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Remembering facial age: Assimilation in memory toward categories of 'Young' and 'Old'

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ABSTRACT

When we meet someone, we make all sorts of judgments based on their age. But how is a person's age represented in the mind at all: do we remember someone as younger, or older, than they actually were? In a matching-from-memory task, observers briefly saw a target face which was either Young (30 years old) or Old (60 years old). Afterward, they saw two new decoy faces — 10 years younger, and 10 years older than the target. Observers were strongly biased to match Young targets to younger decoys, and Old targets to older decoys. These biases held across artificially aged and real faces, regardless of observers' own age, and even when the decoys' races and genders differed from that of the target — suggesting that a common mechanism underlies memory for facial age across races and genders. Additional experiments indicated that these memory biases reflect assimilation toward visual category centers, rather than toward extremes. Thus, social categories of 'young' and 'old' shape and distort our memories of faces.

1. Introduction

When we first see someone, we spontaneously categorize them in many ways, e.g. by race, gender, and age group (Brewer, 1988; Fiske & Neuberg, 1990; Hirschfeld, 2008; Kramer, Young, Day, & Burton, 2017; Lipman, Williams, Kawakami, & Steele, 2021). Although social categorizations are often implicit, they can have important consequences for how we attend to (Ito & Urland, 2003; Kawakami et al., 2014), remember (e.g. Hugenberg & Sacco, 2008; Hugenberg & Wilson, 2013; Papesh, Cash, Guevara Pinto, & Lomba, 2024; Wright & Stroud, 2002), and interact with (Buchan, Croson, & Solnick, 2008; Fershtman & Gneezy, 2001; Wilson, Hugenberg, & Rule, 2017) others. Whereas a great deal of research has focused on how we perceive and remember race and gender (for reviews, see Herlitz & Lovén, 2013; Meissner & Brigham, 2001; Young, Hugenberg, Bernstein, & Sacco, 2012), much less is known about facial age. Yet, how we categorize people on the basis of age can also have far-reaching consequences — e.g., seeing somebody as "old" causes us to attribute to them particular personality traits (Berry & McArthur, 1986; Ebner, 2008; Masip, Garrido, & Herrero, 2004), physical abilities (Hehman, Leitner, & Freeman, 2014; Třebický et al., 2019), and cognitive abilities (Hummert, Garstka, Shaner, & Strahm, 1994). Understanding biases in how we represent facial age is critical given the downstream consequences for how we interact with people across the age spectrum.

1.1. Perception of facial age

We perceive facial age quickly (Colombatto, Uddenberg, & Scholl, 2021) and automatically (Cloutier, Freeman, & Ambady, 2014; Csizmadia et al., 2021; Martin et al., 2015), by analyzing both local features (such as wrinkles; George & Hole, 2000; Quinn & Macrae, 2005) and global shape (Imai & Okami, 2019; Mark et al., 1980). However, our perception of age is also shaped by our social environment. We tend to associate with others in our own age group (i.e., age-based homophily) — a tendency which has only increased in modern, industrialized societies (e.g., Ajrouch, Blandon, & Antonucci, 2005; Hagestad & Uhlenberg, 2006; Uhlenberg & De Jong Gierveld, 2004). Greater exposure to own-age faces results in more representational precision in this part of face space, with better sensitivity when both recognizing the identities and estimating the ages of faces close to our own age (the 'own-age effect'; Anastasi & Rhodes, 2005; McPherson, Smith-Lovin, & Cook, 2001; Voelkle, Ebner, Lindenberger, & Riediger, 2012). Indeed, differential exposure to and perceptual learning of faces in our own age group seems to be the primary driver of the own-age effect, as individuals who have

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more visual experience with other age groups (e.g. preschool-teachers) are more sensitive to differences between faces in these age groups (Cassia, Picozzi, Kuefner, & Casati, 2009; see also van Rijsbergen, Jaworska, Rousselet, & Schyns, 2014).

1.2. Categorical biases in memory

The division of society into groups not only makes us more *sensitive* to faces in particular groups with which we are familiar, but also causes *biases* in how we perceive and remember others. It is not possible to encode every detail of a face, and recognizing a face as a member of a particular category allows us to use knowledge of this category to supplement our visual estimate of its features. Thus, when we perceive a face as belonging to a particular social category, we tend to misremember that face as more closely resembling the average, or prototype, of this category (for a review, see Hugenberg & Sacco, 2008). For example, nearly-White faces are remembered as more White (e.g. Corneille, Huart, Becquart, & Brédart, 2004) and nearly-male faces are remembered as more masculine (e.g. Huart, Corneille, & Becquart, 2005). Given these memory biases for race and gender, might we also be biased in how we remember a face's age? If so, it is possible that our memory for facial age is similarly biased toward nearby attractors within the age continuum — e.g. toward nearby 'young' and 'old' category centers.

1.3. 'Forward' biases in memory

Memory can be biased toward nearby category centers — but it can also be biased toward *predicted future states*. For example, when observers see an object move, their memory for its final position is biased in the direction it had been moving ('representational momentum'; Freyd, 1987; Hubbard, 2005, 2014, 2019). Such forward memory biases have also been observed for more slowly unfolding physical state changes — e.g. such that subjects remember an ice cube as more melted than it really was (Hafri, Boger, & Firestone, 2022). Would this forward momentum occur for even more slowly unfolding events, such as biological aging? If so, we may be biased to remember others' ages as distorted in the direction of these predicted physical changes (i.e., remembering all faces as older, rather than remembering faces as closer to nearby 'young' and 'old' category centers). On the other hand, representational momentum may not occur for facial age, given that facial aging is such a slow process.

1.4. The current study

Are memory biases for facial age more like memory biases for members of social categories, or more like memory biases for dynamic physical processes? In the present study, we hypothesized that observers might show (1) categorical assimilation (with younger faces remembered as closer to a 'young' category, and older faces remembered as closer to an 'old' category), (2) forward momentum, or (3) no bias at all. To investigate this, we showed participants a target face image (Young or Old), and afterward asked them to report which of two images matched the target. Neither actually matched the target — rather, they were memory decoys, which were either 10 years younger or 10 years older than the target. We tested whether participants were biased to select the younger or the older face as the one that they originally saw, and so explored how facial age may be distorted (or not) in memory. If participants choose the older decoy more often for both the Young and Old target faces, this would be consistent with representational momentum. If participants choose the younger decoy more often for the Young target, and the older decoy more often for the Old target, this would suggest categorical assimilation.

