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The own-age face recognition bias is task dependent

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The own-age bias (OAB) in face recognition (more accurate recognition of own-age than other-age faces) is robust among young adults but not older adults. We investigated the OAB under two different task conditions. In Experiment 1 young and older adults (who reported more recent experience with own than other-age faces) completed a match-to-sample task with young and older adult faces; only young adults showed an OAB. In Experiment 2 young and older adults completed an identity detection task in which we manipulated the identity strength of target and distracter identities by morphing each face with an average face in 20% steps. Accuracy increased with identity strength and facial age influenced older adults' (but not younger adults') strategy, but there was no evidence of an OAB. Collectively, these results suggest that the OAB depends on task demands and may be absent when searching for one identity.

Adults often demonstrate superior abilities in the discrimination and recognition of faces belonging to categories with which they have abundant experience compared to faces belonging to less experienced categories. They recognize human faces more accurately than other-species faces (Scott, Shannon, & Nelson, 2005) and within human faces they recognize upright and own-race faces more accurately than inverted (Yin, 1969) and other-race faces (see review by Meissner & Brigham, 2001). Superior recognition of faces from over-experienced categories has been attributed to perceptual expertise as well as to social cognitive factors. According to perceptual expertise accounts, extensive experience with faces from a given category (e.g., own-race) results in exquisite sensitivity to differences among faces in, for example, the shape and spacing of facial features (e.g., Mondloch *et al.*, 2010; Rhodes *et al.*, 2009; Tanaka & Pierce, 2009). According to social cognitive accounts, adults encode faces of in-group members at the individual level whereas they encode faces of outgroup members at the categorical level (Ge *et al.*, 2009; Levin, 2000; Sporer, 2001). Recent proposals have argued for an integrative framework in which social cognition and perceptual expertise interact in determining an individual's sensitivity to individuating facial characteristics (Sporer, 2001; Young, Hugenberg, Bernstein, & Sacco, 2012). This framework provides insights about the recognition bias that is the focus of this paper: the own-age bias (OAB).

Faces change in systematic ways across the lifespan: throughout the first 20 years of life, the nasal and jaw regions increase and the eyes decrease in size relative to the rest of

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the face, the nose and nasal bridge develop a more angular shape, and the forehead becomes more sloping. Later in adulthood, the nose and ears become larger as a result of the cartilage growth, skin begins to sag and develop wrinkles, lips become thinner as fatty tissue dissipates, and eyebrows become thicker (Rhodes & Anastasi, 2012). Facial age is an inherent part of structural encoding and is processed regardless of task demands (Wiese, Schweinberger, & Neumann, 2008). Thus, it is not surprising that facial age influences both identity matching (in two-alternative forced-choice [2AFC] tasks) and recognition memory accuracy.

In a seminal study by Bäckman (1991), both young and young-older (62–69 years) adults recognized own-age faces more accurately than other-age faces regardless of whether the faces were familiar (famous) or unfamiliar; old-older adults (75- and 85-year-olds) showed an own-age advantage for familiar faces only. This original finding of an OAB in young adults has been replicated in numerous studies investigating either identity recognition or identity matching when performance for young adult (i.e., own-age) faces was compared to that for older adult faces (e.g., Anastasi & Rhodes, 2006; He, Ebner, & Johnson, 2011; Wiese, Schweinberger, & Hansen, 2008), child faces (Anastasi & Rhodes, 2005; Harrison & Hole, 2009; Hills & Lewis, 2011; Kuefner, Macchi Cassia, Picozzi, & Bricolo, 2008; Experiment 2) or newborn faces (Kuefner *et al.*, 2008; Experiment 1; Macchi Cassia, Kuefner, Picozzi, & Vescovo, 2009; Macchi Cassia, Picozzi, Kuefner, & Casati, 2009). Differential processing of young and older adult faces among young adult participants has also been observed in electrophysiological studies showing enhanced ERP responses to own-age faces compared to older adult faces and to own-age faces that are correctly categorized as familiar (hits) versus correctly categorized as novel (correct rejections) (Ebner, He, Fichtenholtz, McCarthy, & Johnson, 2011; Wiese, Komes, & Schweinberger, 2012; Wiese, Schweinberger, & Hansen, 2008).

More mixed and inconclusive findings come from studies with older adult samples: whereas some studies demonstrated an OAB in older participants (Anastasi & Rhodes, 2005; Perfect & Harris, 2003), others reported a less reliable or non-existent age bias in older adults relative to young adults (Bäckman, 1991; Bartlett & Leslie, 1986; Fulton & Bartlett, 1991; Wiese, Schweinberger, & Hansen, 2008; Wright & Stroud, 2002). A recent review by Rhodes and Anastasi (2012) showed that the OAB has been found in older adults across many studies, although the effect is weaker compared to that observed in young adults. Indeed it is not surprising that older adults show a less robust OAB than young adults given perceptual experience being accumulated with different age groups over the lifespan (Anastasi and Rhodes, 2006; Wiese, Schweinberger, & Hansen, 2008). Although older adults often report more current experience with older faces (i.e., their own face, their spouse, friends) than young adult faces, experience early in life is primarily with young adult faces (Rennels & Davis, 2008). Given the special influence of early experience in shaping perceptual expertise for adult faces (Macchi Cassia, Bulf, Quadrelli, & Proietti, 2013) and the continuous nature of experience with young adult faces across the lifespan, it is perhaps not surprising that recent experience with older faces does not translate into a robust OAB later in life. Discrepant results also can be attributed to variability among older adults in recent daily-life contact with own-age people (which varies depending on living conditions), and a failure to correct for lower performance among older adults (relative to young adults) masking the influence of face age (see Wiese *et al.*, 2012). Although Wiese, Schweinberger, and Hansen (2008) did not find an OAB among older adults, in a later study by the same group (Wiese *et al.*, 2012), older adults who reported having more recent contact with older adults compared to young adults showed a significant OAB, as well as more a more negative N250 (an event – related potential thought to reflect identity perception, Schweinberger, Pfütze, & Sommer, 1995; Zheng, Mondloch, & Segalowitz, 2012) for correct rejections than hits for own-age faces; these patterns were absent in older adults who reported more recent experience with young than older adults.

The influence of facial age on recognition accuracy may be mediated by distinctiveness (i.e., the extent to which the face deviates from an average or prototypical face). One conceptualization of how faces are represented in memory is norm-based coding (Valentine, 1991). According to this view individual faces reside in a multi-dimensional face space in which each dimension (vector) represents a characteristic (e.g., eye size; distance between eyes and mouth) on which faces vary. A prototype or norm resides in the centre of face space; this norm is the average of the faces viewed previously and is continuously updated by experience. The distance of each individual face from the prototype represents how distinctive the face is, with faces closer to the norm being judged as more typical and attractive than faces far from the norm (Rhodes & Tremewan, 1996). In addition, distinctive faces are easier to recognize (O'Toole, Jiang, Roark, & Abdi, 2006; Valentine, 1991). Valentine (1991) proposed that faces from unfamiliar categories (e.g., other-race faces, inverted faces) are difficult to discriminate and recognize because they all deviate from the norm in the same way and so are clustered together in the periphery of face space. Although recent studies suggest separable norms for various face categories (e.g., Jaquet, Rhodes, & Hayward, 2008; Rhodes *et al.*, 2004), one conceptualization of the cross-race and cross-age effects is that the perceivers' face space is likely optimized for the dimensions of the face categories most frequently observed (Rhodes, Jeffery, Taylor, Hayward, & Ewing, 2014; Valentine & Endo, 1992) and for this reason perceivers are less sensitive to differences along dimensions among faces from less familiar categories. In a highly related characterization of face representation faces are represented in an exemplar-based system; again, faces are located in a multi-dimensional space with the density of faces varying, but they are represented independently of one another with no role for a face prototype (Valentine, 1991; see Bruce & Young, 2012 for a discussion of these two models). According to both the norm-based and exemplar-based models, the OAB among young adults may be attributable to perceivers being less sensitive to dimensions that distinguish among infant, child, or older faces compared to young adult faces.

