucasian young females were identical to the young facial stimuli used in Experiment 1 and 2. One hundred and forty four faces were chosen to be used as target faces, 36 faces from each face category. This left 66 faces from each category to be used as distractors in the test arrays. Each distractor face was used a maximum of three times.

Figure 5. Sample stimuli of Caucasian and African American faces. Top left: African American female; top right: African American male; bottom left: Caucasian female; bottom right: Caucasian male.

Facial Visual Search Task. For each category of faces, Caucasian males, Caucasian females, African American males, and African American females, there were 36 trials. The visual search task was identical to the one used in Experiment 1 except that African American faces replaced the older adult faces. There were four blocks corresponding to each face category. A trial consisted of the presentation of a fixation cross for 500 *ms* followed by a target face for 2000 *ms*, then a fixation cross appeared on the screen for 500 *ms*, and then a test array of four, six, or eight faces from the same category as the target face was presented. The participant indicated whether the target face was present or absent in the test array by pressing either the '/' or 'z' key (counterbalanced) on their keyboard. Once the participant responded, or after 10 *s*, the program advanced to the next trial. There were 12 trials each with test set size of four, six, and eight and within each trial type, half of the test arrays contained the target face in an unpredictable position and half did not contain the target. The trials were presented in a randomized order until all 36 target faces and their accompanying test arrays had been displayed. At the end of each block, participants had the option to take a short break and the program did not advance to the next block until participants indicated they were ready to begin by pressing a key on their keyboard. The four blocks were presented in a random order.

Design and Procedure

A 2 (race of face: African American or Caucasian) x 2 (race of participant: African American or Caucasian) x 3 (test set size: four, six, or eight faces) mixed design was used with the race of participant as the between subjects variable. Following the collection of demographic information, eligible participants, those participants that identified as either African American or Caucasian, were provided with a link to the facial visual search task.

Participants were given online written instructions and were provided with three practice trials. Participants were told they would briefly see a face which they should try to remember and to respond to the test array by indicating whether the face they had just observed was present or absent in the array. They were instructed to respond as quickly and as accurately as possible. The practice phase consisted of only three practice trials intended to familiarize participants with the three different types of trials; test arrays of set size 4, 6, and 8. Only Caucasian adult faces were used for the three practice trials. Like in the actual task, participants were shown a target (practice) face for 2000 *ms*, then a fixation cross appeared for 500 *ms* followed by the test array which consisted of distractor faces from the same category as the target face. At the end of each practice trial, participants were given feedback and reminded of the instructions before advancing to the next trial. At the end of the practice phase, the program advanced to the first block when the participant indicated they were ready to begin by pressing a key on their keyboard. Block order was randomized by the program. Participant responses and reaction times were recorded.

Results

Two separate 2 (race of face: Caucasian vs. African American) x 2 (race of participant: Caucasian vs. African American) x 3 (test set size: 4, 6, or 8) mixed ANOVAs were conducted, with age as the between subjects variable, on both reaction times and *d'* scores. An alpha level of 0.05 was used for all *F*-tests.

Sensitivity

For all trials, *d'* scores were calculated using the hit rate and false alarm rate. The mean *d'* scores are presented in Table 5.

Table 5
Exp. 3: Discriminability (d')

Race of Participant	Caucasian Faces	African American Faces
Caucasian Adults		
Set Size 4	1.97 (.88)	1.59 (.91)
Set Size 6	1.49 (.85)	1.26 (.96)
Set Size 8	1.61 (.80)	1.13 (.69)
African American Adults		
Set Size 4	1.75 (.88)	1.69 (.90)
Set Size 6	1.37 (.82)	1.21 (.64)
Set Size 8	1.16 (.72)	1.29 (.84)

Note. Standard deviations in parentheses.

The main effect of race of face, F (1, 50) = 9.20, p = .004, partial η^2 = 0.155, can be explained by the two-way interaction between the race of face and participant race; *d'* for Caucasian faces was higher than for African American faces only in Caucasian participants. There was also a main effect of set size, F (2, 100) = 24.55, p < .001, partial η^2 = 0.329. Post hoc pairwise comparisons using the Bonferroni correction revealed that *d'* in set size 4 trials (M = 1.75, SD = 0.89) differed significantly from set size 6 trials (M = 1.335, SD = 0.82), p < .001, and from set size 8 trials (M = 1.30, SD = 0.78), p < .001. The difference between the delay condition and the distractor condition was not significant, p = 1.0. There was no main effect for race of participant, F < 1.

