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ORIGINAL ARTICLE PATIENT SAFETY/EDUCATION

How Long and How We Judge Age: A Cross-Racial and Cross-Gender Eye-Tracking Investigation

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Abstract

Background Facial aging results from genetic, environmental, and lifestyle factors, leading to wrinkles, volume loss, and contour changes. These alterations affect perceived age, attractiveness, and self-image. Eye-tracking technology provides insights into gaze patterns, revealing how specific facial regions influence age-related judgments.

Objective This study aimed to examine the role of different facial regions in rapid age estimation, with a specific focus on the midface. We investigated decision times, gaze patterns, and their implications for aesthetic interventions, particularly for middle-aged individuals.

Materials and Methods Fifty-four participants evaluated 60 digitally generated facial images representing diverse ethnicities, genders, and three age groups (young, middle-aged, and older). Eye movements were recorded using a Tobii Pro Nano eye tracker. The custom-defined Times of Interest (TOIs) were defined as the decision times for categorizing images as "young" or "old". Fixation durations were analyzed for predefined Areas of Interest (AOIs), including the upper face, midface, and lower face, further subdivided into left and right sides. Non-parametric statistical tests were used to identify differences between groups.

Results Decision times were significantly longer for middle-aged stimuli (1489.49 ± 1055.56 ms; $p < 0.001$) compared to young (1021.98 ± 480.24 ms) and older stimuli (1048.31 ± 726.03 ms). Stable fixation duration was longest for the midface (863.50 ± 564.48 ms; $p < 0.001$), followed by the lower face (105.99 ± 238.70 ms) and upper face (25.34 ± 116.42 ms). Middle-aged stimuli consistently elicited the longest fixation times across all regions ($p < 0.001$). No significant differences were observed between male and female stimuli for midface fixation ($p = 0.393$). However, male stimuli attracted longer fixations in the upper face ($p = 0.001$), while female stimuli drew attention to the lower face ($p = 0.039$). Right-sided facial regions consistently received longer fixation durations across all stimuli characteristics ($p < 0.001$). Asian participants showed shorter fixation times in the midface but longer fixations on the lower face compared to Caucasian participants ($p < 0.001$).

Conclusion The midface emerged as the focal region for age perception, with its structural prominence and association with age-related changes driving prolonged visual attention. Longer decision times for middle-aged faces reflect their complexity, requiring detailed processing of both youthful and aging features. These findings underscore the importance of prioritizing the midface in aesthetic interventions, particularly for middle-aged patients. Understanding gaze patterns can guide aesthetic providers in developing personalized, effective rejuvenation strategies that align with natural age perception mechanisms.

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Introduction

Facial aging is influenced by intrinsic and extrinsic factors such as genetics, environmental exposure, and lifestyle choices. As a person ages, structural changes manifest visibly in the face, including wrinkles, sagging skin, loss of fat volume, and bone resorption [1–5]. These changes collectively contribute to an aged appearance, significantly affecting social interactions and self-perception. The human face is not only a key identifier of individual identity but also a focal point in the perception of age, attractiveness, and vitality, making it a critical area of study for both psychological and aesthetic purposes [6, 7].

Studies utilizing eye-tracking technology have shown that when observers are tasked with estimating age, their visual attention is predominantly directed toward the lower face, suggesting its importance in forming age-related judgments [8]. Additionally, other findings indicate that the eye region plays a crucial role in assessments of both age and fatigue, as observers tend to focus on this area when evaluating these characteristics [9]. These patterns highlight the lower face and eye region as key areas of interest in understanding age perception and as potential targets for aesthetic and functional facial interventions. While these studies shed light on the areas of the face that influence age perception, they were conducted without creating time constraints on the participants, leaving a critical gap in understanding the minimum time required to determine a person's age. In real-world settings, humans often form rapid judgments about others within milliseconds, and the speed of these evaluations can affect first impressions in both social and professional contexts. Knowing how quickly someone can distinguish whether a person appears young or old can help identify which facial features dominate immediate judgments. This information is essential for designing targeted facial rejuvenation strategies that align with natural, instinctive patterns of age perception.