2. Experiment 1: How do we remember a face's age?

In our initial experiment, observers viewed a single, briefly presented target face (Young or Old), and afterward saw two faces, which were artificially aged or de-aged by 10 years. We simply asked the observer to report which of the two faces matched the target, and measured whether there was a bias in how Young and Old targets' ages were remembered. Our procedure was based on Hafri et al. (2022). A preregistration of the design and analysis procedures can be found at https://osf.io/6d3yq/?view_only=e7d755c067fe42d496e70f99a333eace.

2.1. Method

2.1.1. Participants

720 adults (mean age = 36.94 years, SD = 11.38, range = 18–60; Race: Asian: 8.06 %, Black: 11.39 %, Mixed: 5.97 %, Other: 2.78 %, White: 71.81 %; Sex: Female: 51.11 %, Male = 48.33 %, Prefer not to say: 0.56 %) participated. Participants were recruited through the online labor market Prolific (https://prolific.co/), which is often used for visual perception studies (Palan & Schitter, 2018). Participants were able to participate only if they were aged 18–60, had normal vision, and lived in the United States. Each observer participated in a 5 min online session (https://pavlovia.org/), in return for a small monetary payment.

We ran a pilot experiment with a White female face, and observed strong biases to remember a Young version of the face (30 years old) as younger, and to remember an Old version of the face (60 years old) as older. A power analysis on these pilot data indicated that we would need a sample size of 30 participants in the Young condition and 19 participants in the Old condition in order to observe these effects with 80 % power at an alpha level of 0.05. In order to explore these effects across additional races and genders, we decided to preregister a larger sample size of 720 (30 per cell), with two planned tests (a binomial test for the Young condition collapsing across races and genders, and a binomial test for the Old condition collapsing across races and genders). We also preregistered exploratory tests to examine the Young-assimilation and Old-assimilation effects for each race collapsing across sex (3 races × 2 ages = 6 binomial tests) and for each gender collapsing across race (2 genders × 2 ages = 4 binomial tests).

We preregistered the following exclusion criteria: Participants were excluded if during debriefing they reported that they had switched windows during the experiment, did not understand the instructions, or had a problem with the displays, or they failed the attention check. Participants were also excluded if during debriefing they reported a race or gender for the target face that differed from its assigned label in the Chicago Face Database. Excluded participants were replaced to reach the preregistered sample size of $N = 720$.

2.1.2. Apparatus

The experiment was built using PsychoPy (Peirce et al., 2019), and hosted on the Pavlovia servers. Stimuli were presented in 'height' units in PsychoPy, such that stimuli were scaled relative to the size of the participant's screen. A height unit of 1 corresponds to the distance from the top to the bottom of the display.

2.1.3. Stimuli

Stimuli were generated from face photographs from the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015). We selected photographs of six individuals (1 Asian Male, 1 Asian Female, 1 Black Male, 1 Black Female, 1 White Male, 1 White Female), in which the face was fully frontal, had both ears visible, and had a neutral facial expression. Each individual photograph was input into an aging algorithm (for a full discussion, see Alaluf, Patashnik, & Cohen-Or, 2021), to generate six versions of each face — at 20, 30, 40, 50, 60, and 70 years old (see Fig. 1). All stimuli were displayed on a white background. Face stimuli were presented at 0.3072 × 0.3072 height units. Instructions text was printed in black Open Sans font at 0.04 height units.

Fig. 1. An example aging continuum from Experiment 1, depicting a White female at different ages. Actual stimuli were based on Chicago Face Database images.

2.1.4. Procedure and design

After reading a consent form and indicating their consent, participants read the instructions for the experiment and completed a self-paced practice trial, in which they pressed the spacebar to advance through successive screens. At the start of the practice, they were shown a centered black rectangle (0.3412 × 0.2300 height units) and instructed to press the spacebar to reveal the target image behind the rectangle. An image of a sunset (0.3412 × 0.2300 height units) was then shown with instructions to continue to the next screen. A mask image was then shown with instructions to ignore the mask image and to press the spacebar to continue to the next screen. Two sunset images were then shown side-by-side, one on the left that matched the target sunset image, and one on the right that pictured the sun closer to the horizon. Participants pressed the left or right arrow key to indicate which image they thought matched the target. Unlike the real trial, there was a correct answer ('left arrow key').

The experiment itself consisted of one real trial. Participants first saw a black square (0.3072 × 0.3072 height units) in the center of the screen, along with a prompt which instructed them to press the spacebar to reveal the target image. Participants then saw the centered target face for 1 s: in the Young condition, the target face was 30 years old, and in the Old condition, the target face was 60 years old. This was followed by a 1 s mask (a jumbled version of the target face), followed by two side-by-side decoy versions of the same identity, one of which was 10 years younger, and one which was 10 years older: in the Young condition, the decoys were 20 and 40 years old, and in the Old condition, the decoys were 50 and 70 years old. Participants pressed the left or right arrow key to indicate which face they thought matched the target (see Fig. 2). After making their response, participants were routed to Qualtrics to complete a short debriefing survey.

The experiment had a 2 (Target Age: Young vs. Old) x 2 (Target Gender: Male vs. Female) x 3 (Target Race: Asian/ Black/ White) x 2 (Decoy Sides: Younger Left vs. Younger Right) between-subjects design.

2.2. Results

2.2.1. Planned analyses — Remembering Young targets as younger and Old targets as older

In both the Young target and Old target conditions, we calculated the proportion of participants who selected the older decoy face. These proportions are depicted in Fig. 3. Young targets and Old targets produced opposite memory biases: in the Young target condition, less than half of participants (38.1 %) chose the older face as the one they had just seen, and in the Old target condition, more than half of participants chose the older face as the one they had just seen (60.8 %). As per our pre-registration, we ran two binomial tests, which confirmed that both proportions differed significantly from 50 % (both p's < 0.001).

2.2.2. Exploratory analysis 1 — Effects of target's perceived gender

Fig. 4 breaks the results down by the target face's gender. Inspection of the figure suggests that the tendencies to remember young faces as younger and old faces as older held across both male and female faces: For female targets, in the Young target condition, less than half of participants (46.7 %) chose the older face (binomial test, $p = .412$), and in the Old target condition, more than half of participants (60.6 %) chose the older face (binomial test, $p = .006$). For male targets, in the Young target condition, less than half of participants (29.4 %) chose the older face (binomial test, $p < .001$), and in the Old target condition, more than half of participants (61.1 %) chose the older face (binomial test, $p = .004$).