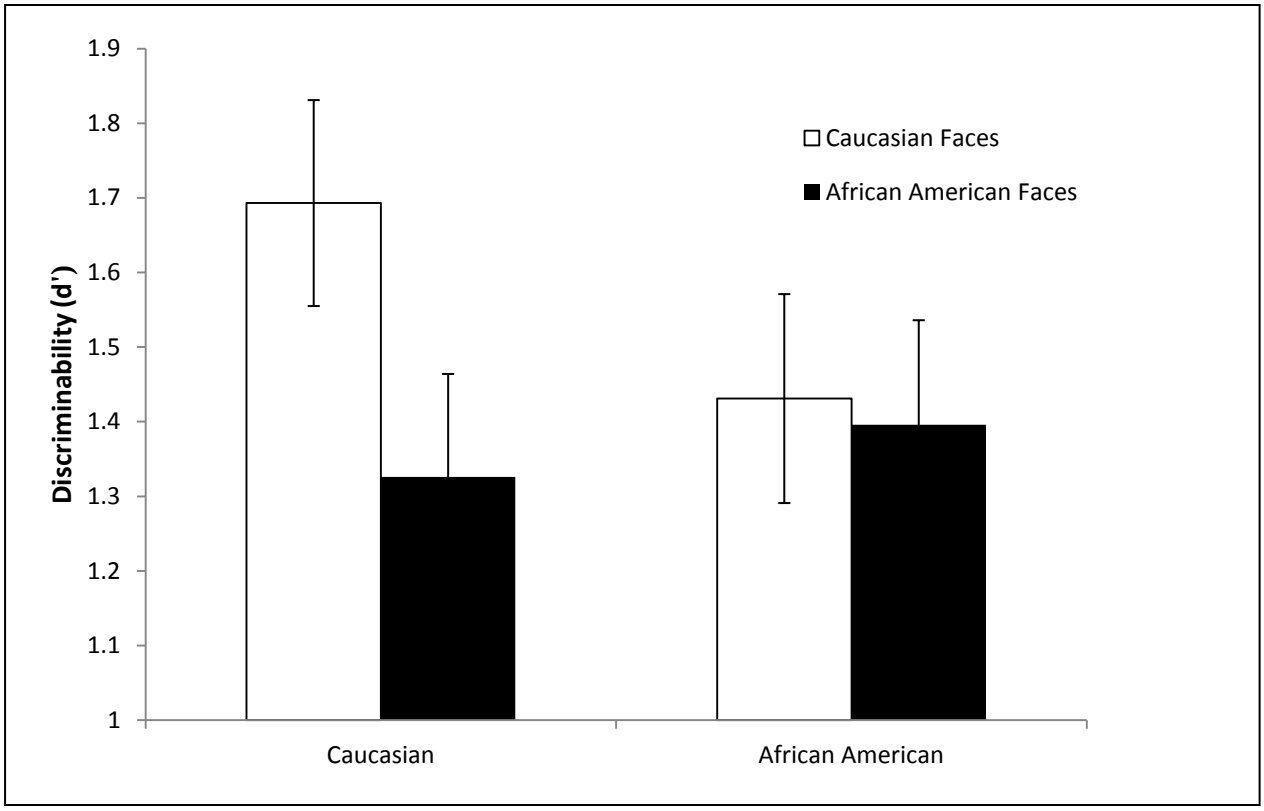

Figure 6. Discriminability for Caucasian and African American faces as a Function of Participant Race. Error bars represent the standard error of the mean.

There was a statistically significant two-way interaction between the race of face and participant race depicted in Figure 6, $F(1, 50) = 6.28$, $p < .016$, partial $\eta^2 = 0.112$. Post hoc pairwise comparisons using the Bonferroni correction revealed that, in Caucasian participants, *d'* scores were higher for Caucasian faces ($M = 1.69$, $SD = 0.86$) than for African American faces ($M = 1.33$, $SD = 0.87$), $p < .001$. However, in African American participants, *d'* was similar for Caucasian faces ($M = 1.43$, $SD = 0.82$) and for African American faces ($M = 1.40$, $SD = 0.82$), $p = .711$. All other two-way interactions were not significant, all $Fs < 1$. The three-way interaction between participant race, race of face, and test set size was not statistically significant, $F(2, 100) = 1.64$, $p = .20$.

