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Own-age and own-sex biases in recognition of aged faces

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ABSTRACT

It is surprising how easily we are able to recognize people whom we have not seen in many years, somehow compensating for the aging-related facial changes that occurred. We measured the limits of the ability to recognize faces across the lifespan by young versus old men and women. Images of five males and five females at young and middle ages were morphed in 10% increments to create aged face images across the lifespan. Fifty-eight participants (28 females) judged whether pairs of photographs were of the same or different identity. Women outperformed men for female faces, exhibiting a sex difference and own-sex bias. Additionally, older participants showed an own-age bias and outperformed their younger counterparts with older stimuli. It appears that the recognition of faces is affected by the own-age and own-sex biases, potentially allowing us to remember some people better than others, thus mediating our interaction with the world.

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1. Introduction

Almost all of us have, at some point, been in a situation where we met a person whose face seemed familiar, but we could not quite recall who the person was, or where we had previously met. After a few moments of a nagging inability to remember, we may suddenly realize that we went to high school together 15 years ago, or perhaps we used to be neighbors 10 years ago. How do we accomplish this incredible task of recognizing someone many years after we last met, compensating for all the aging-related changes their face must have undergone during this time? Such questions in face recognition have been studied within fields as varied as psychology, neuroscience and computer engineering (Zhao, Chellappa, Phillips, & Rosenfeld, 2003). The aim of the current study was to explore the limits within which we are able to accomplish the task of recognizing that a younger face and an older face belong to the same person.

Age-invariant face recognition is a complex process due to the many changes our faces undergo as we age. In addition to growth of the skull during formative years, texture changes in the skin during later years account for a large portion of the perceived age of an individual (Albert, Ricanek, & Patterson, 2007). Far from a simple addition of wrinkles, the aging process of facial skin is complex and driven by several factors, among them sex, genetics, lifestyle, diet, exposure to the elements, smoking and stress (Albert et al., 2007; Ramanathan, Chellappa, & Biswas, 2009). Thus, the continuous facial alterations that occur as we mature and age, and the many environmental factors that interact with the already-complex biological processes involved make the recognition of a face we haven't seen in many years a complex and difficult process.

Despite the various changes that the human skull and skin undergo as faces age, we can often identify individuals even after not having met for many years, provided the changes are within some allowable tolerances.

1.1. Own-age biases

A number of studies have shown that we tend to better recognize people of our own age (Anastasi & Rhodes, 2005; Mason, 1986; Wright & Stroud, 2002), also known as the own-age bias (although these findings are not always consistent, e.g., Macchi Cassia, 2011). More specifically, as discussed in a recent meta-analysis (Rhodes & Anastasi, 2012), recognition memory for "ingroup" faces, such as one's own race or age is often better than for "outgroup" faces. However, a face may also be recognized as though it were "ingroup" due to extensive experience with the particular age group. For example, teachers with 1.5 years of experience working with young children are better at face recognition of young children compared with age-matched controls who have not had such extensive experience with young

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children's faces (Harrison & Hole, 2009). Participants were asked to study faces of young children and own-age adults, and while the control group exhibited an own-age bias with better memory for own-age faces, the teacher group showed no such bias, and instead showed a trend toward better recognition of children's faces. This shows that age-related face processing is directly influenced by our experience.

Even when memory is not involved, participants tend to look longer at images of faces within their own age group (He, Ebner, & Johnson, 2011). Interestingly, when passively viewing face images participants also reported higher exposure to peers within their own age group than to outgroup members, which was significantly predictive of later performance on a surprise old/new face recognition task. Others have even noted that face emotion processing depends both on the age of the viewer and that of the target face, since younger and older participants seem to differ in their interpretations of emotions expressed by young versus old faces (Ebner, He, & Johnson, 2011). This may be affected by daily experience with those of one's own age group, as well as self-relevance.