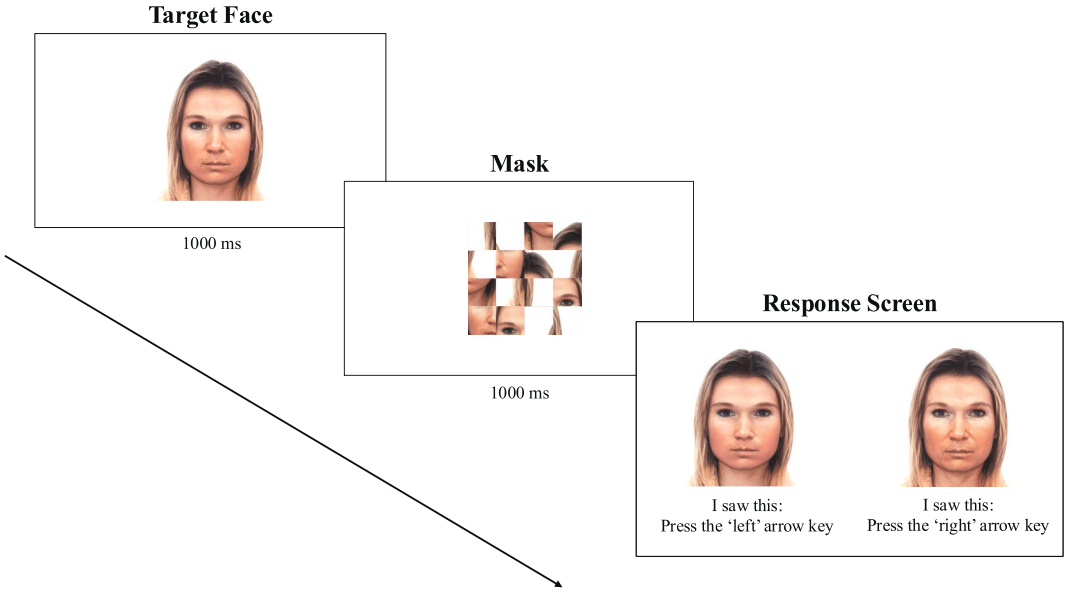

Fig. 2. Experiment 1 procedure.

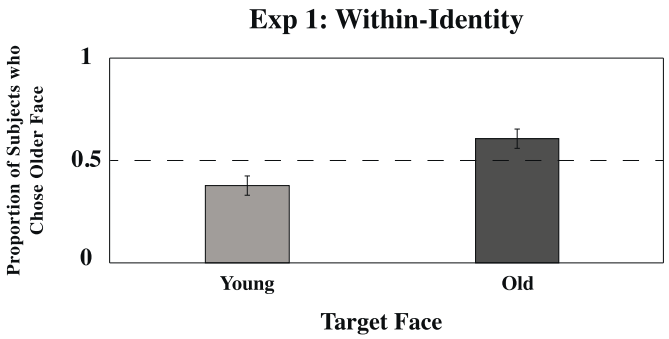

Fig. 3. Results of Experiment 1. Error bars indicate 95 % confidence intervals.

Although these exploratory analyses suggest that the Young-assimilation effect was driven by male faces more than female faces, this gender difference was not reliable in subsequent experiments.

2.2.3. Exploratory analysis 2 — Effects of target's perceived race

Fig. 5 breaks the results down by the target face's race. Inspection of the figure suggests that the tendencies to remember Young faces as younger and Old faces as older held across Asian, Black and White races: For Asian faces, in the Young target condition, less than half of participants (43.3 %) chose the older face ($p = .171$), and in the Old target condition, more than half of participants (55.8 %) chose the older face ($p = .235$). For Black faces, in the Young target condition, less than half of participants (35.0 %) chose the older face ($p = .001$), and in the Old target condition, more than half of participants (60.8 %) chose the older face ($p = .022$). For White faces, in the Young target condition, less than half of participants (35.8 %) chose the older face ($p = .002$), and in the Old target condition, more than half of participants (65.8 %) chose the older face ($p < .001$).

2.2.4. Exploratory analysis 3 — Effects of participant's own age

Given the past literature showing greater sensitivity to own-age faces, we ran an exploratory analysis to test whether participants are also biased to remember faces as closer to their own age. For the Young (30-year-old) target, the decoys were 20 and 40 years old; if participants were biased to misremember a young face as closer to their own age and to thus choose the decoy closer to their own age, then participants under 30 should tend to choose the 20-year-old, and participants over 30 should tend to choose the 40-year-old. To find out whether this was true, we binned participants into a *younger-than-30* group ($N = 220$, mean = 24.15, SD = 2.84, range = 18–29) and an *older-than-30* group ($N = 477$, mean = 43.17, SD = 8.66, range = 31–60). We did not find a significant difference between these age groups in the % choosing the older decoy (*younger-than-30* participants: 38.7 %, *older-than-30* participants: 38.9 %), $\chi 2(1, 697) = 0.001$, $p = .975$, $\phi = 0.001$. Similarly, for the Old (60-year-old) target, for which the decoys were 50 and 70 years old, if participants were biased to pick the decoy that was closer to their own

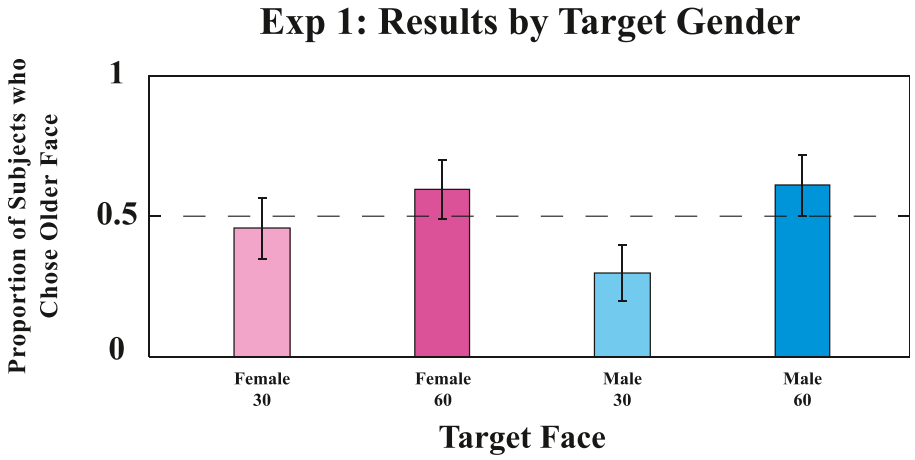

Fig. 4. Proportion of subjects choosing the older decoy, broken down by gender and age of target face, collapsing across race of target face. Error bars indicate 99.55 % confidence intervals, to reflect the Bonferroni-corrected alpha level which was used for the exploratory tests (0.05/11 tests = 0.0045).