Support for this hypothesis comes from a recent study providing direct evidence that both young and older adults are less sensitive to deviations from the norm in older compared to young adult faces (Short & Mondloch, 2013). Participants were shown two versions of a facial identity; one version was undistorted and the other had facial features that were compressed or expanded. For each face pair participants were asked to express two judgements: a normality judgement (which face looks more normal?) and a discrimination judgment (which face looks more expanded?). Face age did not influence accuracy when participants were asked to indicate which member of each pair was expanded, a discrimination task that does not require referencing a prototype. In contrast, both age groups were more accurate with young faces than older faces when asked which member of each pair was more typical, a task that requires referencing a norm. Critically, the older adults in Short and Mondloch's study reported significantly more recent contact with older adults than young adults, comparable to the high-contact older adults tested by Wiese *et al.* (2012) who showed an OAB on an old/new recognition task.

Building on this evidence, in the current study we examined whether older adults and young adults who report preferential contact with own-age people would show an OAB in a recognition task in which deviation from an average face was directly manipulated. To directly assess the influence of face age on sensitivity to facial identity in the context of a norm-based coding model, we adopted a method used by Zheng *et al.* (2012) to investigate the timing of individual face recognition in the brain. We created an average young and an average older adult face based on 24 identities per face age and then varied the identity strength of each individual face by morphing it with the average in 20% steps. In each block of trials participants first learned one facial identity to criterion (at 100%) and then were asked to press a button each time they detected that identity (at 20%, 40%, 60%, 80%, or 100%). If greater sensitivity to how individual young (vs. older) faces deviate from a face prototype/norm underlies the widely reported OAB in young adults, then young adults should be more sensitive to identity strength in young adult faces than older adult faces. Greater sensitivity to identity in young adult faces would be indicated if accuracy was higher overall or if changes in accuracy as a function of identity strength were larger (e.g., if the slope was steeper across the entire or early steps of the identity continuum) for younger faces than older faces. Based on the results of Short and Mondloch (2013), we reasoned that older adults might also show greater sensitivity to identity strength in young faces. Although the literature is filled with conflicting findings, if older adults' greater sensitivity to deviations from the norm in young faces when judging normality (see Short & Mondloch, 2013) extends to judgements of facial identity, then they should show greater sensitivity to facial identity in young faces in an identity task that directly taps norm-based coding.

In addition to assessing face recognition within the context of the norm-based coding model, our identity detection task taps into a different aspect of face recognition than delayed match-to-sample and old/new recognition tasks. Although some early studies investigating age biases (e.g., Wright & Stroud, 2002) used eyewitness paradigms in which participants were asked to identify the culprit of a crime previously seen in a mock crime scene video, in most studies participants performed a task (i.e., learning multiple faces in a short period of time and then completing an old/new task) that does not directly correspond to a behaviour people would normally perform in everyday life. Here, we tested participants in a task that taps into a challenge faced on a daily basis: searching for a specific person among other people of the same age, some of whom look very similar.

Prior to conducting our identity detection task (Experiment 2) we tested young and older adult participants using a standard paradigm known to be sensitive to face age and age experience (Sangrigoli & de Schonen, 2004; Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005): a 2AFC task that included both young and older adult faces. Our goals in administering this task were to (i) replicate an OAB in young adult participants using the 100%-identity faces created for our identity detection task, (ii) determine whether an OAB would be observed in older adults, and (iii) assess whether young and older adults could successfully match identities when identity strength was reduced to 60%.

EXPERIMENT 1

In Experiment 1, we tested young and older adult participants in a 2AFC task with young and older adult faces. To increase ecological validity, we created a set of stimuli in which hair was visible but held constant across identities within each age group (i.e., did not contribute to face recognition; see Figure 1). The 2AFC paradigm has proved to be a sensitive measure of the OAB and the modulatory effects of experience in numerous previous studies. For example, young adults who have minimal experience with older adult faces show an advantage in matching the identity of young adult faces compared to older adult faces, whereas participants working in retirement homes do not (Proietti,

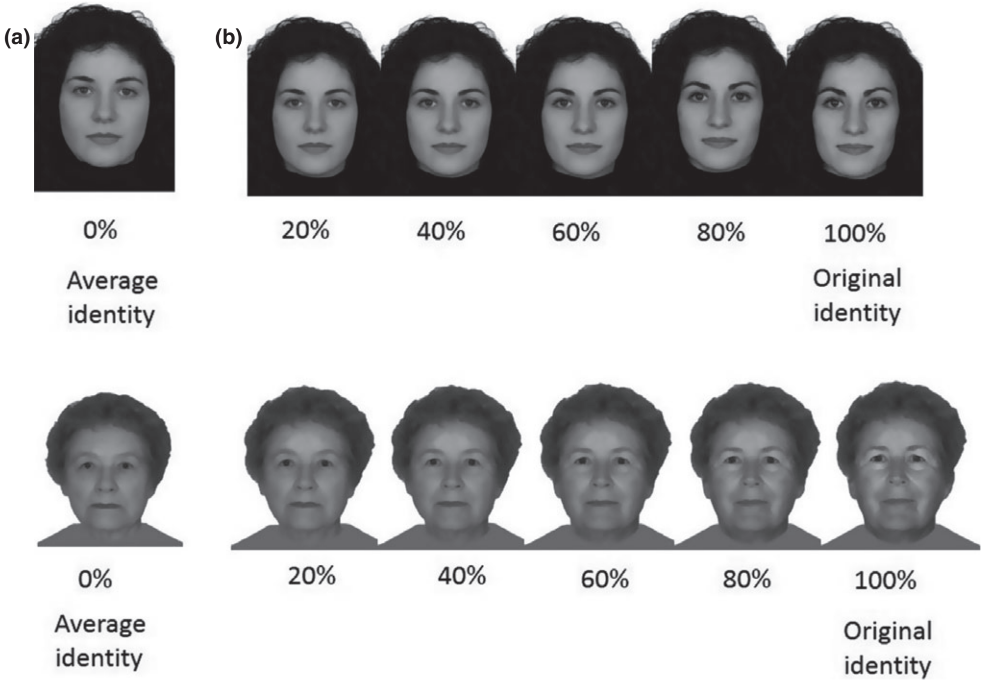

Figure 1. Examples of the face stimuli used in the study. Each original 100% identity was morphed with the "average" face (a) to produce four new levels of identity strength (b). Only the 100% and 60% faces were used in Experiment 1; all versions were used in Experiment 2.

Pisacane, & Macchi Cassia, 2013; see also Kuefner *et al.*, 2008; Macchi Cassia, Pisacane, & Gava, 2012). No previous study using a match-to-sample task has examined the OAB in older adults. This age group is of particular interest because they had early and life-long experience with young adult faces but recent extensive experience with older adult faces. We expected young adults to be better at matching identity for own-age faces compared to older adult faces, thus replicating earlier findings using our new stimulus set. In light of mixed and conflicting evidence for age biases in older adults, we made no specific hypothesis for older adults.

In anticipation of Experiment 2, we tested participants with either 100% or 60% identity faces (i.e., 60% target/40% average; see Figure 1) to determine whether reducing identity strength (i.e., increasing deviations from the norm) would differentially impact matching of young versus older identities. Given that both young and older adults were less sensitive to deviations from an average face when judging normality in older compared to young adult faces (Short & Mondloch, 2013), we predicted that reducing identity strength to 60% (i.e., making the face less distinctive) would impair identity matching of older adult faces more than young adult faces for both participant groups.