It has been shown that age is categorized rapidly within only a few hundred milliseconds (145–200 ms) of face onset (Mouchetant-Rostaing & Giard, 2003; Rhodes & Anastasi, 2012; Wiese, Schweinberger, & Hansen, 2008), which may mean decisions about the face's ingroup/outgroup status, and therefore its relevance, and perhaps even its expressed emotion, are also very rapid, as well as automatic (Bruyer, Lafalize, & Distefano, 1991). Taken together, these findings suggest that age is a socially-relevant cue whose processing is affected by our daily experiences, and in turn it affects how we process information about those around us, and as a result our daily interactions.

Initially, it was thought that younger adults were better than middle aged and older adults at various face recognition and categorization tasks, however, studies supporting this notion typically only tested recognition of young adult and not middle aged or older adult face images (Wright & Stroud, 2002). In light of this, it is therefore possible that the results of previous research suggesting that younger participants have superior face recognition performance compared with older participants may not be due to superior face processing abilities, but rather due to the facilitating effect of recognizing face images of one's own age group. For example, an own-age bias has been shown when testing recognition memory in younger and older women (Mason, 1986), whereby younger women perform significantly better with younger faces, and older women made fewer errors with older faces. However, in studies that utilize memory there is always the possibility that the poorer performance of older participants may be affected by age-related declines in short-term memory (Wright & Stroud, 2002). It is also interesting that younger women are especially good at remembering faces of other young women, thus introducing the additional possibility of a same-sex bias (see next section).

More recently, young (20–31 years), middle aged (44–55 years) and older (70–81 years) participants were asked to estimate the ages of faces in photographs displaying various emotions, such as neutral, angry or happy (Voelkle, Ebner, Lindenberger, & Riediger, 2012). Although performance generally declined with age, older and younger adult groups both performed better for faces within their own age groups, especially when the expression was neutral. These results support the notion that an own-age bias persists even when cognitive or neurobiological changes may affect performance (Voelkle et al., 2012). However, like experiments utilizing memory, cognitive changes may affect the performance of older adults when asked to explicitly think about, and rate the age of target faces, and it is possible that less explicit and more subtle recognition methods may alleviate this effect.

The own-age bias has also been demonstrated when younger and middle-aged adults were shown videos of crimes perpetrated by a young or an older adult male, in the context of eyewitness testimony (Wright & Stroud, 2002). When recognizing the culprits in a photographic lineup, participants performed better with their own age group, and older participants performed particularly poorly when the culprit was young, but slightly better when the culprit was older. This also suggests that younger adults' superior performance is not necessarily a result of better generalized face recognition ability, but rather that the own-age bias persists for both younger and older participants and modulates each group's performance, which again reinforces the notion that social experience may contribute to our processing of faces.

How early in life can the own-age bias be demonstrated? Very young children have been shown to perform best with faces of their own age group. For example, children (aged 5–8) and older adults (aged 55–89) viewed digital photos of faces, and were asked to categorize them into different age groups (Anastasi & Rhodes, 2005). When subsequently given a surprise old/new identity recognition task, children performed best when recognizing photographs of others in their age group, while middle-aged/older adults were better at recognizing photographs of others of their own age, demonstrating that the own-age bias begins at a young age. Further, the own-age bias persists throughout the lifespan, as we age and thus alters our relevant age group, and perhaps loses expertise with our previously relevant younger age groups.

Together, research in this area shows that a clear own-age bias exists across the lifespan, which highlights the importance of assessing the interactions between participant age and face stimulus age when measuring face recognition ability.

1.2. Sex differences and own-sex bias

It has long been demonstrated that women outperform men in various face recognition tasks, including face identity and emotion recognition (Brewster, Mullin, Dobrin, & Steeves, 2011; Burton & Levy, 1989; Godard & Fiori, 2012; Guillem & Mograss, 2005; Lewin, 2001, 2002; Mason, 1986; Park, 2010; Rizzolatti & Buchtel, 1977). Various explanations have been suggested regarding this sex difference, such as better verbal ability that allows women to apply verbal labels rapidly during encoding (Lewin, 2002).

For example, women outperform men in the detection of upright but not inverted faces (McBain, Norton, & Chen, 2009). Further, women outperform men on the discrimination of morphed face identities, a difference that is more pronounced when visual noise is applied to the images or when the limits of working memory are pushed. This suggests that men may need a stronger stimulus signal (i.e., differences among facial features) to perform this task successfully.