Table 6
Exp. 3: Response Latencies (in milliseconds)

Race of Participant	Caucasian Faces	African American Faces
Caucasian Adults		
Set Size 4	2359 (667)	2367 (609)
Set Size 6	2925 (912)	2985 (850)
Set Size 8	3450 (787)	3385 (883)
African American Adults		
Set Size 4	2320 (626)	2301 (591)
Set Size 6	2792 (711)	2960 (571)
Set Size 8	3222 (817)	3342 (717)

Note. Standard deviations in parentheses.

Reaction Times

Reaction times from accurate trials were analyzed. All reaction time data are presented in Table 8.

There was a main effect of set size, F (2, 100) = 251.05, $p < .001$, partial $\eta^2 = 0.834$. Post hoc pairwise comparisons using the Bonferroni correction revealed that reaction times for trials with a test set size of 4 (M =2337, SD = 615) differed significantly from trials with a test set size of 6 (M = 2916, SD = 765), $p < .001$, and from trials with a test set size of 8 (M = 3349, SD = 796), $p < .001$. The difference between set size 6 and set size 8 was also significant, $p < .001$. There was no main effect for participant race, $F < 1$, and there was no main effect for race of face, $F < 1$. There were no statistically significant two-way interactions, all $Fs < 1$. The three-way interaction between participant race, race of face, and test set size was not statistically significant, F (2, 100) = 1.34, p = .267.

Discussion

I found evidence of the ORB only in Caucasian participants. Caucasian participants demonstrated higher sensitivity for Caucasian faces than for African American faces. In African Americans, however, sensitivity was similar for Caucasian and African American faces. Caucasian and African American participants had similar *d'* scores overall. Sensitivity was affected by set size, such that *d'* scores were higher in trials of set size 4 than in trials of set size 6 or 8. Sensitivity in trials of set size 6 did not differ from trials of set size 8.

For response latencies, only set size had an effect. All set sizes differed significantly from each other, such that increasing set size led to slower reaction times. There were no other

significant effects or interactions. There was no three-way interaction between participant race, the race of face, and set size, which indicates that larger set sizes did not lead to an ORB.

Experiment 4

Methods

Participants

Twenty two undergraduate students (18 females; *M* age = 19.2, *SD* = 1.4) from Washington University in St. Louis were recruited through the psychology department pool. All participants completed a visual search task which took about 35 minutes and participated for course credit. All participants identified as Caucasian.

Materials

All participants were tested individually in a private testing room. Participants completed the experiment using a computer with a 15-inch monitor, which was used to present the task, and responded using the computer keyboard. The experiment was presented using Superlab 4.5 software (Cedrus Corporation, San Pedro, CA).

Facial Stimuli. The same facial stimuli used in Experiment 3 were used in this experiment. Refer to Figure 3 for an example. As in Experiment 3, there were 102 unique faces each of Caucasian young males, Caucasian young females, African American males, and African American females. One hundred and forty four faces were chosen to be used as target faces, 36 faces from each face category. Sixty six faces from each category were used as distractors in the test arrays and each distractor face was used a maximum of three times.

Facial Visual Search Task. For each block of faces, Caucasian young males, Caucasian young females, African American males, and African American females, there were 36 trials. There were three different types of trials: immediate, delay, and distractor. The task was identical to the one used in Experiment 2 except that African American faces replaced the older adult faces. The visual search task for the immediate condition consisted of a fixation cross for 500 *ms*