Understanding the speed and focus of gaze patterns under time constraints has significant implications for the field of facial surgery. Procedures such as facelifts, eyelid surgeries, and dermal filler treatments often aim to restore or enhance specific facial features to achieve a youthful appearance. By identifying the facial regions most critical to rapid age judgments—whether the lower face, as suggested by Liao et al. [8], or the eye region, as emphasized by Nguyen et al. [9]—clinicians can better tailor surgical and non-surgical interventions to optimize aesthetic outcomes. Furthermore, addressing the speed of age perception can refine preoperative consultations, allowing surgeons to guide patients toward treatments that effectively target areas of concern while meeting their expectations.

This study aims to fill the gap in existing research by investigating the gaze patterns and the minimum time required for individuals to determine whether a person appears old or young. In the context of this work, the eye-tracking parameters, Time of Fixation (TFD) and Time until First Fixation (TTFF), are not intended as direct measures of facial aging in an anatomical sense; rather, they serve as observer-independent metrics of visual attention that identify which facial regions a naive observer relies upon when making a rapid age judgment. Regions characterized by a short TTFF and a long TFD therefore correspond to those facial areas carrying the strongest perceptual signal of age, and represent—by virtue of this perceptual prominence—the most relevant targets for facial rejuvenation strategies aiming at improvements in perceived age.

Materials and Methods

Study Sample

The study included 54 participants (26 Asian and 28 Caucasian) with a mean age of 28.44 ± 10.33 years (range 18–70), comprising 25 males (46.3%) and 29 females (53.7%). The study had no specific inclusion criteria. Exclusion criteria included significant visual impairment preventing image evaluation or the inability to achieve binocular vision (e.g., due to the loss of one eye). All participants were laypersons with no background in aesthetic surgery. Before enrollment, participants were informed about the aim and the scope of this study and provided written informed consent for the use of their research-related and demographic data. The study was approved by the Institutional Review Board of Ludwig-Maximilian University Munich (IRB protocol number: 20-1018).

Eye-Movement Analysis

Participants' eye movements and gaze patterns were recorded using a Tobii Pro Nano binocular eye tracker (Tobii Pro AB, Stockholm, Sweden) in accordance with established protocols [10–12]. The device was positioned at the base of a 15-inch Surface Laptop 3 monitor (Microsoft, Redmond, WA, USA) with a screen size of 340 × 244 mm. Operating at a frequency of 60 Hz, the eye tracker captured eye movements within a range of 65 cm and lateral and cranial distances of 35 cm and 30 cm, respectively.

Visual Stimulus and Participant Task

In this study, frontal facial images representing African, Asian, Caucasian, Latino, and Middle Eastern ethnicities were generated using Midjourney (Midjourney, San Francisco, CA, USA), an artificial intelligence image creation platform. For each ethnicity, images were produced across three age groups: young adults (20 years), middle-aged adults (40 years), and older adults (60 years), with equal representation of male and female subjects. Two images were created for each combination of ethnicity, age group, and gender, yielding a total of 60 images.

The images were presented to participants, who were instructed to make a quick judgment based on their first impression regarding whether the individual depicted appeared to be young or old. Participants responded by pressing the “Y” key (representing “Young”) or the “O” key (representing “Old”) on the keyboard accordingly.

Data Analysis

The captured data of eye movements and decision times of participants were processed with the eye-tracking internal software toolkit (Tobii Pro Lab).

We defined Times of Interest (TOIs) to capture the decision-making period for age judgment. The start point of the interval was set as the onset of the image stimulus, and the end point was marked by the participant’s key press. The following variables were analyzed:

1. Duration of interval: the decision time for the age judgment.
2. Number of saccades: the number of saccades occurring during the interval.

Areas of interest (AOIs) were defined in all images which included upper face, right upper face, left upper face, midface, right midface, left midface, lower face, right lower face, and left lower face (Fig. 1). The following variables were analyzed:

1. Time of fixation: the duration of eye fixations inside the AOI during the interval.
2. Time until first fixation: the time between the onset of the visual stimulus and the initial eye fixation inside the AOI during the interval.

Conceptually, these two parameters were chosen to capture complementary aspects of visual attention during the age judgment task. Time until first fixation reflects how rapidly a given AOI captures the observer’s gaze and therefore indexes the immediacy with which the region is engaged during age categorization, whereas time of fixation reflects how long the AOI retains the observer’s gaze during the decision interval and therefore indexes the extent to which the region is actively used to resolve the age category. Used in combination, these parameters provide a quantitative, observer-independent map of the perceptual cues driving age perception under time-constrained conditions.