In addition, differences in brain physiology as it relates to this task may be a major factor in these sex differences. It has been proposed that sex differences in behavior may be accounted for by sex differences in hemispheric lateralization, stemming from different interhemispheric cooperation and transmission times (Godard & Fiori, 2012). Faster transmission times certainly aid performance at a behavioral level (Bourne & Hole, 2006), and women exhibit faster and more symmetrical face processing across the hemispheres than men (Godard & Fiori, 2012; Nowicka & Fersten, 2001). Recently, differences between men and women in hemispheric cooperation during face identity-matching across faces of different emotional expressions were examined (Godard & Fiori, 2012). Symmetrical interhemispheric cooperation was demonstrated in women, but not in men. In men, when probe and target faces were presented in different hemifields, processing time was faster only when the probe face was encoded by the right hemisphere (i.e., presented in the left hemifield) and slower when probe and target were presented in different hemifields and the hemispheres were thereby required to cooperate. Other evidence, such as event-related potentials (ERPs), supports this notion of a right lateralization asymmetry in men but not in women (e.g., Proverbio, Brignone, Matarazzo, Del Zotto, & Zani, 2006). Perhaps bilateral coding of faces will facilitate women's ability, more than men's, to recognize the face of someone whom they have not seen in many years, such as a friend or a relative.

Most studies agree that women exhibit an own-sex bias in a variety of face-related tasks such that female participants' recognition memory is better for female faces (Lewin, 2002; Loven, Herlitz, & Rehnman, 2011; Rehnman & Herlitz, 2006). Results with men have been less consistent. Performance is usually equal for faces of either sex, but occasionally men have been shown to perform better for female than male faces, suggesting an opposite sex bias for men (Godard & Fiori, 2010; Rehnman & Herlitz, 2006; Wright & Sladden, 2003). In light of this possible own-sex bias, are women also better at recognizing faces of other females (as opposed to male faces) whom they have not seen for many years?

1.3. Study rationale

To answer the questions posed above, we measured the performance of young and middle-aged men and women at recognizing whether pairs of young and middle-aged male and female faces show the same identity. It is common in face recognition literature to use face stimuli that are designated into two discrete bins of "younger" and "older" face images. However, this may not reflect everyday life accurately, since our daily experience consists of encounters with faces along various stages of the age continuum. In light of this, the present study measured thresholds for age differences in face images using morphed versions (in 10% increments) of older and younger faces across the lifespan. These face images may represent a more ecologically valid continuum between the "younger" and "older" extremes.

We predicted (1) an own-age bias — that performance will be better when the faces are within the participant's own age group, (2) a sex difference — that women will perform better than men, and (3) an own-sex bias — that women will perform better for female stimuli than will men, and men will perform better for male stimuli than will women.

2. Method

2.1. Participants

Thirty-five younger participants (52% female; range = 18–30 years, mean age = 20.6 years, sd = 3.1) and 23 older participants (46% female; range = 31–62 years, mean age = 45.1 years, sd = 9.8) were tested. Thirty participants were male (mean age = 30.2 years, sd = 13.8) and 28 were female (mean age = 30.4 years, sd = 14.0). Of the total 58 participants, 31 were undergraduate students at York University (with $n = 5$ for ages above 30) and, for their participation, they received course credit toward their grade in an introductory psychology course. Those who were not students were acquaintances and received small gift certificates ($5) for participation. All participants had either normal or corrected to normal vision.

2.2. Stimuli

Access was obtained to the FG-NET (Face and Gesture Recognition Research Network) face database, and images of five male and five female identities were selected for their consistency in lighting, face viewpoint and neutral expression. None of the images contained outstanding features (e.g. glasses and mustaches). The selected face images showed the individuals at two different ages: (1) a young face, designated "100% young" and (2) an old face, designated "0% young".