followed by a target face presented in the center of the screen for 2000 *ms*, then a fixation cross appeared for 500 *ms,* and, immediately after, a test array of six faces that belonged to the same category as the target face was presented. The delay condition was exactly the same as the immediate trials except that the retention interval lasted for 5000 *ms*; after the target face was presented, the screen was blank for 4500 *ms* and then a fixation cross appeared for 500 *ms* before advancing to the test array. The third type of trial, the distractor condition, consisted of a target face presented for 2000 *ms* and was followed by a fixation cross that appeared for 500 *ms*. Then, four distractor faces, from the same category as the target face, were presented consecutively for 1000 *ms* each and were followed by another fixation cross which remained on the screen for 500 *ms*. For distractor trials, participants were told to ignore the distractor faces and to focus only on the target face. In all trials, participants indicated whether the target face was present or absent in the test array by pressing either the '/' or 'z' key on their keyboard. Once the participant responded, or after 10 *s,* the program advanced to the next trial. Each condition, immediate, delay, and distractor, consisted of 12 trials; within each condition, half of the test arrays contained the target face in an unpredictable position and half did not contain the target. For all trials, all of the test arrays had a set size of six faces. The trials were presented in a randomized order until all 36 target faces and their accompanying test arrays had been displayed. The same task was employed for all four blocks of faces.

Design and Procedure

A 2 (race of face: Caucasian or African American) x 3 (trial type: immediate, delay, and distractor) within subjects design was used.

After participants consented to the study and demographic information was collected, the experimenter went over the instructions and practice trials with the participant. Participants were

told they would briefly see a face which they should try to remember and to respond to the test array by indicating whether the face they had just observed was present or absent in the array. They were instructed to respond as quickly and as accurately as possible. The practice phase consisted of only three practice trials intended to familiarize participants with the three different types of trials; immediate, delay, and distractor trials. Only Caucasian adult faces were used for the three practice trials. The practice trials were identical to the three types of trials in the visual search task. After each practice trial, participants were given feedback and reminded of the instructions before advancing to the next trial. At the end of the practice phase, the experimenter started the first block of trials and the task began when the participant indicated they were ready to begin by pressing a key on the keyboard. The experimenter left the testing room after starting the block and returned once the participant had advanced through all 36 trials in order to begin the next block of trials. The blocks were presented in a random order. Participant responses and reaction times were recorded.

Results

Sensitivity

For all trials, *d'* scores were calculated using the hit rate and false alarm rate. The mean *d'* scores for all conditions are presented in Table 7.

There was a main effect of race of face, F (1, 21) = 6.18, p = .021, partial η^2 = 0.227, such that *d'* was higher for Caucasian faces (M = 1.82, SD = 0.72) than for African American faces (M = 1.59, SD = 0.85). There was a main effect of trial type, F (2, 42) = 17.74, p < .001, partial η^2 = 0.458. Post hoc pairwise comparisons using the Bonferroni correction revealed that *d'* in the immediate condition (M = 2.11, SD = 0.67) differed significantly from the delay

Table 7
Exp. 4: Discriminability (d')

Trial Type	Caucasian Faces	African American Faces
Immediate	2.31 (.59)	1.92 (.70)
Delay	1.66 (.59)	1.66 (.90)
Distractor	1.49 (.71)	1.19 (.81)

Note. Standard deviations in parantheses.

condition (M = 1.66, SD = 0.75), p =.008, and from the distractor condition (M = 1.34, SD = 0.77), $p < .001$. There was a trend for the difference between the delay condition and the distractor condition, $p = 0.059$. There was no interaction between race of face and trial type, F (2, 42) = 1.78, $p = .182$, partial $\eta^2 = 0.078$.

Reaction Times

Reaction times from accurate trials were analyzed. All mean reaction times are presented in Table 8. The assumption of sphericity was violated for trial type, as assessed by Mauchly's test of sphericity, $\chi^2(2) = 6.846$, $p = .033$. Therefore, a Greenhouse-Geisser correction was applied ($\varepsilon = 0.775$). There was a main effect of trial type, F (1.551, 32.562) = 21.46, $p < .001$, partial $\eta^2 = 0.505$. Post hoc pairwise comparisons using the Bonferroni correction revealed that reaction times in the immediate condition (M =2584, SD = 316) differed significantly from the delay condition (M = 2825, SD = 350), $p < .001$, and from the distractor condition (M = 2814, SD = 348), $p = .001$. The difference between the delay condition and the distractor condition was not significant, $p = 1.0$. There was no main effect for race of face, $F < 1$. There was also no interaction between race of face and trial type, F (2, 42) = 1.66, $p = .203$.