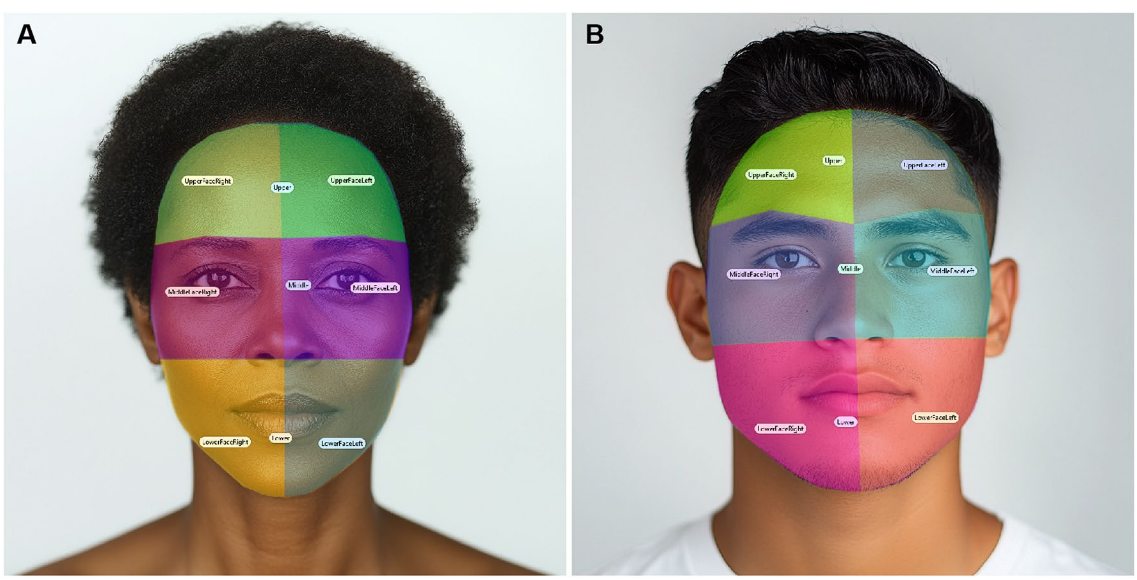
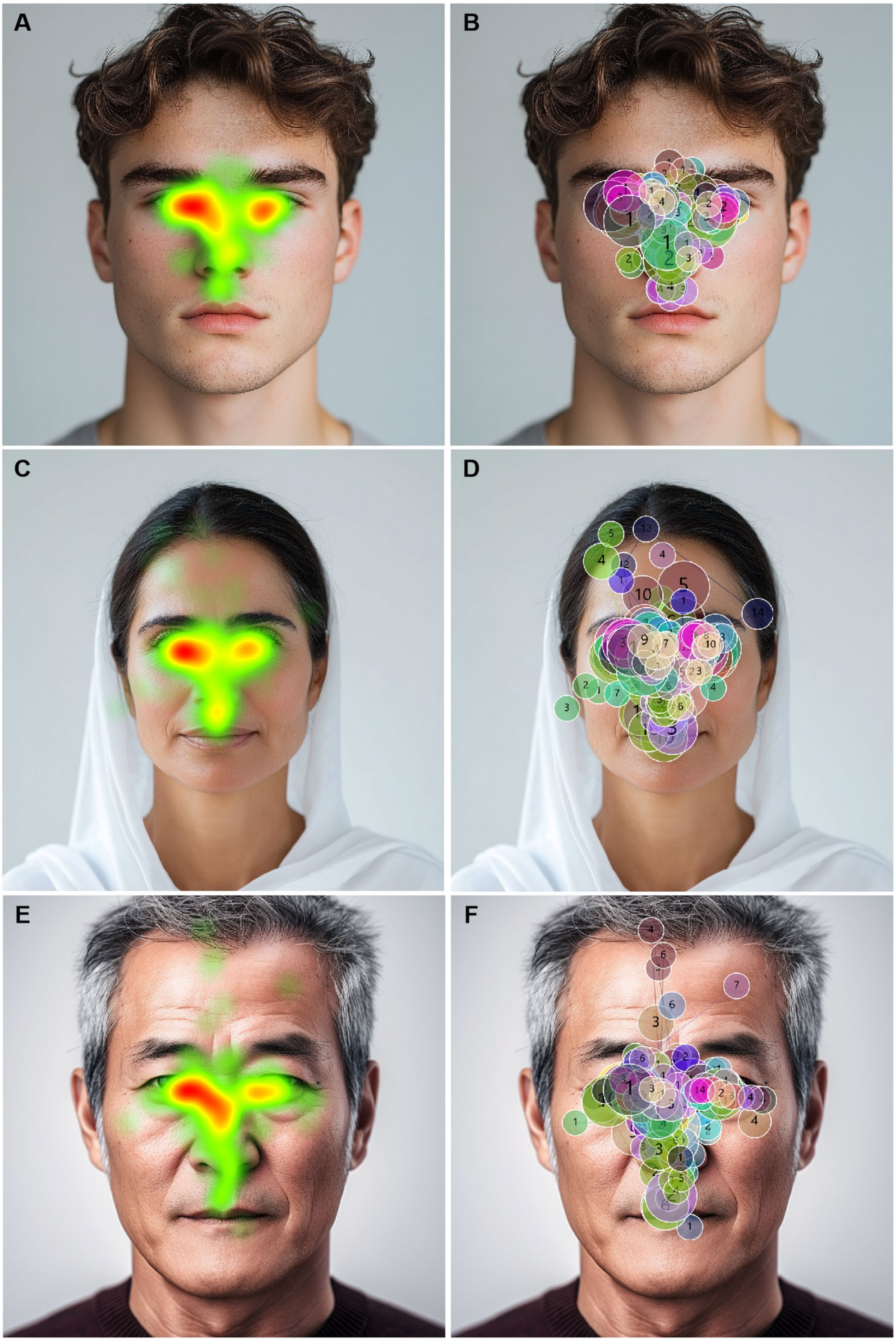