After noting the ages provided by the database, face images were rated for their perceived age by 20 independent observers (13 females; age range = 22–58, median age = 25) to ensure that the faces chosen had high rater reliability for perceived age. All images were rendered grayscale, and an oval aperture was used to cut away the non-face cues to age, such as hair or ears. While viewing the faces on a computer screen, raters were asked to choose from a pulldown menu list of age-range options (5-year age bins or sets, e.g., 25–29, 30–34) that they thought best fit the image. None of the images produced oscillating or otherwise unusual ratings. Actual ages for the chosen images were as follows: Young female faces: mean age = 17 years, sd = 1; young male faces: mean age = 17 years, sd = 1; older female faces: mean age = 46 years, sd = 6; older male faces: mean age = 43 years, sd = 4.

Using FantaMorph 5 (Abrosoft), each individual's 100% young and 0% young photos were morphed together in 10% increments in order to create additional composite images, which contained varying degrees of young and old facial information along the age continuum (similar to the process used by Anzures, Ge, Wang, Itakura, & Lee, 2010; McBain et al., 2009). Including the original 100% young and 0% young images, there were 11 images per individual (see Fig. 1 for an example), for a total of 110 target faces across the 10 target face identities. Distractor non-target face identities were created with composite images of other non-target individuals. After the morphing was complete, the composite images were rendered grayscale. The face area was made visible through an oval aperture, as in Fig. 1, in order to exclude non-face cues to face identity and age, such as the hair and ears. All faces subtended approximately 6.5 × 8 degrees of visual angle.

2.3. Procedure

Stimuli were presented on a Macintosh computer with SuperLab (version 4.0; Cedrus Corp.), in the center of the screen, with a white background. Participants were seated approximately 57 cm from the display. Before the experiment, participants were told that in each trial they will be shown images of people of different ages and that some individuals will be of the same identity (but shown at a different age) while others will be images of two different identities. Using a two-interval paradigm, trials began with a fixation cross, followed by the first image, followed by another fixation cross and the second image (Fig. 2). Both the fixation crosses and images were presented for 500 ms each. The presentation of the second image was followed by a 4 s blank screen during which the participant was required to indicate, as quickly as possible, whether the two photos were of the same or two different identities, regardless of age, by pressing either the "z" or "m" keys on the computer keyboard. Key assignment was counter-balanced across subjects. If no response was recorded within the 4 s window, the next trial was presented. Any participant who failed to respond within the 4 s window on more than 10 trials was excluded from analysis.

The experiment consisted of 220 same-identity trials where the two faces were of the same identity (of varying ages), and 440 different identity trials, or distractor trials, where the two faces were of different identities (also of varying ages). In order to be able to group trials and compare them consistently, we used either "young" or "old" base faces as the comparison face in each trial. Thus, a same identity trial consisted of either a 100% young base face or a 0% young (i.e. "old") base face and a composite morphed face of a different age but the same identity, presented sequentially in random order. Trials were categorized according to the percent age separation between the two images. For example, a trial where the 100% young base face was compared to a 20% young face of the same identity was categorized as an 80% age separation trial. Trials comparing aged morphed faces to the young base face were equal in number to those comparing aged morphed faces to the old base face. On half of the trials the base face was presented first.

Combinations of the images for the face pairs presented were chosen systematically such that each image was compared with each other image (as well as itself) within the same sex. Each comparison occurred twice for the same identity trials, and 4 times for the different identity trials, which increased the difficulty of the task, and focused participant attention.

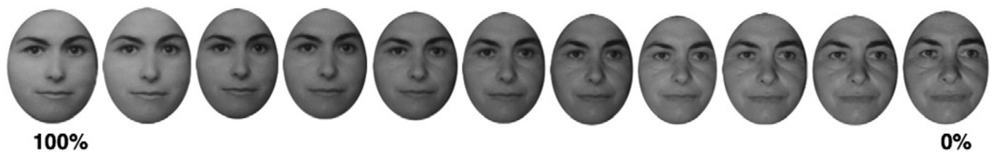

Fig. 1. Eleven images of one female identity in 10% age-increments. Left to right: 100% young to 0% young (original images taken from FG-NET database).