Method

Participants

Forty Caucasian undergraduate students (mean age = 21.25 years; range = 18–27; 10 males) and 40 Caucasian older adults living in independent housing (mean age = 67.8 years; range = 60–83 years; 13 males) participated in the study. Half of the participants in each group were tested in Canada and half in Italy. Experience with older adults can shape perceptual mechanisms involved in face recognition (Proietti *et al.*, 2013), so young adult participants were selected for having acquired less than 500 hr of experience with older faces in the last year (modelled after Proietti *et al.*, 2013). Both young and older adult participants reported spending more time with own-age peers (58.4 and 50.32 hr per week, respectively) than with other-age (3.4 and 11.8 hr per week, respectively) individuals. Young adult participants reported normal or corrected-to-normal vision. Older adults had at least 20/30 vision with 31 participants having 20/20 vision.

Materials

Questionnaire

Each participant completed a questionnaire to determine the amount of experience he/she had accumulated with young versus older adult faces. The questionnaire assessed the composition of the participant's household, the amount of contact with relatives, friends and acquaintances belonging to different age groups, and contact with people belonging to different age groups through full- or part-time employment.

Stimuli

Stimuli consisted of grey-scale photographs of young adult (20- to 30-year-old) and older adult (60- to 90-year-old) faces (n = 24 per age). All faces were Caucasian, female, displayed full-front neutral expressions, and were unfamiliar to the participants. Older adult faces were acquired from the Center for Vital Longevity Face Database (Minear & Park, 2004) whereas younger adult faces were the same as those used in Zheng *et al.* (2012). We generated an average of the 24 identities within each age group using Norrkross MorphX software. Because the morphing procedure reduces the salience of wrinkles and other age-related cues, we applied the texture of an additional unfamiliar older adult face to the older average face. That average face was then morphed with each identity to create four new levels of identity strength: 20% (i.e., 20% identity, 80% average), 40%, 60%, and 80% (Figure 1). Only the original identities and 60% identities were used in Experiment 1; all identity strengths were used in Experiment 2. To eliminate hair cues to identity we applied the same hair-style to all faces within each age group. All faces subtended 15.3 × 12.1 visual degrees when viewed from 60 cm and appeared on a white background. We created 12 face pairs for each face age; pairs were selected based on subjective criteria of similar luminance and overall similarity, so as to maximize task difficulty despite our task having minimal memory demands and presenting identical pictures at study and test. An additional four male face images (two for each face age) were used as stimuli in the practice trials.

Procedure

All procedures in Experiments 1 and 2 received clearance from the Research Ethics Boards of the University of Milano-Bicocca and Brock University. Informed written consent was obtained before testing each participant. We used a 2AFC task (e.g., Kuefner *et al.*, 2008; Proietti *et al.*, 2013), in which a target face was presented centrally for 1,000 (young participants) or 2,000 (older adults) ms, followed by a 500-ms blank inter-stimulus interval

(ISI) and then two probe stimuli, the target and a distracter, presented side by side until a response was made. Our goal in using different presentation times for younger and older adults in this study and in Experiment 2 was not to match performance; rather, we wanted to encourage participants in both groups to be engaged in the task. We presented stimuli to young adults for 1,000 ms to match the presentation time used in previous studies in which a similar paradigm was used (Kuefner *et al.*, 2008; Macchi Cassia *et al.*, 2012; Proietti *et al.*, 2013), with the specific goal of replicating a recognition bias for young over older adult faces in young adults (Proietti *et al.*, 2013). We chose a longer presentation time for older adults based on pilot testing and on previous studies reporting a longer presentation time for this age group (Chaby, Narme, & George, 2011; Short & Mondloch, 2013). Participants were asked to indicate which face was the target by pressing one of two keys on the keyboard as quickly and as accurately as possible. Each session began with four practice trials with male faces (two young adult, two older adult) followed by 48 test trials. All participants were tested with both young and older faces, which were presented in alternating blocks (12 trials per block); the age of face presented in Block 1 was counterbalanced across participants. Half of the participants were tested with 60% stimuli and half were tested with 100% stimuli. Each face pair was presented twice (once in each block) but which member of the pair was the target varied.

Results

To compare participants' performance for young and older adult faces we analysed mean per cent correct and median response times for correct responses in two mixed Analyses of Variance (ANOVAs). Each ANOVA had one within-subjects factor – face age (young and older), and two between-subjects factors – participants' age (young adult and older adult) and identity strength (100% and 60%). Median response times were used to control for outliers.

Response accuracy

The analysis of mean per cent correct revealed a main effect of face age, $F(1, 76) = 7.115$, $p = .009$, $\eta^2 = .086$; as shown in Figure 2, participants recognized young faces ($M = 92.9.\%$) more accurately than older faces ($M = 90.7\%$). There was a significant effect of identity strength, $F(1, 76) = 6.536, p = .013, \eta^2 = .079$, with higher accuracy in the 100% ($M = 93.5\%$) than in the 60% condition ($M = 90.1\%$), and a marginal effect of age group, $F(1, 76) = 3.712$, $p = .058$, $\eta^2 = .047$, with young adults being slightly more accurate ($M = 93.1\%$) than older adults ($M = 90.5\%$). These main effects were qualified by an interaction between face age and age group, $F(1, 76) = 5.326$, $p = .024$, $\eta^2 = .065$. Young adults' performance was affected by face age, with higher performance for young ($M = 95.2\%$) than older adult faces ($M = 91.0\%$), $t(39) = 3.559$, $p = .001$, $d = 0.69$, whereas older adults' performance was not ($M_{\text{young faces}} = 90.6\%$; $M_{\text{older faces}} = 90.3\%$), $p = .80$. Identity strength did not interact with any other factor, all ps $> .10$. We conducted one additional planned t-test comparing young adults' accuracy for young versus older adult faces at 100% identity strength to confirm replication of a basic OAB in young adults. Accuracy was significantly higher for young ($M = 97.4\%$) than older ($M = 92.0\%$) adult faces, $t(19) = 4.96, p < .001, d = 1.19$.

In addition, given that Bäckman (1991) only found an OAB for unfamiliar faces in young-older adults (age range 62–69), we compared accuracy for young versus older adult