Table 8
Exp. 4: Response Latencies (in milliseconds)

Trial Type	Caucasian Faces	African American Faces
Immediate	2570 (318)	2598 (321)
Delay	2847 (350)	2802 (358)
Distractor	2855 (362)	2772.60 (336)

Note. Standard deviations in parentheses.

Discussion

I found that participants, who in this study were all Caucasian, had higher sensitivity for Caucasian faces than for African American faces which is evidence of the ORB and replicates our findings in Experiment 3. I also found that trial type affected sensitivity. Immediate trials resulted in higher *d'* than delay and distractor trials. There was a trend for the difference between the delay and distractor condition, such that delay trials resulted in higher *d'* than distractor trials. There was no interaction between the race of face and trial type; overall, *d'* scores were higher for own race faces and the OAB was not affected by trial type.

Reaction times did not show an ORB, replicating our findings from Experiment 3. There was an effect of trial type, such that reaction times in the immediate condition were faster than in the delay and distractor conditions. There was no interaction between the race of face and trial type, which indicates that longer retention intervals and the presentation of distractor faces did not lead to an ORB.

General Discussion

Researchers studying the OAB and the ORB have primarily used long-term memory tasks and the boundary conditions for these effects have not been definitively established. The aim of these experiments was to determine whether the OAB and the ORB are present in a perceptual task, given that very few studies have focused specifically on perceptual processes, and how various factors, such as set size and retention interval, impact the magnitude of the bias. For the online OAB task, because both younger and older participants were tested, it was also of interest whether increasing set size had a differential impact on the OAB in older and younger adults.

I found expected age effects in the online experiment, such that older adults were slower overall compared to younger adults and larger set sizes had a greater impact on older adults' reaction times compared to younger adults; the difference between older and younger adults reaction times increased as set size increased, which confirms previous findings (Hommel, K. Li, & Z. Li, 2004). There was no difference in sensitivity between older and younger adults, which is contrary to prior evidence showing poorer recognition in older adults (Shapiro & Penrod, 1986; Searcy, Bartlett, & Memon, 1999; Bartlett, Memon, & Swanson, 2001). Equivalent performance in older and younger adults suggests that eliminating the long-term memory component, which affects older adults more than younger adults, minimized previously found differences in facial recognition (Grady & Craik, 2000). However, declines in memory for faces may accelerate after age 70 and since only four participants in Experiment 1 were 70 years old or older, differences between young and older adults may be more evident with an older sample of older adults (Crook & Larrabee, 1992).

Surprisingly, I found no evidence of the OAB in a perceptual task in either younger adults or older adults. Sensitivity and reaction times did not differ for own-age and other-age faces across two experiments. Both older and younger adults' sensitivity and reaction times were affected by increasing test set size but larger set sizes did not give rise to an OAB. In the lab, young adults did not show a preference for younger faces but the three different trial conditions led to overall differences in sensitivity and reaction time.

Our findings were in opposition to robust evidence of the OAB across numerous studies and a variety of tasks, however, most past studies had a large memory component (Rhodes & Anastasi, 2012; Lamont et al., 2005; Randall, Tabernik, Aguilera, Anastasi, & Valk, 2012). A recent study by Kueffner et al. (2008) investigated the OAB with a perceptual task similar to the one used in this study and found that young adults recognized own-age faces more accurately and more quickly than children's faces. The authors found that child faces and newborn faces were not processed by adult participants as holistically as adult faces. However, child faces are configurally different compared to mature faces; structural changes due to craniofacial growth occur during the first 20 years of life (Mark & Todd, 1983, 1985; Pittenger, Shaw, & Mark 1979). Kueffner et al. found that although holistic processing in adults was finely tuned for adult faces, child faces were processed more holistically than newborn faces, which suggests that facial maturation facilitates processing. Although there are numerous structural changes that occur due to natural aging, such as wrinkling and continued cartilage growth, it is possible that these differences do not impede perceptual processing of older adult faces (Rhodes, 2009). If older and younger faces are processed similarly, it would help explain why I found equivalent performance for younger and older faces, regardless of participant age, and past evidence of the

OAB could be attributed to memorial processes. More research is needed to establish how younger and older adults process faces of varying maturity levels.