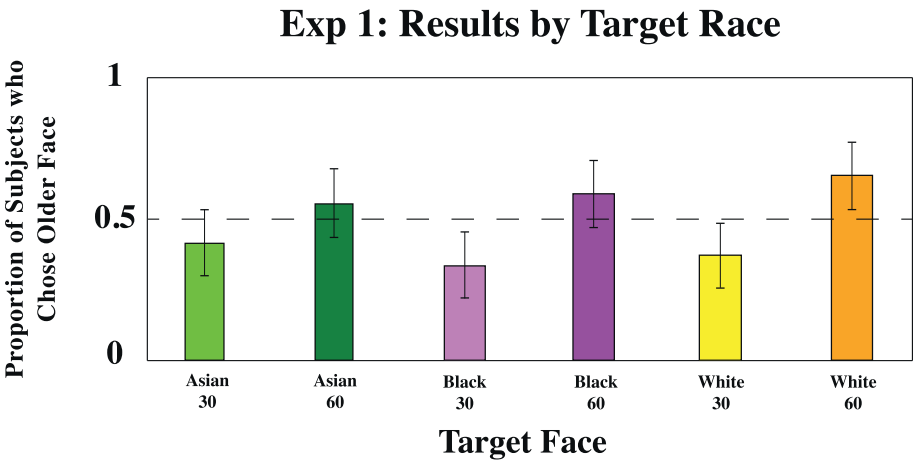

Fig. 5. Proportion of subjects choosing the older decoy, broken down by race and age of target face, collapsing across gender of target face. Error bars indicate 99.55 % confidence intervals, to reflect the Bonferroni-corrected alpha level which was used for the exploratory tests (0.05/11 tests = 0.0045).

age, then participants under 60 should tend to pick the 50-year-old, and participants over 60 should tend to pick the 70-year-old. It was not possible to run a similar test for the Old target face, because the Old target was 60 years old, and we had no participants in our sample who were > 60 years old. We do not discuss own-age effects further, as none of our experiments found any evidence of participants' own age on memory biases for facial age.

2.3. Discussion

Participants remembered 30-year-old faces as younger and 60-year-old faces as older. These biases were robust when aggregating across all identities, and in exploratory analyses, they were visible numerically (though not necessarily statistically) for each gender and race that we tested. We conclude that there is an overall tendency to remember Young faces as younger and Old faces as older. Does the same underlying mechanism subserve the Young-assimilation and Old-assimilation biases for faces of different races and genders?

3. Experiment 2: Cross-identity transfer of the Young-assimilation and Old-assimilation biases

The perception of facial age shows adaptation effects even when there are gender differences between the adapting and test stimuli, suggesting that partly shared mechanisms underlie the perception of age for faces of different genders (Schweinberger et al., 2010). Are the mechanisms underlying the Young-assimilation and Old-assimilation age distortions similarly shared for faces of different genders and races? If so, they might occur even with gender or race differences between the target and decoys. To test this, we reran Experiment 1 using the same six target identities, but always selected the young and old decoys from an opposite-gender, different-race morph continuum. Participants selected the decoy whose age they thought matched the age of the target face. A preregistration of the design and analysis procedures can be found at https://osf.io/nqap5/?view_only=cb39ebdd4f164b27b91fdd42e0a68dc7.

3.1. Method

This experiment was identical to Experiment 1, except as noted here. 384 adults (mean age = 35.29 years old, SD = 9.95, range = 19–60; Race: Asian: 11.20 %, Black: 10.94 %, Mixed: 8.59 %, Other: 2.86 %, White: 66.41 %; Sex: male = 51.56 %, female = 48.44 %).

This sample size was determined as follows: We ran post-hoc power analyses on the Young-assimilation and Old-assimilation effects in Experiment 1, which confirmed that the experiment was overpowered to observe both of these effects. For Experiment 2, we reduced our sample size to 384 (8 per cell), in order to be able to observe the Young-assimilation and Old-assimilation effects with 80 % power at an alpha level of 0.05.

Participants first completed a practice trial in which they saw a White female target face, and then chose which of two White male faces (which were of the same identity as one another, and aged or de-aged by 10 years relative to the age of the target face). Faces used in the practice trial were taken from the Chicago Face Database, and were not otherwise used in the experiment.

On the real trial, the target image and mask were followed by two side-by-side decoy faces, which had a different gender and race from the target, and which came from the same identity continuum as one another, with one 10 years younger, and one 10 years older than the target. In the Young condition, the target was 30 years old, and the decoys were 20 and 40 years old, and in the Old condition, the target was 60 years old, and the decoys were 50 and 70 years old. Participants pressed the left or right arrow key to indicate which face they thought matched the age of the target.

The experiment had a 6 (Target identity) x 2 (Target Age: Young vs. Old) x 1 (Decoy Opposite Gender to Target) x 2 (Decoy Opposite Race to Target) x 2 (Decoy Sides: Younger Left vs. Younger Right) between-subjects design.

3.2. Results

In both the Young target and Old target conditions, we calculated the proportion of participants who selected the older decoy face. These proportions are depicted in Fig. 6. Inspection of this figure suggests that Young targets and Old targets produced opposite memory biases, similar to Experiment 1: in the Young target condition, less than 50 % of participants (27.1 %) chose the older face, and in the Old target condition, more than 50 % of participants chose the older face (78.1 %). As per our pre-registration, we ran two binomial tests, which confirmed that both proportions differed significantly from 50 % (both p's < 0.001).

3.3. Discussion

Once again, there was evidence of Young-assimilation and Old-assimilation: Young target faces were more likely to be remembered as matching the age of younger decoys, and Old target faces were more likely to be remembered as matching the age of older decoys — even when those decoys' races and genders differed from the target. Together with the results of Schweinberger et al. (2010), this suggests that a common mechanism underlies the encoding of facial age across different social groups.

4. Experiment 3: Replication with real faces

Were these Young-assimilation and Old-assimilation memory biases just an artifact of the artificial aging algorithm that we used? To rule this out, we next replicated both effects using images of real faces of different ages. A preregistration of the design and analysis procedures can be found at https://osf.io/72k4q/?view_only=1a64a00d70b645739c39156eb44e9784.