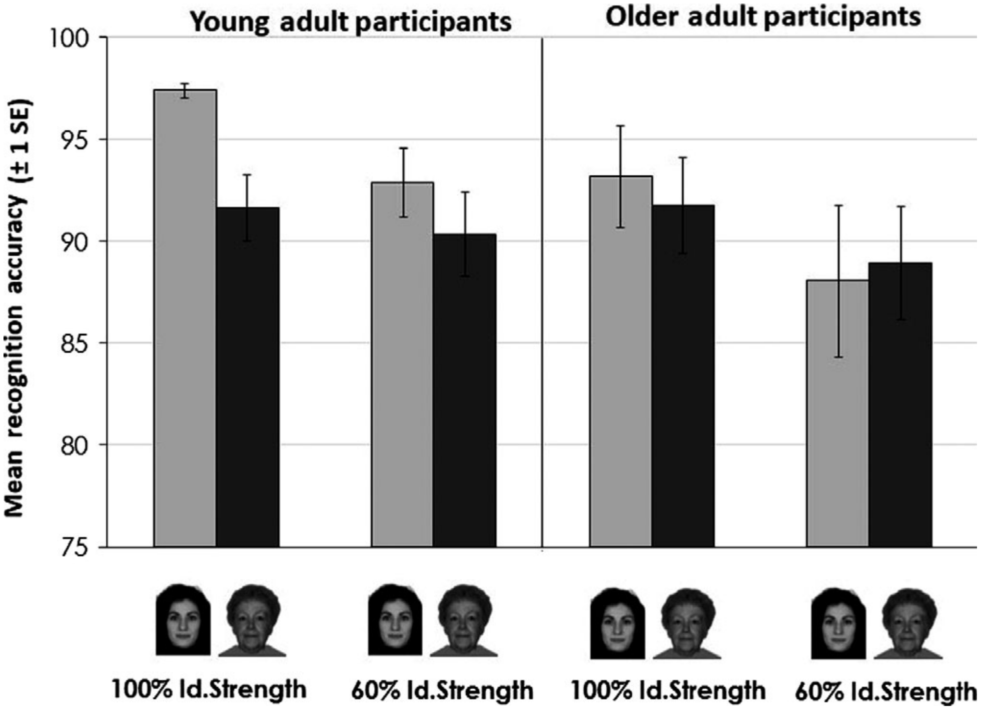

Figure 2. Mean per cent of correct responses for young and older adult faces exhibited by young adults and older adults in the 100% and 60% conditions of Experiment 1.

faces among the young-older adults in our sample collapsed across the two identity strengths (N = 17, age range 62–69). As reported in the main analysis, their accuracy was essentially identical for the two face ages (young faces, M = 90.6%; older faces, M = 91.2%).

Response times

The analysis revealed significant main effects of age group, $F(1, 76) = 110.976, p < .001, \eta^2 = .594$, and identity strength, $F(1, 76) = 12.300, p = .001, \eta^2 = .139$. As shown in Figure 3, young adults were faster (Median = 724.6 ms) than older adults (Median = 1,181.02 ms), and response times were faster on 100% trials (Median = 876.825 ms) than on 60% trials (Median = 1,028.76 ms). There was no effect of face age, $p = .82$, and no interactions were significant, ps > .14.

Discussion

Young adults were more accurate when tested with young compared to older adult faces, replicating the well-established OAB in young adults (for reviews see Macchi Cassia, 2011; Rhodes & Anastasi, 2012; Wiese, Komes, & Schweinberger, 2013) using a set of stimuli in which hair was visible but did not contribute to face recognition. Better recognition of young adult faces cannot be attributed to them being inherently easier to recognize because older adults did not show this advantage. The recognition advantage for young

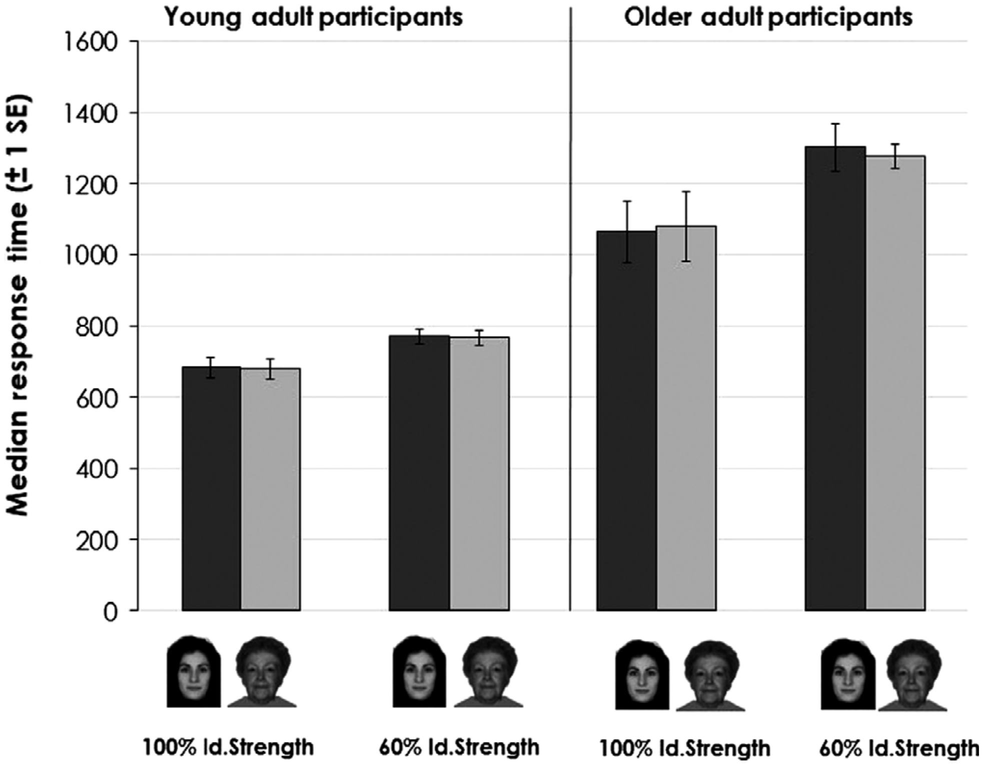

Figure 3. Median response time for correct responses for young and older adult faces exhibited by young adults and older adults in the 100% and 60% conditions of Experiment 1.

adult faces cannot be attributed to a speed-accuracy trade-off either; response times did not vary as a function of face age. Rather, this advantage may be explained by experiential or motivational mechanisms leading to enhanced sensitivity to perceptual differences among own-age faces in young adults.

In contrast, neither older adults' accuracy nor their response times varied as a function of face age, a finding that is consistent with some (e.g., Bartlett & Leslie, 1986; Wiese, Schweinberger, & Hansen, 2008), but not all (e.g., Anastasi & Rhodes, 2006) previous studies. Our ability to detect an OAB in older adult participants was not constrained by floor effects, because accuracy in the 100% identity-strength condition was above 90%. Furthermore, although older adults' response times were consistently slower compared to those of young adults, response times were not influenced by face age (see also Proietti *et al.*, 2013).

The older adults we tested reported more recent contact with older adults than young adults. The lack of effect may reflect the mutual influence of early and continuing experience with young adult faces and recent experience with older adult faces. Social cognitive models may partially account for the lack of an OAB among older adults. Although older adults may perceive older individuals as part of their social in-group, both young and older adults often provide more positive evaluations of young people (He *et al.*, 2011). Just as minority ethnic groups often fail to show an own-race recognition advantage (see Meissner & Brigham, 2001), older adults may fail to show a consistent OAB because encoding the identities of young adult faces is likely to be motivationally relevant to them.

Indeed, when shown young and older faces simultaneously in naturalistic scenes, both young and older adults attend preferentially to young adult faces (Short, Semplonius, Proietti, & Mondloch, 2015).

Identity strength influenced recognition performance irrespective of participants' age. Both young and older adults were more accurate and faster when tested with 100%-identity than 60%-identity faces, consistent with evidence that distinctive faces (O'Toole *et al.*, 2006; Valentine, 1991) and full-identity faces (Zheng *et al.*, 2012) are easier to recognize than typical and reduced-identity faces because the former deviate more from the face prototype. The lack of interaction with face age may be attributed to task characteristics. We presented identical photographs at study and test and emphasized the encoding stage of visual processing, rather than tapping memory and access to face representations. Nonetheless, the results of Experiment 1 confirm the suitability of the stimuli for our primary study (Experiment 2), in which we introduced an identity detection task. Both young and older adults accurately recognized young and older adult faces (Mean per cent correct exceeded 88% in all conditions) despite identical hairstyles on all exemplars within each age group and despite reduced (60%) identity strength.