Wiese (2011) conducted a study looking at event-related potentials and found an OAB in Caucasian younger adults favoring young Caucasian faces but not young Asian faces, which indicates that the OAB is sensitive to the race of the face as well as age. In the current OAB experiments, I did not collect information about participants' race so it is possible that our null findings are due to participants' racial diversity because only Caucasian faces were used to assess the OAB. However, a study by Zhao & Bentin (2008) had participants categorize faces by race and age and found that observer race did not interact with the race of the face for age categorizations. The authors concluded that the physiognomic characteristics which allow categorization by age are universal. Although they found an interaction between observer race and the race of the face for race categorizations, it is unclear whether there is an interaction between observer race and race of face in a perceptual recognition task involving faces of different ages, which requires the individuation of target faces and not just general judgments of race or age. If Zhao and Bentin's findings are applicable to a perceptual recognition task, then the lack of a significant OAB is not due to racial diversity in our participant sample.

Another possibility is that the boundary conditions of the OAB are narrower than expected. The perceptual tasks in the current study always presented a target face for 2000 *ms* and had a retention interval of 500-5000 *ms*. Perhaps shorter exposure to the target and longer retention intervals are required to obtain the effect. The manipulation of set size, retention interval, and the presentation of distractor faces during the brief retention interval were not successful in uncovering an OAB despite numerous studies showing the effect in long-term memory tasks (Rhodes & Anastasi, 2012).

In the ORB experiments, I observed a preference for own-race faces, at least in Caucasian participants, as evidenced by the two-way interaction between race of face and participant race in the online study and by the main effect of race of face in the laboratory study. Caucasian individuals exhibited higher sensitivity for own-race faces than for African American faces but African Americans did not show the ORB.

Interestingly, I did not find an ORB in response latency despite previous research showing the effect in accuracy and reaction times in long-term recognition tasks (Meissner & Brigham, 2001; Wright & Sladden, 2003). Discriminability was better for own-race faces in Caucasian participants but reaction times did not differ by race of face either in the online study or in the laboratory, even though higher accuracy tends to be associated with faster reaction times (Sporer, 1993). Furthermore, a previous study by Megreya et al. (2011) found evidence of the ORB in a perceptual task in both accuracy and reaction time data. The authors found that UK and Egyptian individuals were more accurate and quicker when presented with own-race faces than with other-race faces on a perceptual matching task. Another study by Marcon et al. (2010) also found that Hispanic participants responded more accurately and more quickly to own-race faces than to other-race faces in a perceptual task similar to the one used in the current experiment. It is unclear why participants were not quicker with own-race faces especially when there is some evidence that indicates the ORB is present in response latencies (Marcon et al., 2010).

The current study failed to find a full crossover interaction of the ORB in both racial groups; only Caucasian individuals displayed the effect. One possible explanation for this is that the stimuli were not equivalent for each race of face. It is often assumed that the words ‘white’ and ‘black’ refer to homogenous racial groups whereas there is actually immense within-group

diversity in faces that could be categorized as white or black. For example, Chiroro et al. (2008) found a recognition advantage only for regional own-race faces. White South African participants showed better recognition performance for white South African faces compared to black South African faces but had no advantage for white American faces; black South African participants also showed an ORB for South African faces but not for American faces. In the current study, ethnic background and regional differences in participants that identified as Caucasian or African American were not controlled so it could be the case that African American participants in this study considered both groups of faces as out-groups rather than identifying more with the African American faces.

In general, sensitivity was affected by larger set sizes, longer retention intervals, and the intervening distractor faces. Set size and the duration of the retention interval are known to affect general facial recognition memory and may impact the ORB in long-term memory tasks but it is still unclear whether these factors have the same effect in perceptual tasks (Meissner & Brigham, 2001; Shapiro & Penrod, 1986; Penrod, 2008; Palmer et al., 2013). Intervening distractor faces have been shown to impact recognition accuracy in a long-term memory task (Laughery, Alexander, & Lane, 1971). However, in the current study, increasing test set size, longer retention intervals, and the addition of intervening distractor faces did not lead to a larger ORB.