4.1. Method

Experiment 3 was identical to Experiment 2, except as noted here. 512 adults (mean age = 36.34, SD = 11.41, range = 18–60; Race: Asian: 8.98 %, Black: 9.77 %, Mixed: 7.81 %, Other: 3.71 %, White: 69.73 %; Sex: female: 51.56 %, male: 45.31 %, other: 2.34 %, prefer not to say: 0.78 %). We chose this sample size to match the number of participants per cell in Experiment 2.

4.1.1. Stimuli

The face stimuli were taken from the UTKFace dataset (Zhang, Song, & Qi, 2017). This dataset contains face images with annotations of age, gender, and race. Two White male and two White female faces were selected at each of the following ages: 20, 30, 40, 50, 60 and 70, for a total of 24 identities. As natural images, the stimuli in the UTKFace

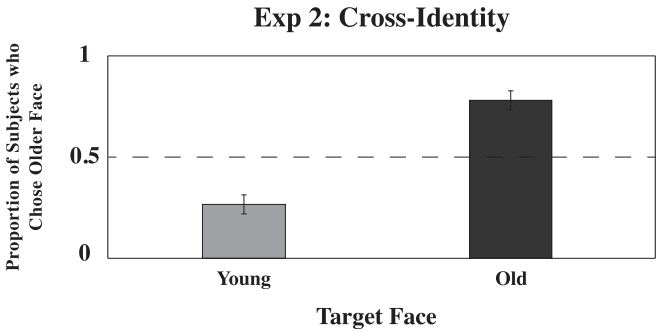

Fig. 6. Results of Experiment 2. Error bars indicate 95 % confidence intervals.

dataset are quite variable; we selected only images in which the face was smiling, was without glasses, and was photographed at relatively high resolution.

4.1.2. Procedure

On the practice trial, subjects viewed a screen with a target 50-year-old White male face, followed by a mask, followed by a screen with two side-by-side response faces of different identities from the target and each other — a 50-year-old White male face on the left, and a 70-year-old White male face on the right. The practice stimuli were drawn from the Chicago Face Database, and aged using the aging algorithm used in Experiments 1 and 2 (Alaluf et al., 2021).

On the real trial, a target UTKFace stimulus and mask were shown, followed by two side-by-side decoy faces, which had different identities but the same gender as the target, with one 10 years younger, and one 10 years older than the target. In the Young condition, the target was 30 years old and the decoys were 20 and 40 years old, and in the Old condition the target was 60 years old and the decoys were 50 and 70 years old. Participants pressed the left or right arrow key to indicate which face they thought matched the age of the target.

Experiment 3 had a 2 (Target Age: Young vs. Old) x 2 (Target Gender: Male vs. Female) x 2 (Target Identity 1 vs. Target Identity 2) x 2 (Younger Decoy Identity 1 vs. Younger Decoy Identity 2) x 2 (Older Decoy Identity 1 vs. Older Decoy Identity 2) x 2 (Decoy Sides: Younger Left vs. Younger Right) between-subjects design.

4.2. Results

In both the Young target and Old target conditions, we calculated the proportion of participants who selected the older decoy. These proportions are depicted in Fig. 7. Inspection of this figure suggests that Young targets and Old targets again produced opposite memory biases: in the Young target condition, less than 50 % of participants (16.8 %) chose the older face, and in the Old target condition, more than 50 % of participants chose the older face (78.9 %). As per our pre-registration, we ran two binomial tests, which confirmed that both proportions differed significantly from 50 % (both p's < 0.001).

4.3. Discussion

This experiment confirms that the Young-assimilation and Old-assimilation memory biases occur when viewing real faces.

5. Experiment 4: A 'Blindfold Test'

Did these biases just arise due to participants' explicit, higher-level categorization of different ages as more similar to one another? For example, it is possible that participants were unbiased in how they remembered target faces, but that they conceptually represented 30-year-olds as more similar to 20 year olds than 40 year olds, even without any visual face processing. To rule out this possibility, we ran a 'Blindfold Test'. We replicated Experiment 3, but replaced the target and decoy images with verbal age labels. If the Young-assimilation and Old-assimilation effects replicate, this would suggest that visual processing is not necessary, and that higher-level categorization is sufficient, for these biases to arise. However, if the biases do not replicate when merely describing the visual stimuli, this would demonstrate that visual processing is necessary to induce them (for a fuller exposition of the logic of the 'Blindfold Test', see van Buren & Scholl, 2025). A preregistration of the design and analysis procedures can be found at https://osf.io/jw4ef?view_only=098909461ec348e7966c2b4e03a2414f.

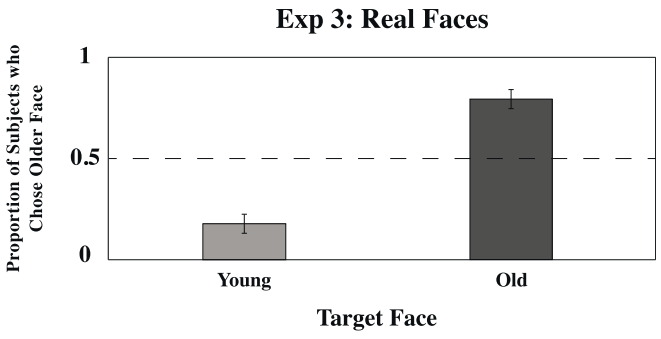

Fig. 7. Results of Experiment 3, with natural images of faces. Error bars indicate 95 % confidence intervals.

5.1. Method

This experiment was identical to Experiment 3, except as noted here. 512 adults (mean age = 37.89 years old, SD = 11.0, range = 18–60; Race: Asian: 10.74 %, Black: 13.09 %, Mixed: 7.03 %, Other: 3.52 %, White: 65.63 %; Sex: female: 61.52 %, male: 37.89 %, prefer not to say: 0.59 %). We chose this sample size to match the number of participants in Experiment 3.[1]

5.1.1. Procedure

In all conditions, the text was displayed in a black Open Sans font with a size of 0.04 height units, on a white background.