EXPERIMENT 2

In Experiment 2 we used an identity detection task to measure individuals' sensitivity to identity in both young and older adult faces. The task mimics a challenge faced on a daily basis: recognizing particular identities (an older neighbour or professor) among other faces. Within each block of test trials participants learned one facial identity and then performed a target detection task in which the target identity and five same-age distracter identities were presented at five different identity strengths: 20%, 40%, 60%, 80%, and 100%. Participants were instructed to press a button only when they detected the target identity or someone who looked like the target identity (i.e., when that identity was presented at any strength). To take into account the likelihood that original identities vary in distinctiveness (i.e., deviations from an average) across participants, we used four different target identities and 20 distracters for each face age group.

In a previous study in which young adults were tested using the same young adult faces presented here (but in 10% steps), both accuracy and the amplitude of the N250, an event-related potential (ERP) component associated with face identification, increased as a function of identity strength (Zheng *et al.*, 2012). Importantly, variations in identity strength did not affect the amplitude of the P100 and the N170, two ERP components associated with processing of low-level stimulus characteristics and structural encoding of face stimuli, respectively. These results provide evidence of brain responses to variations in identity strength relative to an "average" face and suggest that sensitivity to identity strength is not carried by responses to low-level stimulus features.

We hypothesized that both young and older adults would be more sensitive to identity in young adult faces than in older adult faces based on evidence that both young and older adults are more sensitive to deviations from the prototype in young relative to older adult faces when making normality judgments (Short & Mondloch, 2013). Greater sensitivity to deviations from the prototype in young faces compared to older faces would be evident in our identity detection task if sensitivity (measured as d') was higher overall for young adult faces compared to older adult faces and if the slope of the curve representing changes in d' across identity strengths was steeper for young compared to older faces. We also analysed hit rate (defined as proportion of correctly detected target identities) and false alarm rate (defined as proportion of incorrect responses to distracter identities) separately. Doing so was motivated by evidence that both the own-race (Meissner & Brigham, 2001) and own-age (Rhodes & Anastasi, 2012) advantage are based on higher false alarm rates rather than lower hit rates for other-race and other-age faces. Finally, we obtained a response bias measure (c) to determine whether the use of conservative versus liberal strategies varied as a function of participant or face age.

Method

Participants

Twenty-four Caucasian Canadian undergraduate students (18 female; M = 24.4 years, age range = 22–28 years) and twenty Caucasian older adults living in independent housing (15 female; M = 73 years, age range = 64–82 years) in Canada, participated in this experiment. The same inclusion criteria used in Experiment 1 were applied. Participants reported spending more time with own-age (45.26 and 39.8 hr per week for young and older adults, respectively) peers than with other-age (4.33 and 4.00 hr per for young and older adults, respectively) individuals. All young adults reported normal or corrected-to-normal vision and older adults had at least 20/40 vision with 11 older adults having 20/20 vision. An additional two older adults were tested but excluded from final analysis for failing to meet criterion on training trials (see Procedure).

Materials

Participants completed the same questionnaire used in Experiment 1 and all identity steps (20%, 40%, 60%, 80%, 100%) of the young and older identities used in Experiment 1 served as stimuli (Figure 1).

Procedure

The entire protocol consisted of a practice session with male faces, followed by the target detection task with female faces. In the practice session, participants were shown a photograph of a young/older man and asked to memorize his face. They were then shown a series of faces (one target and five distracters) that appeared one at a time on the computer screen and asked to press a button each time they saw that target face. The target face was presented six times and each distracter was presented three times, for a total of 21 trials.

The target detection task followed this practice session and comprised four blocks of trials, two for each face age, with the age of faces alternating across blocks and the age of the faces presented in the first block counterbalanced across participants. At the beginning of each block, participants viewed a target identity for 10 s and were asked to memorize it. To ensure that participants were familiar with the target identity prior to manipulating identity strength, they first completed 21 training trials in which only 100% identity faces (the target and five distracters) were presented. The target identity was presented six times and each same-age distracter identity was presented three times. Participants were instructed to press a button each time they saw the target identity. Each face was presented for 1.5 s to young adults and 2.5 s to older adults. As mentioned above our goal in using different presentation times for younger and older adults was not to match performance; rather we wanted to encourage participants in both groups to be engaged in the task. Pilot testing revealed that 1.5 s was too short for older adults and 2.5 s was too long for young adults, who complained of boredom. Participants were required to make fewer than six errors (75% correct) prior to proceeding to the test trials. They were given three chances to do so; two older adults failed to meet this criterion and were excluded from analyses.

During test trials we presented the same identities at five different identity strengths: 20%, 40%, 60%, 80%, and 100%. The target identity was presented in its 100% version on 10 trials and at each of its reduced-identity strengths on four trials. The 100% version was presented most frequently to reduce participants' frustration with the task. Each of the five distracter identities was presented twice at each identity strength. Participants were asked to press the spacebar each time they saw the target face or someone who looked very much like the target. To reduce the possibility of participants forgetting which identity was the target, we interrupted testing twice to show them a picture of the target for few seconds.

A different target face and a new set of same-age distracters were presented in each of the four blocks of trials. Thus, each participant viewed two target identities and 10 distracter identities per face age. To enhance the generalizability of our findings, we used the 24 identities from Experiment 1 to create two stimulus sets composed of 12 identities; half of the participants were tested on each set so that across participants there were four target and 20 distracter identities per face age.

Results

For each dependent variable (d', hits, false alarms, c, median RTs), we conducted a mixed model ANOVA with face age (young faces and older faces) and identity strength (20%, 40%, 60%, 80%, and 100%) as within-participants factors, and age group (young and older adult) as the between-participants factor.

Sensitivity, d'

The main effect of age group, $F(1, 42) = 19.73$, $p < .001$, $\eta^2 = .32$ revealed that young adults were more accurate than older adults (see Figure 4). The main effect of identity strength, $F(4, 168) = 363.62$, $p < .001$, $\eta^2 = .896$, revealed that performance increased as a function of identity strength. No other main effects or interactions were significant (all *p*s > .10). Most notably, there was no effect of face age, $F(1, 42) = 0.011$, $p = .916$, $\eta^2 = .000$, and no Participant age × Face age interaction, $F(1, 42) = 0.249$, $p = .620$, $\eta^2 = .006$. Analyses of within-subjects contrasts were used to determine whether the linear, quadratic, and/or cubic relationships between d' and identity strength were significant and whether the slope of any significant relationships varied as a function of participant or face age. The linear effect of identity strength was significant, $F(1, 42) = 1{,}271.17$, $p < .001$, $\eta^2 = .968$; the quadratic and cubic trends were not, *p*s > .10. Thus, accuracy increased monotonically as a function of identity strength. A marginal interaction between identity strength and age group, $F(1, 42) = 4.01$, $p = .052$, $\eta^2 = .087$, revealed that the slope was steeper for young adults than older adults, indicating greater improvement in accuracy as a function of identity strength among young participants. A significant interaction between identity strength and face age, $F(1, 42) = 5.08$, $p = .030$, $\eta^2 = .108$, indicated that the slope was steeper for young adult faces than older adult faces. However, as shown in Figure 4, accuracy was comparable for young and older faces at each step. Quadratic and cubic interactions were not significant, *p*s > .30. Thus, the ANOVA did not reveal a differential effect of face age for young versus older adults.