3. Results

Four different discrimination thresholds were calculated for each participant's performance for trials showing (1) female faces, (2) male faces, (3) 100% young base faces and (4) 0% young (i.e., old) base faces. In this case, analyzing threshold data (instead of accuracy, i.e., percent correct values) allowed us to evaluate which group was better able to compensate for wider age separations between the images within a trial, since we were able to assess the limits of each group's performance. Thresholds were calculated by determining the percent correct responses (for each participant) for each of the age separations between the base and morphed images, for the female and male, young and old base faces. To obtain the thresholds, percent correct values for each condition were first plotted as a function of the value of age separation within a trial (in percent of age difference), as seen in Fig. 3. A logistic regression analysis (SigmaPlot, v 10.0; Systat Software Inc.) was then performed for each participant, which allowed us to find the respective threshold (75%) for each of the four categories. We chose to use this value since it is half-way between perfect performance (100%) and chance performance (50%).

In order to examine the effects of participant sex and stimulus sex, we initially performed a 4 × 4 mixed-model analysis of variance (ANOVA; SPSS, IBM Statistics version 20), with Participant Sex × Participant Age × Stimulus Sex × Stimulus Age as factors. We found a trend toward a main effect of Participant Age, $F(1, 57) = 3.590$, $p = 0.063$. A Bonferroni post-hoc adjustment for multiple comparisons revealed a significant difference in the performance of old and young participants for old male faces ($p = 0.035$), with older participants (threshold = 64.2%) outperforming their younger counterparts (threshold = 58.6%).

In order to increase power and sample size per bin, we then collapsed the categories into four bins: women, men, young and old. A 2 × 2 (Participant Sex × Stimulus Sex) mixed-model ANOVA was then performed. This analysis revealed a significant main effect of Participant Sex, $F(1, 54) = 5.565$, $p = 0.022$. A post-hoc Bonferroni adjusted t-test showed that when stimuli were of female faces, women (threshold = 62.6%) outperformed men (threshold = 53.9%), $p = 0.014$ (see Fig. 4B and Table 1).

An analysis of the effects of Participant Age and Stimulus Age was also performed with a 2 × 2 (Participant Age × Stimulus Age) mixed-model ANOVA, and showed a significant interaction between Participant Age and Stimulus Age, $F(2.514, 54) = 3.818$, $p = 0.017$, and a trend toward significance for the main effect of Participant Age, $F(1, 54) = 3.431$, $p = 0.069$. A Bonferroni-corrected post hoc t-test showed that when stimuli were of old base faces, older participants (threshold = 69.6%) outperformed their younger counterparts (threshold = 54.1%), $p = 0.002$ (see Fig. 4A and Table 1).

4. Discussion

Overall, we found that performance decreased as age separation between the pair of face photographs increased. This is reasonable, since larger age separations caused the faces to look progressively different from each other, thus increasing the task's difficulty. We showed a form of own-age bias, since older participants performed significantly better when the photograph pair contained older base faces. Similarly, younger participants also tended to perform slightly better with younger base faces (see Table 1), although this difference did not reach significance. Further, we also show a sex difference such that women performed significantly better than men, particularly with female face stimuli (see Table 1).

To measure discrimination performance, we determined age difference thresholds for face comparison. This allowed for a quantitative discrimination of age separation along the stimulus age continuum — in our case between about 17 and 45 years old, which gives a more complete picture of participants' performance. Most previous studies have simply analyzed percent correct performance for two discrete age bins of "young" and "old" faces, and therefore were only able to conclude that certain groups did better with one or the other age bin. Additionally, in some experiments, participants' performance was based on

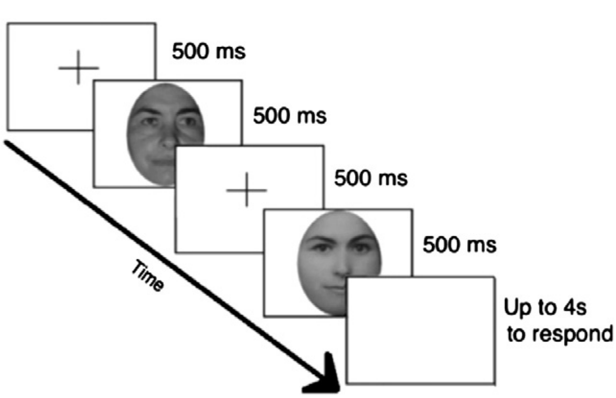

Fig. 2. A schematic showing the order of presentation of stimuli within a trial. This example shows two images of the same identity.