Participants in the Young condition viewed a screen displaying the following written question:

> *Imagine that you are in a psychology experiment in which you are shown an image of a 30-year-old person's face for one second, and asked to remember it. You are then shown two new images of two different faces side-by-side. One is a 20-year-old face, and the other is a 40-year-old face. Which of these faces do you think would more closely match the age of the 30-year-old face? Press the left or right arrow key to select the corresponding face of your choice.*

Below this question were two side-by-side written response options, one that said "20-year-old face" and one that said "40-year-old face". The sides of the screen (left vs. right) where the response options appeared were counterbalanced between observers.

Participants in the Old condition viewed a screen displaying the following written question:

> *Imagine that you are in a psychology experiment in which you are shown an image of a 60-year-old person's face for one second, and asked to remember it. You are then shown two new images of two different faces side-by-side. One is a 50-year-old face, and the other is a 70-year-old face. Which of these faces do you think would more closely match the age of the 60-year-old face? Press the left or right arrow key to select the corresponding face of your choice.*

Below this were two side-by-side written response options, one that said "50-year-old face" and one that said "70-year-old face". The sides of the screen where the response option text boxes appeared were counterbalanced between observers.

Thus, Experiment 4 had a 2 (Target Age: Young vs. Old) x 2 (Decoy Sides: Younger Left vs. Younger Right) between-subjects design.

5.2. Results

In both the Young target and Old target conditions, we calculated the

[1] A power analysis on pilot data indicated that 25 participants each in the Young and Old conditions would give us 80 % power to observe the predicted chi-square differences relative to Experiment 3. However, we decided in advance to recruit a total of 512 participants to match the sample size of Experiment 3 in order to overpower our experiment, to give it the best chance at detecting a Young-assimilation or Old-assimilation effect.

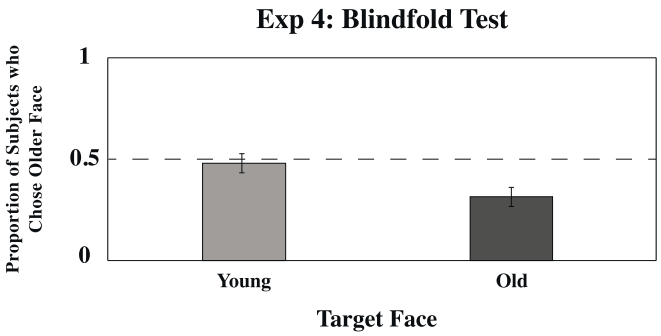

Fig. 8. Results of Experiment 4, with written descriptions of the displays. Error bars indicate 95 % confidence intervals.

proportion of participants who selected the older decoy, and these results are plotted in Fig. 8. Inspection of this figure suggests that written descriptions of the targets and decoys did not produce the Young-assimilation or Old-assimilation memory biases evident in the previous three experiments: in the Young target condition, the proportion of participants who chose the older face did not differ from 50 % (47.3 %, binomial test, $p = .417$). In the Old target condition, less than 50 % of participants chose the older face (30.9 %, binomial test, $p < .001$; a pattern *opposite* to the Old-assimilation effect).[2]

To formally compare the proportions in the current experiment to those in Experiment 3, we also ran two chi-square tests. The proportion of participants in the Young condition of Experiment 3 who chose the older face was significantly less than the proportion of participants in the Young condition in the current experiment who chose the older face, $\chi 2(1, N = 512) = 54.47$, $p < .001$, $\phi = 0.33$. The proportion of participants in the Old condition of Experiment 3 who chose the older face was significantly greater than the proportion of participants in the Old condition in the current experiment who chose the older face, $\chi 2(1, N = 512) = 119.10$, $p < .001$, $\phi = 0.48$.

5.3. Discussion

These biases do not replicate with verbal descriptions. This shows that they cannot solely be due to participants' reasoning about how people of different ages ought to be related, and that visual processing must play a role (perhaps in concert with higher-level categorization).

6. Experiment 5a: Is memory for facial age biased toward prototypes or extremes?

The Young-assimilation and Old-assimilation biases observed in Experiments 1–3 may reflect assimilation toward category centers (e.g. Huttenlocher, Hedges, & Vevea, 2000), or toward category extremes (e.g. Sun, Han, & Firestone, 2024). To determine which of these is more likely, we showed participants 80-year-old target faces with 70-year-old and 90-year-old decoys. If the Old-assimilation effect reflects assimilation toward extreme old age, then it should continue to operate even for 80-year-old faces, and participants should show a bias to select the older (90-year-old) face as matching the face that they saw. However, if the Old-assimilation effect reflects assimilation to an 'old' category center in the 60's or 70's, participants viewing an 80-year-old target should be biased to select the younger (70-year-old) face as matching the face they saw. A preregistration of the design and analysis procedures can be found at https://osf.io/cfz3x?view_only = 098909461ec348e7966c2b4e03a2414f.[3]

6.1. Method

Experiment 5a was identical to Experiment 3, except as noted here. 320 adults (mean age = 38.62 years old, SD = 11.58, range = 18–70; Race: Asian: 7.19 %, Black: 14.06 %, Mixed: 7.50 %, Other: 2.50 %, White: 68.13 %, prefer not say: 0.63 %; Sex: female: 57.81 %, male: 40.94 %, prefer not to say: 1.25 %). Participants were able to participate only if they were aged 18–100, had normal vision, and lived in the United States. A power analysis on pilot data indicated that this sample size would be sufficient to observe a bias to select the younger face with 80 % power at an alpha level of 0.05.

6.1.1. Stimuli

Two White male and two White female faces were selected at each of the following ages: 70, 80, 90, for a total of 12 identities from the UTKFace dataset. We again selected only images in which the face was smiling, was without glasses, and was photographed at relatively high resolution.

6.1.2. Procedure

On the real trial, a target face and mask were shown, followed by two side-by-side decoy faces, which had different identities but the same gender as the target, with one 10 years younger, and one 10 years older than the target. The target was 80 years old and the decoys were 70 and 90 years old. Participants pressed the left or right arrow key to indicate which face they thought matched the age of the target.

The experiment had a 2 (Target Gender: Male vs. Female) x 2 (Target Identity 1 vs. Target Identity 2) x 2 (Younger Decoy Identity 1 vs. Younger Decoy Identity 2) x 2 (Older Decoy Identity 1 vs. Older Decoy Identity 2) x 2 (Decoy Sides: Younger Left vs. Younger Right) between-subjects design.

6.2. Results

We calculated the proportion of participants who selected the older decoy.[4] This proportion is depicted in Fig. 9. Inspection of this figure suggests that observers tended to remember very old targets (80 years old) as *younger* — opposite to the previously observed bias to misremember Old targets (60 years old) as older. For 80-year-old targets, less than 50 % of participants (35.6 %) chose the older face. As per our preregistration, we ran a binomial test, which confirmed that this proportion differed significantly from 50 % ($p < .001$).