Finally, given previous studies using real faces, we wanted to compare our findings to the literature by directly comparing participants' sensitivity to young versus older

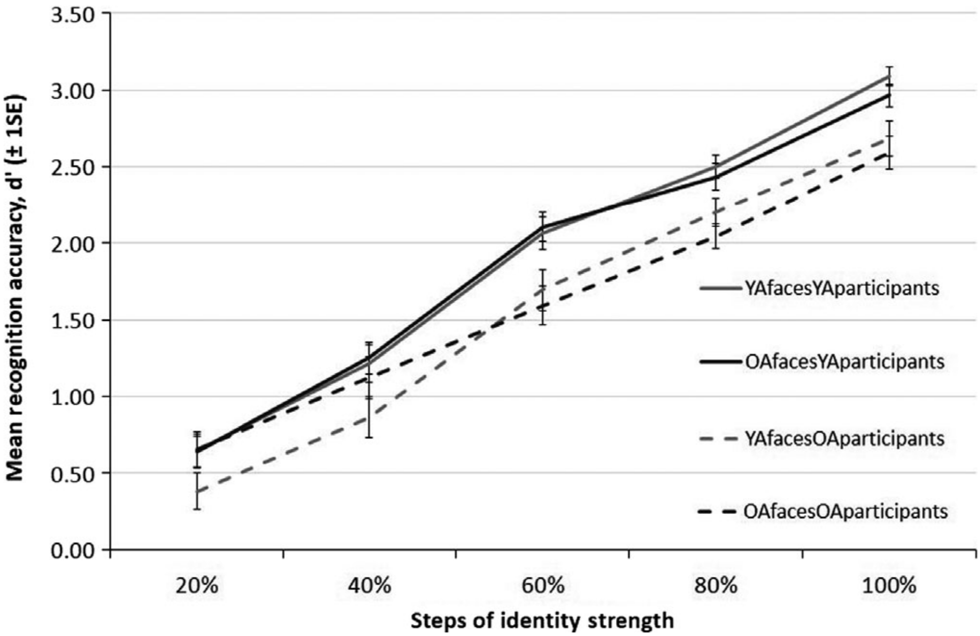

Figure 4. Mean sensitivity (d') of the target face as a function of face identity strength and face age for young adults (solid line) and older adults (dash line).

identities at the 100% step of identity strength continuum. Sensitivity did not differ as a function of facial age in either young or older adult participants (ps > .17).

Hit rate

Comparable analyses of hits revealed that hits increased with identity strength, $F(4, 168) = 86.24, p < .001, \eta^2 = .67$ (Figure 5). This main effect was qualified by significant interactions of identity strength with both age group, $F(4, 168) = 4.78$, $p = .001$, $\eta^2 = .10$, and face age, $F(4, 168) = 3.31$, $p = .01$, $\eta^2 = .07$. No other main effects or interactions approached significance, ps > .10. Both young and older participants made more hits for young adult than older adult faces at lower, but not higher, identity strengths; older adults made more hits than younger adults at lower, but not higher, identity strengths. These findings are consistent with the results of the analyses of within-subjects contrasts, which revealed a significant linear trend for identity strength varying across both face age, $F(1, 42) = 5.48$, $p = .024$, $\eta^2 = .115$, and age group, $F(1, 42) = 6.67$, $p = .013$, $\eta^2 = .137$. When task difficulty is high (i.e., when identity strength is low), more hits for young faces may reflect a recognition advantage for young compared to older faces, and more hits for older adults compared to young adults may reflect higher recognition performance for older participants. Nevertheless before drawing such conclusion one must first look at false alarm rates.

False alarm rate

Comparable analyses of false alarms revealed a main effect of identity strength, $F(4, 168) = 61.95, p < .001, \eta^2 = .60$; false alarms decreased with increasing identity strength

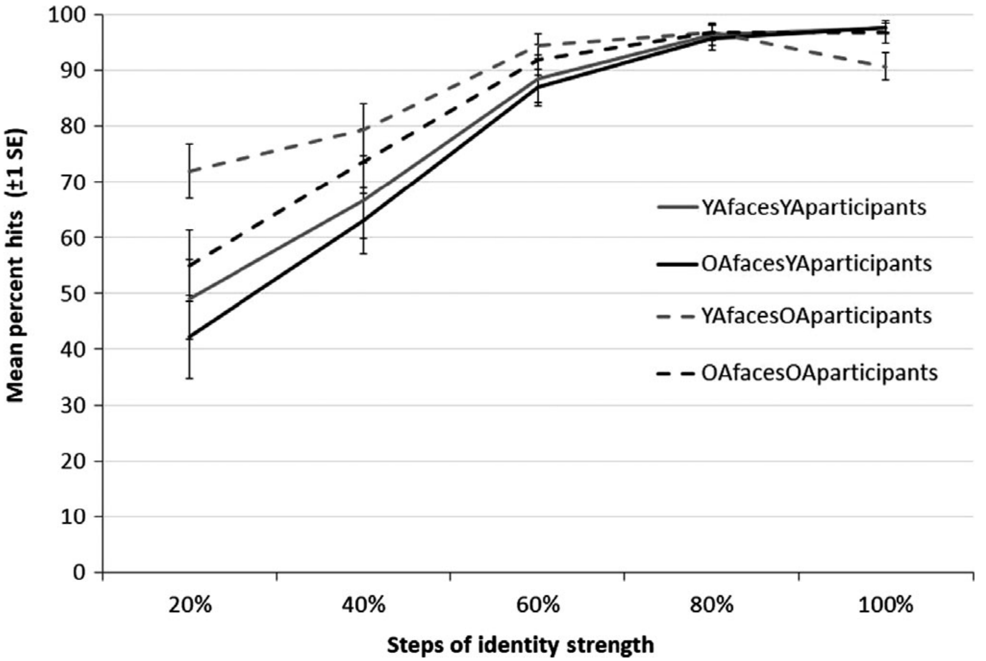

Figure 5. Hit rate in detecting a target face as a function of face identity strength and face age for young adults (solid line) and older adults (dash line).

(see Figure 6). There was a significant main effect of age group, $F(4, 168) = 13.69$, $p = .001$, $\eta^2 = .25$, with more false alarms for older adults than young adults. These main effects were qualified by a significant Identity Strength × Face Age interaction, $F(4, 168) = 10.67$, $p < .001$, $\eta^2 = .20$, and a significant Identity Strength × Face Age × Age Group interaction, $F(4, 168) = 4.05$, $p = .004$, $\eta^2 = .09$. No other effects were significant, ps > .08. To explore the 3-way interaction, we conducted separate analyses for young versus older adults. The analysis on young adults revealed only a main effect of identity strength, $F(4, 92) = 25.59$, $p < .001$, $\eta^2 = .53$. The ANOVA on older adults revealed a main effect of identity strength, $F(4, 76) = 36.45$, $p < .001$, $\eta^2 = .66$, and a significant Identity Strength × Face Age interaction, $F(4, 76) = 9.62$, $p < .001$, $\eta^2 = .34$. Older adults made more false alarms for young adult than older adult faces at lower identity strengths, but more false alarms for older adult faces than young adult faces at higher identity strengths, a finding that is consistent with the significant linear trend for identity strength varying across face age in older adults, $F(1, 19) = 12.80$, $p = .002$, $\eta^2 = .40$. Different patterns of false alarms for young versus older adults suggest that these groups used different strategies to perform the target detection task and that for older adults strategies varied across face age.