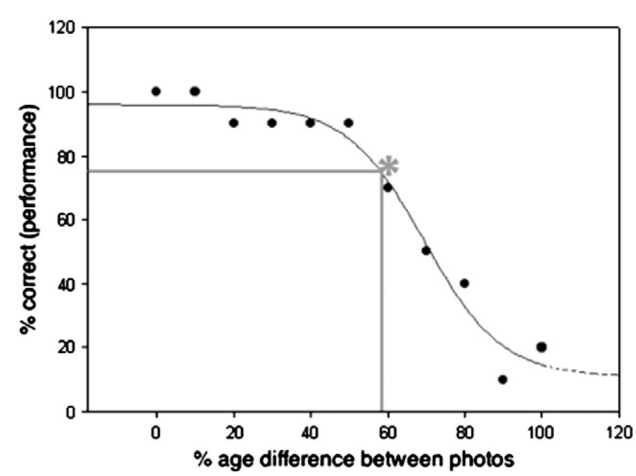

Fig. 3. Thresholds: an example of the logistic regression used to obtain one participant's 75% threshold for one condition, in this case for age of the faces. The threshold was at approximately 58% of the age difference between two photos within a trial, and is indicated on the figure with a star. This means that performance beyond 58% age difference was at chance levels for this participant.

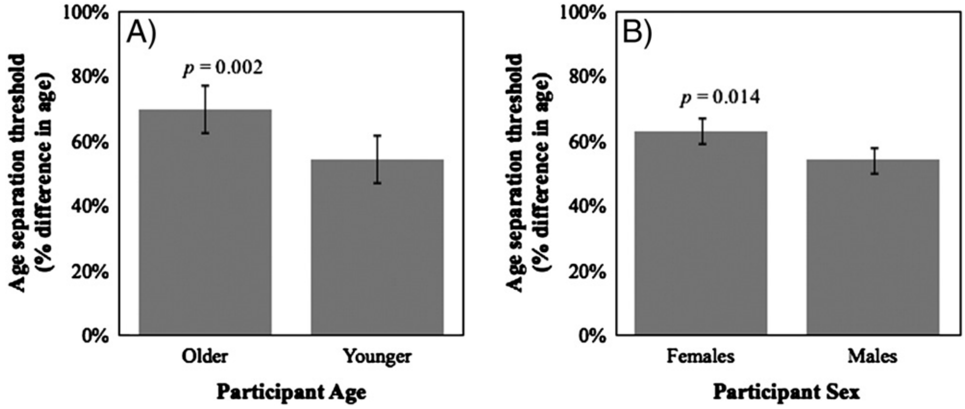

Fig. 4. Panel A. Thresholds for age discrimination of old and young participants for old base pairs. Panel B. Thresholds for age discrimination of male and female participants of female faces. Error bars show standard error of the mean.

learning and recall (e.g. Anastasi & Rhodes, 2005), and therefore selective attention for ingroup faces during encoding may have affected participants' subsequent performance during the recall phase of the task. In contrast, the current study examined participants' perceptual face recognition and comparison within trials that lasted only a few seconds, thus reducing long-term memory load and instead measuring face recognition and comparison abilities within the limits of working memory. Moreover, as previously mentioned, age information has been shown to be extracted from faces extremely rapidly (Rhodes & Anastasi, 2012), and thus, in our several-second trials, age information may be available for processing before the participant has the opportunity to apply social biases, such as ingroup or outgroup biases.