6.3. Discussion

Observers showed a strong bias to match 80-year-old targets to a *younger* decoy. Together with the results of Experiments 1–3, this indicates that the previously observed bias to remember 60-year-old faces as older reflects a prototype attraction effect (toward an 'old' category center between ages 60 and 80), rather than a bias to remember ages near the tails of the age continuum as more extreme.

[2] In the U.S., the age of retirement is between 65 and 67. In the absence of visual displays, participants' conceptualization of 50 and 60 year olds as 'pre-retirement age', and 70 year olds as 'post-retirement age', may have led some to reason that a 60-year-old should be matched to a 50-year-old, rather than to a 70-year-old.

[3] The Young-assimilation effect might similarly reflect a bias either toward a 'young' prototype or toward an extremely young age; we did not run an analogous experiment with 10-year-old targets and 0-year-old and 20-year-old faces because aging is very rapid and nonlinear at this stage of development (Enlow & Hans, 1996).

[4] For experiments 5a and 5b, our preregistrations indicated that we would analyze the proportions of participants who chose the younger decoy. However, we opted to analyze and visualize our data in terms of the proportions of participants who chose the older decoy to make the present results easier to compare with the previous experiments.

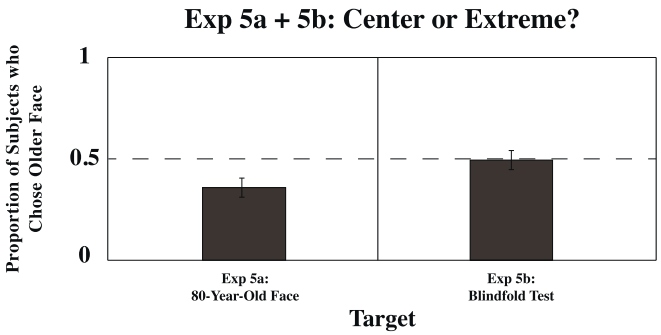

Fig. 9. Results of Experiment 5a (with 80-year-old target faces, and 70- and 90-year old decoys) and 5b (a replication with written descriptions). Error bars indicate 95 % confidence intervals.

7. Experiment 5b: Is memory biased toward prototypes or extremes?: A 'Blindfold Test'

Does this bias to match an 8o-year-old face to a 70-year-old face rather than a 90-year old-face just reflect participants' higher-level judgments about how these ages ought to be related to one another? Or does this bias depend critically on visual processing? To investigate this, we again applied the Blindfold Test. A preregistration of the design and analysis procedures can be found at: https://osf.io/f8y6k?view_only=098909461ec348e7966c2b4e03a2414f.

7.1. Method

This experiment was identical to Experiment 5a, except as noted here. 320 adults (mean age = 36.61 years old, SD = 11.46, range = 18–79; Race: Asian: 8.13 %, Black: 14.06 %, Mixed: 6.25 %, Other: 3.13 %, White: 68.44 %; Sex: female: 60.63 %, male: 39.06 %, prefer not to say: 0.31 %). This sample size was chosen to match the number of participants in Experiment 5a.

Procedure. In all conditions, the text was displayed in a black Open Sans font with a size of 0.04 height units, on a white background. Participants viewed a screen displaying the following written question:

Imagine that you are in a psychology experiment in which you are shown an image of an 80-year-old person's face for one second, and asked to remember it. You are then shown two new images of two different faces side-by-side. One is a 70-year-old face, and the other is a 90-year-old face. Which of these faces do you think would more closely match the age of the 80-year-old face? Press the left or right arrow key to select the corresponding face of your choice.

Below this were two side-by-side written response options, one that said "70-year-old face" and one that said "90-year-old face". The sides of the screen (left vs. right) where the response options appeared were counterbalanced between observers.

The experiment had a 2 (Decoy Sides: Younger Left vs. Younger Right) between-subjects design.

7.2. Results

We calculated the proportion of participants who selected the older decoy, and these are plotted in Fig. 9. The proportion of participants who chose the older face did not differ from 50 % (49.4 %, binomial test, $p = .867$).

To compare the proportions in the current experiment to those in Experiment 5a, we also performed a chi-square test. The proportion who chose the older face in Experiment 5a was significantly less than the proportion who chose the older face in the current experiment, $\chi 2$ (1, $N = 640$) = 12.36, $p < .001$, $\phi = 0.14$.

7.3. Discussion

In the present experiment, in which participants read written descriptions of the target and decoy faces used in Experiment 5a, 80-year-old targets were not consistently matched to either the younger (70-year-old) or the older (90-year-old) decoy. As with the previously observed effects, this bias requires actually seeing the stimuli, and does not arise solely due to higher-level reasoning about how these different ages ought to be related.

8. General discussion

In three experiments, observers were strongly biased to remember Young (30-year-old) faces as younger, and Old (60-year-old) faces as older. These biases held when age was manipulated artificially (Experiments 1 and 2) or naturally (Experiment 3), across genders and races (Experiments 1 and 2), and even when the decoys' identities differed from that of the target face (Experiments 2, 3 and 5a) — suggesting that a shared mechanism underlies our memory of facial age for different genders, races and identities. To find out whether these memory biases are caused by assimilation toward age category centers or toward extreme ages, we also ran an experiment with very old faces (80 years old; Experiment 5a), which revealed a bias to remember very old faces as younger — suggesting that the foregoing effects reflect assimilation toward 'young' and 'old' age prototypes, rather than toward extremes. Finally, additional control experiments (Experiments 4 and 5b) confirmed that these biases occur only when actually viewing faces, as none replicated when participants matched faces whose ages were merely verbally described.

The present research on memory biases for facial age was inspired by memory biases which have been observed in other domains. On the one hand, recent work has found that observers are biased to remember slowly unfolding physical processes as further along (e.g. remembering an image of an ice cube as more melted than it really was; Hafri et al., 2022) — raising the intriguing possibility that a similar 'forward bias' might occur for biological processes, such as facial aging. On the other hand, work on memory for faces has found biases toward nearby demographic categories such as races (e.g. remembering nearly-North-African faces as more North African; Corneille et al., 2004; but see Uddenberg & Scholl, 2018) and genders (e.g., remembering nearly-female faces as more female; Huart et al., 2005). If facial age is treated categorically like other demographic features, then faces near the edges of subcategories might be remembered as nearer to these attractors. Was memory for facial age in our study more like memory for dynamic properties, or like memory for demographic features?