Response bias (c)

The analysis of response bias measure, *c*, where positive values indicate a conservative strategy and negative values a liberal strategy, confirmed the results on false alarms. As shown in Figure 7, there were significant main effects of age group, $F(1, 42) = 8.92$, $p = .005$, $\eta^2 = .18$, with young adults being overall more conservative (Mc = .195) than older adults (Mc = -.097). There was a significant main effect of identity strength,

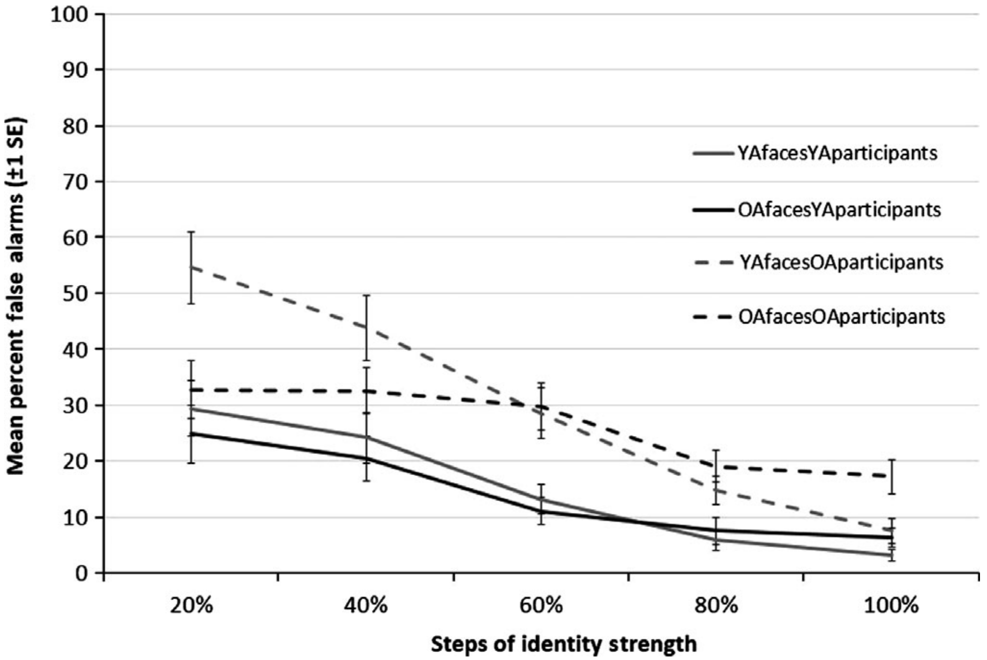

Figure 6. False alarm rate as a function of face identity strength and face age for young adults (solid line) and older adults (dash line).

$F(4, 168) = 5.53, p < .001, \eta^2 = .116$, as well as significant interactions between identity strength and age group, $F(4, 168) = 3.92, p = .005, \eta^2 = .08$, and identity strength and face age, $F(4, 168) = 10.38, p < .001, \eta^2 = .20$. These two-way interactions were qualified by a significant Identity Strength × Age Group × Face Age interaction, $F(4, 168) = 3.53, p = .009, \eta^2 = .08$. To investigate this 3-way interaction we analysed the effects of face age and identity strength separately for young and older adult participants. For young adults, there was only a main effect of identity strength, $F(1, 92) = 7.44, p < .001, \eta^2 = .24$ (all other *p*s > .24); young adults became less conservative as identity strength increased. Analyses of within-subjects contrasts confirmed significant linear, $F(1, 23) = 8.00, p = .010, \eta^2 = .258$, and cubic trends, $F(1, 23) = 6.78, p = .016, \eta^2 = .228$, and no significant interactions, *p*s > .16, indicating that changes in criterion as a function of identity strength did not vary as a function of face age. For older adults, there were no significant main effects, *p*s > .28. However, the Face Age × Identity Strength interaction was significant, $F(4, 76) = 9.15, p < .001, \eta^2 = .32$, showing that older adults' criterion changed in opposite directions for young versus older adult faces. Older adults became less conservative as identity strength increased for older adult faces, but more conservative as identity strength increased for young adult faces. Analysis of within-subjects contrasts for these participants confirmed a significant Identity Strength × Face Age interaction for the linear trend, $F(1, 19) = 11.86, p = .003, \eta^2 = .384$.

Discussion

The primary goal of our study was to determine whether sensitivity to identity strength varies as a function of facial age in young and older adult participants. Although accuracy

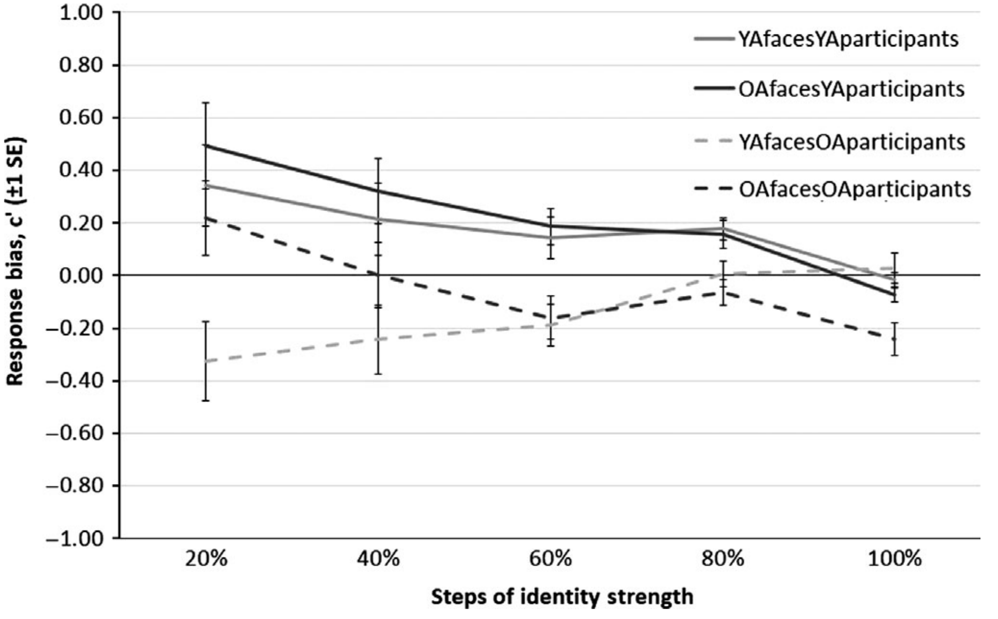

Figure 7. Mean response bias (c) in detecting a target face as a function of face identity strength and face age for young adults (solid line) and older adults (dash line).

was higher overall in young adults than older adults, despite older adults viewing each face for a longer period of time (2.5 s) than young adults (1.5 s), d' did not vary as a function of face age for either young or older adults. Unlike previous studies that used old/new recognition (e.g., Firestone, Turk-Browne, & Ryan, 2007; Wiese *et al.*, 2012) and eyewitness line-up (Perfect & Harris, 2003) tasks, in our detection task neither young adults nor older adults showed an own-age advantage. The only evidence of an age bias in sensitivity to facial identity came from our analysis of within-subjects contrasts. The slope of the line showing the relationship between d' and identity steps was steeper for young adult faces than older adult faces in both participant groups, but because the effect of face age held across young and older adults this does not provide evidence of an OAB. Furthermore, d' for young versus older adult faces was similar across the entire identity strength (see Figure 4), which is consistent with there being no effect of face age on overall accuracy.

Although d' analyses revealed only minimal evidence of face age influencing recognition, analyses of hits, false alarms, and criterion revealed that face age did influence older participants' strategy. Although young adults became less conservative as face identity strengths increased when judging both young and older faces, older adults showed different patterns of results as a function of face age. Wiese, Schweinberger, and Hansen (2008) reported that older adults presented with full identities were more conservative for young adult faces than older adult faces, whereas young adults showed no differences in criterion as function of face age. Our findings add to this evidence by showing that criterion differences in older adults between young and older adult faces switch as task difficulty increases (see General Discussion). Nonetheless, when asked to find a particular identity among same-age distracters neither young nor older adults showed an OAB. We discuss the implications of this finding below.