Our findings contradict many long-term memory studies looking at the ORB and at least one perceptual study (Meissner & Brigham, 2001; Marcon et al. 2010). Marcon et al. (2010) found that the ORB was exacerbated when target exposure time was decreased and retention interval was increased. They also found that larger test set sizes led to a more pronounced ORB. The current findings, however, suggest that whereas set size, retention interval, and distractor faces impact sensitivity and reaction times overall, there is no effect on the ORB. Clearly more

research is needed to clarify the boundary conditions of the ORB and to determine whether factors that exacerbate the ORB in long-term memory studies have the same effect in perceptual tasks. It should be noted that exposure to the target in Marcon et al.'s study ranged from 100-1500 *ms* and that they did not find an ORB at exposure times of 1000 *ms* or 1500 *ms*. The current experiments held exposure time constant at 2000 *ms* yet still succeeded in finding an ORB. Perhaps differences in overall task difficulty between the current study and the experiments by Marcon et al. could explain the differences in our findings.

Participants were shown the same target images in the test arrays rather than a second photograph of the same individual. It was necessary to reduce the possibility that participants would rely on photograph-specific details in place of facial features to recognize images of faces. For this reason, I cropped, auto-balanced, and converted all stimuli to grayscale, which may have increased the overall task difficulty. There is some reason to believe that when the outer features of the face are removed, such as when faces are cropped, participants are not as accurate at processing the configural relationship of features as when the whole face is presented (Rhodes et al., 1989). Although this could simply be due to an added benefit from the presence of hair cues, it is also possible that the outline of a face allows for increased holistic processing (Rhodes et al., 1989; Rhodes et al., 2006; Sporer & Horry, 2011). Rhodes et al. (2006) and later Sporer and Horry (2011) found that out-group faces were hurt more by the removal of outer facial features than in-group faces. However, there is no reason to believe that cropping faces could have detracted from the current findings because I found clear evidence of the ORB even with facial stimuli devoid of hair cues and outer features. Also, a previous study looking at the OAB found a strong effect in children and adults using faces that were cropped and converted to grayscale in the same manner as the facial stimuli used in the present experiments (Kueffner et al., 2008,

Cassia, Picozzi, & Bricolo, 2008). Failure to find the OAB in this study is unlikely to be attributable to the nature of the facial stimuli.

The contact hypothesis and experience-based theories, which have previously been applied to both the OAB and ORB, assert that differential experiences with in-group and out-group faces affect the processing of faces which underlies the observed differences in performance. One way to interpret the current findings, which failed to reveal any evidence for an OAB but did find an ORB using the same search paradigm task, is that differential attention to in-group members, as a result of different levels of contact, occurs during any type of information processing task even when the memory load is minimized to one face and the retention interval is very brief, as in the current experiments. Since participants were not asked to provide information about current contact or experience with out-group faces, it is impossible to determine whether the OAB is present among young adults and older adults who have little contact with the other age group. The ORB can be explained by the magnitude of life-time experiences with other-race faces or current contact with other-race faces; also, the possibility of a simple in-group/out-group framework, motivated solely by social factors, cannot be excluded. However, current contact with other-age faces may be the mechanism underlying the OAB since there was no evidence of an OAB in the current tasks. Given that the same tasks revealed an ORB, it is unlikely that the in-group/out-group framework is driving the effect. The current findings suggest that different mechanisms may underlie the OAB and the ORB although the effects appear similar on the surface.

The current study confirmed that the ORB is present in a perceptual task but I found no facial bias in response latency. From our findings, it is clear that further research is required to assess the boundary limits of the OAB and the ORB, especially because no preference for own

age faces was demonstrated. Although past studies have shown that factors such as retention interval and test set size impact the magnitude of the ORB and the OAB, these findings were not confirmed in the current perceptual tasks. From a more practical standpoint, it is apparent that cross-racial recognition is less accurate even when the memory component is minimized, which could have implications for identification checks made by law enforcement. In the United States, passport photos and I.D. card photos are renewed years after the original picture was taken; in addition to cross-racial identifications, aging, cosmetic changes in appearance, and disguises could make facial recognition more difficult. Future research should determine how other factors, such as changes in appearance, impact the ORB and the OAB. It is yet to be definitively established whether there is an OAB in perceptual tasks and whether the boundary conditions differ between the ORB and the OAB. Understanding how in-group and out-group faces are processed at the perceptual level can elucidate the factors that give rise to facial recognition bias.

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