8.1. Memory for facial age is biased toward categories of 'young' and 'old'

Observers remembered 30-year-olds as more similar to 20-year-olds than to 40-year-olds, and 60-year-olds as more similar to 70-year-olds than to 50-year-olds, despite the decoys' equal distance in age from the target face. These results resemble previously observed categorical assimilation effects toward nearby races and genders. Such effects may arise from our learning of statistical regularities in our social environment. In the population that we tested (U.S. residents), 30-year-olds may behave more similarly to younger people, and 60-year-olds may behave more similarly to older people (e.g., Rolison, Hanoch, Wood, & Liu, 2013; Shanahan, Porfeli, Mortimer, & Erickson, 2005). Quickly categorizing faces as 'young' or 'old', and placing 30- and 60-year-old faces in these respective categories may provide us with a shortcut to predict their behaviors (e.g. Chalik, Rivera, & Rhodes, 2014; Franklin, 2023; Keil, 2006; Montepare & Zebrowitz, 1998). Moreover, in situations in which we cannot encode the details of a face with high fidelity (e.g. after brief visual exposures, such as were tested here), we may rely on category membership in order to fill in visual information which is missing

from our memory representation (Huttenlocher et al., 2000).

Previously observed race and gender assimilation effects have typically been interpreted as assimilation toward category centers (e.g. Corneille et al., 2004), but in many cases could also be explained by memory biases toward extremes or 'caricatures' (e.g. Sun et al., 2024). For example, remembering a nearly-White face as more White could reflect assimilation toward a typical White face, or an extremely White face. In the present research, we were able to arbitrate between these two possible explanations of the Old-assimilation effect: we found that memory for both 60- and 80-year-old targets was assimilated toward a 70-year-old decoy. This rules out assimilation toward extreme old age, and suggests instead that there is an 'old' age attractor between the ages of 60 and 80 years old toward which nearby ages are assimilated.

8.2. Nonlinearities in facial aging

An alternative possibility is that the biases to match Young targets to younger vs. older decoys and Old targets to older vs. younger decoys arise not from memory biases, but rather from patterns of physical stimulus similarity, due to nonlinearities in facial aging. For example, although women's faces change size at the same rate throughout their 20's and 30's, men's faces change more rapidly during their 20's than during their 30's (Velemínská, Jaklová, Kočandrlová, et al., 2022). And although men's faces change at the same rate throughout their 50's and 60's, women's faces change more rapidly during their 50's, due to menopause (Li et al., 2023; Windhager et al., 2019). Physical nonlinearity may explain one of our results: in the case of older women's faces, there are typically more low-level differences between a 50-year-old and a 60-year-old face, than between a 60-year-old and a 70-year-old face, which might explain the female Old-assimilation effect (i.e., the bias to match a 60-year-old female to a 70 year old, rather than to a 50 year old). But what remains striking is that these nonlinearities cannot account for the directions of any of our other results — e.g. in the case of young male faces, greater physical differences between a 20 year old and a 30 year old than between a 30 year old and a 40 year old, should, on their own, produce the opposite of a Young-assimilation effect (i.e., a bias to match a 30-year-old male face to a 40 year old, rather than to a 20 year old, as we observed). Thus, the Young-assimilation and Old-assimilation biases cannot be driven just by patterns of brute physical similarity in the stimuli, but must also reflect more abstract categorical representations of facial age in the mind.

8.3. Limitations & applications

In the future, it will be important to test memory biases for facial age for targets across the whole age spectrum (perhaps with a continuous response measure) in order to locate the ages of the 'young' and 'old' attractors more precisely. Such an approach could also potentially discover new attractors, e.g. around 'early childhood' or 'middle age'. Our exploratory analyses in Experiment 1 did not turn up any differences in the Old-assimilation and Young-assimilation biases for target faces of different races and genders — but higher-powered experiments (involving both more subjects and more target identities) should be run to confirm the robustness of these effects for individual demographic categories. In addition, future research should also consider how categorical biases in memory for facial age may differ depending on one's social environment — we find that U.S.-based observers assimilate 30-year-old faces toward a 'young' category, but 30 year olds might be categorized and remembered as older in cultures with different life expectancies/life histories (Dunin & van Buren, in press; Fershtman & Gneezy, 2001; Frankenhuis and Amir, 2022; Rindfuss, & St. John, C., 1983; Roebuck, 1979; Sear, 2020; Stearns & Rodrigues, 2020).

While much remains to be learned about memory biases for facial age, it is already clear that such biases could have a number of important real-world implications. For example, they may cause employers to make worse hiring decisions: misremembering a young person as younger may cause us to assume that they have less experience than they really have; and misremembering an old person as older may cause us to assume that they are less capable than they really are. The insights derived from this research might also assist in understanding potential age-related biases in eyewitness testimony (e.g., misremembering a young perpetrator as younger than they really were), and correcting for these may increase the reliability of the criminal justice system.

9. Conclusion

In conclusion, memory for facial age is assimilated toward 'young' and 'old' attractor ages. These biases occur even when comparing age across faces of different genders and races — suggesting that a common mechanism underlies the memory biases for facial age across different demographic categories. Thus, social categories shape and distort our memory of the visual world.

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Artificial intelligence

No artificial intelligence assisted technologies were used to write this article.

Ethics

This received approval from a local ethics board.

Computational reproducibility

Data and analysis instructions are available on the Open Science Framework. The authors will provide analysis code upon request.

Preregistration

The hypotheses, methods and key analyses were preregistered prior to data collection.

Statement of relevance

After seeing a person's face, do we remember them as younger, or as older, than they actually were? Here we find that young faces (30 years old) tend to be misremembered as younger than they were, and that old faces (60 years old) tend to be misremembered as older than they were — demonstrating how social categories of 'young' and 'old' can bias our memories of faces. It is important to be aware of these biases, as how we perceive and remember a person's age can have important consequences — including in eyewitness testimony, and in hiring decisions.

CRediT authorship contribution statement

Didi Dunin: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Joan Danielle K. Ongchoco:** Writing – review & editing, Writing – original draft, Visualization, Supervision. **Benjamin F. van Buren:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration.

Declaration of competing interest

All authors declare no conflicts of interest.

Data availability

All data for the experiments reported in this manuscript are available on the Open Science Framework: https://osf.io/mvxay

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