Fig. 1 Examples of AOIs in the stimuli: (**A**) African middle-aged female, (**B**) Latino young male


A
B
C
D
E
F

◂**Fig. 2** Typical heat maps (left) and gaze plots (right): (**A** and **B**) Caucasian young male, (**C** and **D**) Middle Eastern middle-aged female, (**E** and **F**) Asian old male. In the heat maps, warmer colors (such as red) indicate longer fixation durations; cooler colors (such as green) represent shorter fixation durations (**A**, **C**, and **E**). In the gaze plots, the fixation circle with the number "1" marks the first fixation on the image. Subsequent numbers trace the location and order of the following fixations. Fixation duration is represented by the size of the circles—the longer the fixation, the larger the circle (**B**, **D**, and **F**)

Statistical Analysis

Tests for homogeneity of variance and normality were conducted, revealing non-normally distributed data ($p < 0.05$) and unequal variances ($p < 0.1$). Consequently, differences between two groups were assessed using the Mann–Whitney U test, while differences among multiple groups were assessed using the Kruskal–Wallis test. When statistically significant differences were observed, post hoc pairwise comparisons were performed using the Mann–Whitney U test with Bonferroni correction applied to adjust for multiple comparisons. All analyses were performed using SPSS Statistics 27 (IBM Corp., Armonk, NY) at a significance level of $\alpha = 0.05$.

Results

Decision Time for Age Judgment

The decision time for age judgment was longest in middle-aged stimuli (1489.49 ± 1055.56 ms; $p < 0.001$) compared to other age groups, with older and young stimuli having decision times of 1048.31 ± 726.03 ms and 1021.98 ± 480.24 ms, respectively. No statistically significant difference was found in decision times between male and female stimuli (1181.36 ± 837.40 ms vs. 1191.83 ± 798.94 ms; $p = 0.513$), nor among stimuli from different ethnic groups ($p = 0.076$).

Male participants exhibited slightly longer decision times compared to female participants (1187.96 ± 898.34 ms vs. 1185.42 ± 742.64 ms; $p = 0.009$). There were no significant differences when male or female participants assessed the age of their own-gender versus other-gender stimuli (1195.62 ± 902.13 ms vs. 1180.30 ± 895.07 ms; $p = 0.869$ and 1201.77 ± 706.02 ms vs. 1169.07 ± 777.61 ms; $p = 0.287$, respectively). Decision times did not differ significantly between Asian and Caucasian participants (1219.46 ± 885.90 ms vs. 1156.08 ± 749.05 ms; $p = 0.182$), nor were there significant differences when Asian or Caucasian participants judged the age of their own-race versus other-race stimuli (1241.76 ± 894.15 ms vs. 1213.88 ± 884.10 ms; $p = 0.507$ and 1148.34 ± 657.59 ms vs. 1158.02 ± 770.43 ms; $p = 0.902$, respectively).