We found that older participants were significantly better than younger participants at recognizing identities when trials contained older base pairs. For example, if shown the 0% young (i.e., the old) base face and then a 60% young face (thus, a 60% trial), older participants were far likelier than younger participants to indicate that the two faces showed the same person. This finding shows that middle-aged individuals may be more sensitive than younger observers to comparisons of middle-aged to younger faces, a form of own-age bias that may depend on the older group's age membership. Anecdotally, after the experiment, a number of the older participants within the middle-aged group mentioned that they found trials with older base faces easier than those with younger base faces. Since the older group performed better overall than the younger group (see Table 1), this supports the notion that better performance may be accounted for by the fact that the older participants, across their lifespan, have had more experience with all of the age groups that are contained within our stimuli. This hypothesis has also been suggested by others (Rhodes & Anastasi, 2012).

We found that the performance of women surpassed that of men for both male and female faces, but was particularly higher for female stimuli (see Table 1). This suggests an own-sex effect but also that women can better recognize face identity even when the age disparities within a pair of photographs were quite large. For example, when the age separation in a trial between the pair of female faces was as large as 90%, women were much likelier to correctly select "same" identity than were men (See Table 1). This notion is supported by previous literature that frequently – although not always – found that women perform better than men with female faces (e.g. Lewin, 2002; Loven et al., 2011; Rehnman & Herlitz, 2006).

Several explanations have been proposed in an attempt to understand the possible sources of variation between the performance of men and women. Mounting evidence suggests that while men demonstrate strong right hemisphere lateralization of face processing (Proverbio et al., 2006), women show more bilateral coding of faces and also a faster, more efficient inter-hemispheric cooperation which results in faster reaction times, even when accuracy scores are similar (Godard & Fiori, 2010; Ino, Nakai, Azuma, Kimura, & Fukuyama, 2010). Thus, faster processing may facilitate women's performance during the very fast stimulus presentation implemented in the current experiment. Other explanations suggest that greater exposure to females during childhood may facilitate women's performance (Lewin, 2002).

Our results should be viewed with a number of caveats. First, although we attempted to produce stimuli that were as uniform as possible, some non-age-related differences may have been present, such as slight head angle variations. Second, our image morphing process did not include filtering techniques that would have allowed for the images to retain more of the skin's textural information. This may have caused slight loss of skin texture in the photographs. Finally, although we had 35 younger participants, we had only 23 older participants in our study, and future replication with an equal sample size per group would be ideal.

Despite the various changes that the human skull and skin undergo as faces age, we can often identify each other even after not having met for many years, provided the changes are within some allowable tolerances. The purpose of this study was to learn more about the tolerances within which we are able to compensate for age-related facial changes. We utilized a novel method of exploring possible sex and age effects when young and old women and men viewed faces of young and old females and males. We show a version of the own-age bias such that older participants perform better than younger participants with older base

Table 1
Mean thresholds of age discrimination for participant and stimulus groups, with lower and upper bounds of 95% CI. Bolded pairs of thresholds show a significant difference, with asterisk marking the group that performed best. In the first case, older participants outperformed their younger counterparts on old base faces, and in the second case female participants outperformed males when viewing female faces.

	Young base faces	Old base faces	Female faces	Male faces
Younger	56.1 (50.7, 61.5)	**54.1 (47.97, 60.2)**	57.0 (52.7, 61.4)	57.9 (52.6, 63.4)
Older	57.3 (50.7, 64.0)	**69.6 (62.1, 77.1)***	59.5 (54.1, 64.9)	61.2 (54.5, 67.8)
Women	60.1 (53.9, 66.2)	64.9 (58.0, 71.8)	**62.6 (57.7, 67.6)***	63.0 (56.9, 69.1)
Men	53.4 (47.3, 59.4)	58.8 (51.9, 65.6)	**53.9 (49.0, 58.8)**	56.1 (50.1, 62.1)

faces. We also show a sex-difference and with an own-sex bias such that women perform better than men, in particular for female faces.

Thus, it seems that perhaps women may indeed be better at recognizing a long-lost female friend, while men may be less able to recognize long-lost friends of either sex, and older people may be better at recognizing a friend who is currently within their relevant age group. These data further our understanding of the limits within which the brain accomplishes this task. It seems that the recognition of faces – a very social form of perception – is affected by the own-age and same-sex biases, potentially permitting us to remember some people better than others, and thus mediating our interaction with the outside world.

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