GENERAL DISCUSSION

In the current study, we aimed to extend evidence on age biases in face recognition in young and older adults using an identity detection task in which deviation from an average face was systematically manipulated. Based on evidence that both young and older adults are more sensitive to deviations from a face prototype among young faces than older faces when judging normality, we hypothesized that young, and possibly older adults, would show an advantage for young faces in this identity detection task. However, contrary to past studies showing a robust OAB in young adults (e.g., Anastasi & Rhodes, 2006; He *et al.*, 2011) and to Experiment 1, in which young adults showed an OAB bias in a 2AFC task with the same identities, in Experiment 2 we found no evidence of a recognition advantage for own-age faces among young adult participants. Although accuracy (d') increased with identity strength more rapidly for young than older adult faces across young and older adult participants, at no point on the identity continuum was accuracy higher for young than older faces. A similar pattern was observed for hits (higher hit rate for young than older faces at low identity strengths) and there was no effect of face age on either false alarm rates or criterion for young adults.

The results for young adults are surprising given abundant evidence of an OAB in old/new recognition tasks (see above) and normality judgment tasks (Short & Mondloch, 2013). We note, however, that the OAB observed by Short and Mondloch was limited to normality judgments; there was no evidence of an OAB in a discrimination task in which participants were asked to judge which member of each face pair was more expanded. Thus, even among young adults the OAB is task dependent. The results of Experiment 2 suggest that when searching for a particular familiarized target identity among same-age distracters, a task analogous to searching for a particular person in a crowd, sensitivity to deviations from an average face (identity strength) is not influenced by facial age. Given that the OAB is robust for unfamiliar faces (Rhodes and Anastasi, 2012), but disappears when faces are familiar, future studies should investigate whether faces from less familiar categories (e.g., other-age; other-race) are harder to learn than faces from highly familiar categories.

Older adults' accuracy did not differ as a function of facial age in either our 2AFC task (Experiment 1) or our identity detection task (Experiment 2). The lack of an OAB bias cannot be attributed to our participants' lack of experience with older adult faces; all participants reported having greater daily contact with own-age (40–50 hr per week) than with other-age individuals (4–11 hr per week). The lack of OAB also cannot be attributed to floor effects in older adults' performance. In Experiment 1, their accuracy for older faces in both the 100%- and 60%-identity strength conditions was comparable to that of young adults in the 60% condition (*p*s > .54), yet in neither condition did older adults show an OAB. Moreover, in Experiment 2, d' values for older adults ranged from about .5 to 2.5 as a function of identity strength and yet at no point did they show an OAB. Rather, our results indicate that, like young adults, older adults' ability to detect a particular familiarized identity is not influenced by face age. Whether this would be true if images of identities varied in pose, lighting, and/or emotional expression is a matter for future research.

Although their accuracy was not influenced by facial age, older adults' strategy was. When the task was difficult (i.e., at low identity strengths) their hit and false alarm rates were higher for young than older adult faces. As the task became easier (identity strength increased) differences in hit rates disappeared, and false alarm rates were higher for older faces. This pattern was reflected in criterion scores, with responses becoming more liberal for older faces and more conservative for young faces as a function of identity strength. This finding resonates with the results reported by Rhodes and Anastasi (2012) showing that older adults exhibited more liberal strategies responding to same-aged faces compared to young adult faces (only full-identity faces were presented). A similar pattern has been observed for other- versus own-race faces, with adults using a more liberal strategy to recognize other-race faces (e.g., Meissner & Brigham, 2001; Meissner, Brigham, & Butz, 2005). This effect has been explained by making reference to the face space model (Valentine, 1991) according to which faces from less familiar categories (e.g., other-race/age) are clustered together in the periphery of the face space. The lack of perceived distinctiveness among these faces would induce participants to make more false alarms for other-race/age faces. On the other hand, older adults' use of a more liberal strategy for young than older faces when identity strength was low (i.e., when faces were not distinctive) suggests that adults may perceive non-distinctive young faces as familiar. That this tendency changed with identity strength is interesting and should be replicated; it would be especially interesting to investigate whether this pattern would be replicated if younger and older faces were intermixed, a modification that would mimic how faces are often (but not always) encountered in the real world and that might reduce the possibility of using different strategies for young versus older faces.

We acknowledge that both the actual and the perceived distance between individual faces and the average face varies across identities within an age group, with more distinctive faces being farther from the mean. These distances may differ systematically between young and older adult faces if, for example, faces become more variable with aging (i.e., greater actual distances from the prototype in older vs. young faces) or if perceivers are generally less sensitive to differences among older faces than younger faces (i.e., decreased perceived distances from the prototype in older vs. young adult faces). Furthermore, we acknowledge that adding the texture of an individual identity to the older adult average, a manipulation done to counteract the effect of morphing on perceived age (Tiddeman, Burt, & Perrett, 2001), likely reduced the prototypicality of our older average face. A potential consequence of adding an individual texture to our average older face was that individual identities were not equally far from this average, making some targets easier to identity than others. To test for this possibility, we conducted a 4 (face identity) $\times$ 5 (identity strength) ANOVA that directly compared performance (d') across exemplars for each face age. We found no main effect of face identity and no interaction between face identity and identity strength for either older adult face targets $p > .41$ or young face targets, $p > .30$, suggesting that, although our average face did not have an average texture, it was about equal-distant from all target identities. Nonetheless, systematically varying identity strength provides a useful tool for investigating whether differential sensitivity to deviations from the norm as a function of face age (Short & Mondloch, 2013) influences identity judgements. Future studies should examine perceived attractiveness and distinctiveness (measured by both the face-in-a-crowd task and a deviation-from-average task; Wiese, Altmann, & Schweinberger, 2014) in relation to recognition in both an old/new and our identity detection task to further elucidate the relationships among these variables for older versus young adult faces.

Zheng *et al.* (2012) reported that the N250 increased in amplitude as a function of identity strength when young adults were tested with the same young adult identity detection task used in Experiment 2. Wiese, Schweinberger, and Hansen (2008) and Wiese *et al.* (2012) have reported a 3-way interaction between face age, participant age and response (hits/correct rejections) on N250 amplitude when using an old/new recognition task with young and older adults. Young adults had a larger N250 on hits than correct rejections for young, but not older faces (Wiese, Schweinberger, & Neumann, 2008; but see Wiese *et al.*, 2012 for a non-replication); older adults with higher levels of contact with older than young adults had a larger N250 for correct rejections than hits for older, but not young faces (Wiese *et al.*, 2012). We did not collect EEG data in the current study and so do not know whether N250 was influenced by face age in either participant group. Future studies should examine the influence of face age on both accuracy and neural correlates across a variety of task types to determine the conditions under which an OAB is evident. Our findings suggest that in an identity detection task there would be no effect of face age on N250 amplitudes.

To sum up, the OAB in both young and older adults appears to vary as a function of task demands even when relative experience with own- versus other-age faces and overall accuracy is controlled for. As noted by Wiese *et al.* (2012) theoretical accounts vary in their emphasis on the importance of early experience (predicting a young adult bias in all age groups), recent experience (predicting an OAB in young adults and older adults with abundant experience with older faces), and social cognitive factors (predicting an OAB in both young and older adults). Our results suggest that theoretical accounts of the OAB must also take into accounts task demands. Face age appears to influence performance in an old/new recognition task (e.g., Wiese, Schweinberger, & Hansen, 2008), judgments of deviation from the norm in manipulated faces (Short & Mondloch, 2013), delayed match-to-sample (for young adults, Experiment 1) and consensus in attractiveness judgments (Short, Chan, Hackland, & Mondloch, 2014), but not discrimination of manipulated faces (Short & Mondloch, 2013), delayed match-to-sample (for older adults, Experiment 1) or identity detection (Experiment 2). Integrating the influence of multiple factors in a single model will be necessary to move the field forward.

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