Number of Saccades

Middle-aged stimuli elicited the highest number of saccades (3.39 ± 2.70; $p < 0.001$), compared to older stimuli (2.23 ± 2.04) and young stimuli (2.25 ± 1.52). No statistically significant difference was found in the number of saccades between male and female stimuli (2.56 ± 2.15 vs. 2.69 ± 2.27; $p = 0.144$), nor among stimuli from different ethnic groups ($p = 0.405$).

Male participants exhibited fewer saccades compared to female participants (2.53 ± 2.46 vs. 2.71 ± 1.97; $p < 0.001$). No significant differences were found in the number of saccades when male or female participants observed their own-gender versus other-gender stimuli (2.52 ± 2.45 vs. 2.54 ± 2.46; $p = 0.944$ and 2.81 ± 2.08 vs. 2.60 ± 1.84; $p = 0.056$, respectively). No significant difference in saccade count was found between Asian and Caucasian participants (2.61 ± 2.26 vs. 2.64 ± 2.16; $p = 0.468$), or when they viewed their own-race versus other-race stimuli (2.71 ± 2.13 vs. 2.58 ± 2.30; $p = 0.116$ and 2.69 ± 2.25 vs. 2.63 ± 2.14; $p = 0.587$, respectively).

Time of Fixation

Stable eye fixation duration was longest for the midface (863.50 ± 564.48 ms), followed by the lower face (105.99 ± 238.70 ms), and shortest for the upper face (25.34 ± 116.42 ms) ($p < 0.001$) (Fig. 2). Middle-aged stimuli consistently elicited the longest fixation durations in all facial areas ($p < 0.001$), whereas no significant differences were found between older and young stimuli in any of these regions ($p > 0.05$) (Table 1). Fixation time did not significantly differ between male and female stimuli in the midface (858.65 ± 554.42 vs. 868.36 ± 574.50 ms; $p = 0.393$). However, male stimuli prompted longer fixations in the upper face (29.62 ± 123.20 vs. 21.06 ± 109.08 ms; $p = 0.001$), while female stimuli led to longer fixations in the lower face (112.42 ± 241.39 vs. 99.56 ± 235.89 ms; $p = 0.039$). No statistically significant differences in fixation times were found among stimulus ethnic groups for each facial region ($p > 0.05$).

There was no statistically significant difference in fixation time between male and female participants in the upper face (29.97 ± 135.65 vs. 21.35 ± 96.67 ms; $p = 0.361$). However, male participants had shorter fixation times in the midface compared to female participants (827.04 ± 640.97 vs. 894.94 ± 487.04 ms; $p < 0.001$), but significantly longer fixation times in the lower face (167.71 ± 311.58 vs. 52.79 ± 127.78 ms; $p < 0.001$). Asian participants showed shorter fixation times than Caucasian participants for both the upper face (16.04 ± 72.22 vs. 33.98 ± 145.42 ms; $p = 0.010$) and midface (855.57 ± 650.67 vs. 870.87 ± 470.60 ms; $p < 0.001$), but longer fixation times for the lower face (154.10 ± 302.27 vs. 61.32 ± 144.70 ms; $p < 0.001$).

Table 1 Mean time of fixation and time until first fixation for the upper, middle, and lower face regions across the stimuli age groups

Region	Stimulus age	Time of fixation (ms)	Time until first fixation (ms)
Upper face	Middle-aged	41.70±144.46	1014.48±1160.54
	Old	21.96±118.92	647.09±628.09
	Young	12.37±72.27	203.86±415.45
	p	<0.001*	<0.001*
Midface	Middle-aged	1046.46±706.16	34.39±111.65
	Old	764.37±487.77	41.54±125.42
	Young	779.67±411.76	33.15±105.17
	p	<0.001*	0.209
Lower face	Middle-aged	148.70±271.96	746.09±648.41
	Old	96.82±254.74	431.04±538.25
	Young	72.45±170.74	456.61±448.73
	p	<0.001*	<0.001*

Values are mean±standard deviation

*Indicates statistical significance ($p < 0.05$)

Table 2 Mean time of fixation and time until first fixation across the different face regions

Region	Time of fixation (ms)	Time until first fixation (ms)
Right upper face	13.31±72.91	836.02±1156.74
Left upper face	10.72±68.09	926.95±811.56
Right midface	504.96±422.46	157.83±243.52
Left midface	348.79±341.44	297.12±374.28
Right lower face	59.31±174.01	588.86±669.80
Left lower face	44.06±132.36	779.64±890.35
p	<0.001*	<0.001*

Values are mean±standard deviation

*Indicates statistical significance ($p < 0.05$)

Upon further analysis of the upper, middle, and lower face regions divided into left and right sides, it was found that fixation times were longer for the right side of each facial region compared to the corresponding left side (Table 2, Fig. 2). When stratified by stimulus gender, age, ethnicity, or participant ethnicity, the same trend was observed for the middle and lower face regions, where gaze points were concentrated. The differences in fixation times between the left and right midface regions were consistently statistically significant ($p < 0.001$). However, when stratified by participant gender, the trend remained the same for male participants, while female participants exhibited shorter fixation times for the right lower face compared to the left (17.05 ± 67.51 vs. 34.24 ± 103.55 ms; $p < 0.001$).

Time Until First Fixation

Compared to the lower face (579.62 ± 589.11 ms) and upper face (730.53 ± 959.95 ms), the midface exhibited the shortest time until first fixation (36.35 ± 114.38 ms; $p < 0.001$) (Fig. 2). When analyzed separately by facial region, no statistically significant differences were observed in the time until first fixation on the midface across the stimuli age groups ($p = 0.209$). However, for the upper and lower face regions, the time until first fixation was consistently longer for middle-aged stimuli compared to older or young stimuli ($p < 0.001$; Table 1). There were no statistically significant differences in the time until first fixation across stimuli genders for any facial region ($p > 0.05$). Except for the upper face, where a statistically significant difference was observed among stimuli ethnic groups ($p = 0.002$), no ethnic differences were found for the midface or lower face ($p > 0.05$).

No statistically significant differences were found in the time until first fixation between male and female participants for the upper face and midface regions ($p > 0.05$). However, male participants exhibited a shorter time until first fixation on the lower face compared to female participants (459.36 ± 557.82 vs. 764.04 ± 588.91 ms; $p < 0.001$). Between Asian and Caucasian participants, no significant difference was observed for the upper face (799.46 ± 1255.24 vs. 682.88 ± 686.53 ms; $p = 0.790$). However, Asian participants showed a longer time until first fixation on the midface (39.08 ± 118.40 vs. 33.86 ± 110.56 ms; $p = 0.020$) and a shorter time on the lower face (534.23 ± 585.22 vs. 647.90 ± 589.19 ms; $p < 0.001$).

Further analysis of the left and right sides of each facial region revealed that the time until first fixation was consistently shorter for the right side (Table 2, Fig. 2). This trend persisted in the midface and lower face across stimulus gender, age, ethnicity, or participant ethnicity. The differences between the left and right midface regions were consistently statistically significant ($p < 0.001$). Among male participants, the right side preference was evident, whereas in female participants, the time until first fixation on the right lower face was numerically longer than on the left (860.46

± 799.75 vs. 821.53 ± 588.18 ms; $p = 0.830$), though this difference did not reach statistical significance.

Discussion

This study utilized eye-tracking technology to examine the time required for participants to estimate the age of individuals from different age groups, genders, and ethnicities, while simultaneously recording their eye movements. A custom Time of Interest (TOI) was used to capture response times, with participants keeping their index fingers on the "Y" and "O" keys for quick, first impression judgments. This approach offers a more accurate measure of age estimation time than traditional questionnaires, improving the precision and reliability of the findings.

The study showed that the decision time for age judgment was significantly longer for middle-aged stimuli compared to young and older stimuli. This finding aligns with previous electrophysiological studies indicating that face perception involves multiple processing stages, including the extraction of global, holistic, featural, and configural information [13]. Interestingly, the longest decision time was observed for middle-aged stimuli (1489.49 ± 1055.56 ms; $p < 0.001$) compared to younger (1021.98 ± 480.24 ms) and older faces (1048.31 ± 726.03 ms). This extended processing time can be explained by several factors. Middle-aged faces exhibit a combination of youthful and aging features, making their classification more complex. Unlike young or elderly faces, which often have more distinct age-related markers, middle-aged faces require a more detailed configural and featural analysis. The gradual onset of wrinkles, subtle changes in skin texture, and the redistribution of facial fat contribute to increased difficulty in categorization [14–18]. Middle-aged individuals display a broader range of aging patterns due to lifestyle factors, genetics, and environmental influences. This heterogeneity makes it harder to rely on a standard set of aging cues, prolonging the decision-making process. Holistic and configural processing, which are essential for face individuation, may be more engaged when processing middle-aged faces. Age estimation is influenced by perceptual expectations [19, 20]. Middle-aged faces may challenge categorical boundaries more than young or elderly faces, requiring additional cognitive resources for accurate classification. Given that global structure (first-order relations) and second-order relations are crucial for identifying subtle age-related changes, the brain may allocate more time to resolve these complex facial patterns [21–23].

Notably, an event-related potential (ERP) component called N170 is evoked approximately 170 ms after the depiction of a face. The N170 is associated with extrastriate visual mechanisms involved in detecting human faces and leading to their characteristic structural encoding [24, 25]. Between the N170 response and the eventual pressing of the button indicating whether the face is young or old, several cognitive and perceptual processes occur. These include the engagement of higher level visual processing areas responsible for extracting featural and configural details, the comparison of the perceived face to stored facial prototypes in memory, and the application of categorical decision-making mechanisms. Additionally, attentional modulation and response selection mechanisms influence the final judgment, particularly when the categorization task involves ambiguous facial features, as observed with middle-aged faces.

The eye-tracking parameters used in the present study warrant brief conceptual clarification with regard to their relevance for facial rejuvenation. Time of fixation and time until first fixation do not measure facial aging in an anatomical sense; rather, they identify which facial regions a naive observer relies upon when judging age under time-constrained conditions. By definition, the regions that capture the observer's gaze earliest and retain its longest during age judgment are those whose age-related morphological changes most strongly signal age to the observer. Aesthetic interventions targeting these regions therefore yield the greatest perceptual return per unit of anatomical correction, since they modulate precisely the features that observers rely on to categorize a face as young or old. Our finding that the midface exhibits both the shortest time until first fixation and the longest time of fixation across all stimulus age groups thus provides an objective, perception-based rationale for prioritizing the midface in rejuvenation planning, complementing the established anatomical literature on midface aging [14–18] with evidence grounded in the perception of the observer rather than in clinician-rated photographic scales.

The findings of this study are relevant to patients undergoing aesthetic plastic surgery, especially in the middle-age group. Middle-aged individuals often seek procedures to enhance their facial appearance while maintaining a natural, youthful look. The extended processing time for middle-aged faces highlight several important considerations. Since middle-aged faces are subject to extended diligence during age assessment, even minor enhancements can have a significant impact on perceived age. Patients undergoing midface rejuvenation, such as filler injections, facelifts, or skin resurfacing, may benefit from procedures that subtly address early aging signs without overcorrection. Given that middle-aged faces possess both youthful and aging attributes, surgical interventions should aim to preserve key youthful features while mitigating age-related changes. Treatments that restore volume loss, improve skin elasticity, and enhance facial symmetry can help optimize age perception without making the face appear unnatural. Understanding that middle-aged faces are more challenging to categorize underscores the importance of patient education. Surgeons should communicate realistic outcomes, emphasizing that the goal is to refresh rather than dramatically alter the face. Addressing the psychological impact of aging and aligning surgical goals with natural aging trajectories can improve patient satisfaction.

The findings of this study highlight the midface as a key region of visual attention, with stable eye fixation duration being significantly longer in this area compared to the lower and upper face. This suggests that the midface plays a central role in facial age perception, potentially due to its structural prominence and relevance in conveying emotional expressions, symmetry, and age-related changes. Interestingly, the middle-aged stimuli elicited the longest fixation durations across all facial regions, whereas no significant differences were observed between younger and older stimuli. This contrasts with previous research, which found that younger faces were fixated upon for shorter durations than older faces, independent of observer age or gender [8, 26].

Several factors may explain these discrepancies. First, variations in study design, including differences in stimulus presentation, participant demographics, and eye-tracking methodologies, could contribute to divergent outcomes. The prior study emphasized the perioral region as the primary area of focus, with the highest fixation durations recorded in this zone. In contrast, the current findings suggest that the midface, rather than the perioral region, is the dominant area of gaze concentration. This shift in attention could be attributed to the nature of facial stimuli used, with midface structures such as the cheeks, nasolabial folds, and infraorbital region being more indicative of age-related changes in the present dataset. Additionally, the increased prominence of non-invasive midface rejuvenation treatments in aesthetic practice may have heightened awareness and visual attention toward this region.

Another key difference lies in the role of gender and age in fixation patterns. While the prior study reported no significant differences in fixation times between male and female stimuli, our results indicate subtle but significant gender-specific effects, with male stimuli eliciting longer fixations in the upper face and female stimuli drawing more attention to the lower face. Additionally, while the previous study found that younger faces were viewed for shorter durations than older faces, our study did not observe significant differences between these groups.

Further insights emerged when examining the lateralization of fixation patterns. Across all facial regions, gaze durations were consistently longer for the right side compared to the left, particularly in the midface and lower face. This finding was robust across different stimulus characteristics, suggesting a potential bias in facial scanning strategies. Interestingly, while male participants followed this rightward preference uniformly, female participants exhibited a reversed trend for the lower face, with longer fixations on the left side. Such asymmetrical gaze behavior may be linked to perceptual biases related to hemispheric processing of facial features or attentional asymmetries influenced by social or cultural conditioning [27–29].

Another notable aspect of this study is the influence of participant ethnicity on fixation behavior. Asian participants demonstrated shorter fixation times in the upper and midface regions compared to Caucasian participants but spent significantly longer durations observing the lower face. These findings suggest that cultural differences in facial feature prioritization and aesthetic focus may contribute to variations in gaze patterns.

Conclusion

Based on the provided findings and context, the key takeaway for aesthetic providers and surgeons involved in facial rejuvenation is the critical importance of the midface as a focal region in both age perception and aesthetic outcomes. The combination of the shortest time until first fixation and the longest time of fixation observed in this region indicates that the midface carries the dominant perceptual signal of age in a naive, time-constrained observer, and rejuvenation strategies targeting this region are therefore expected to deliver the greatest perceptual impact on the perceived age of the face.

This study highlights that the midface is not only central to visual attention but also plays a pivotal role in conveying age-related changes. For middle-aged individuals, whose faces exhibit a mix of youthful and aging features, the midface presents unique challenges for both perception and treatment. Aesthetic interventions targeting this region—such as volumetric restoration with fillers, facelifts, or skin rejuvenation techniques—should aim to subtly restore lost volume, improve skin texture, and enhance symmetry. Overcorrection or disproportionate treatments should be avoided to maintain natural and harmonious outcomes. In summary, the midface should be a priority in facial rejuvenation strategies, with treatments designed to address subtle age-related changes while preserving the natural balance and harmony of the face.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest to disclose.

Ethical Approval The study was approved by the Institutional Review Board of Ludwig-Maximilian University Munich (IRB protocol number: 20-1018).

Informed Consent Prior to the enrollment into the study, participants were informed about the aim and the scope of this study and provided written informed consent for the use of their research-related and demographic data.

References

1. Frank K, Moellhoff N, Engerer N, Kaye KO, Alfertshofer M, Gotkin RH, et al. Understanding the interplay between skin, fascia, and muscles of the midface in facial aging. Aesthet Plast Surg. 2024;48(18):1–9.
2. Alfertshofer M, Engerer N, Frank K, Moellhoff N, Freytag DL, Cotofana S. Multimodal analyses of the aging forehead and their clinical implications. Aesthet Surg J. 2023;43:NP531–40.
3. Engerer N, Frank K, Moellhoff N, Alfertshofer M, Giunta RE, Green JB, et al. Aging of the neck decoded: new insights for minimally invasive treatments. Aesthet Plast Surg. 2022;46:1698–705.
4. Cotofana S, Assemi-Kabir S, Mardini S, Giunta RE, Gotkin RH, Moellhoff N, et al. Understanding facial muscle aging: a surface electromyography study. Aesthet Surg J. 2021;41:NP1208–17.
5. Swift A, Liew S, Weinkle S, Garcia JK, Silberberg MB. The facial aging process from the "inside out." Aesthet Surg J. 2021;41:1107–19.
6. Chopik WJ, Bremner RH, Johnson DJ, Giasson HL. Age differences in age perceptions and developmental transitions. Front Psychol. 2018;9:67.
7. Pilz KS, Lou H. Contextual and own-age effects in age perception. Exp Brain Res. 2022;240:2471–80.
8. Liao D, Ishii LE, Chen J, Chen LW, Kumar A, Papel ID, et al. How old do I look? Exploring the facial cues of age in a tasked eye-tracking study. Fac Plast Surg Aesthet Med. 2020;22:36–41.
9. Nguyen HT, Isaacowitz DM, Rubin PA. Age-and fatigue-related markers of human faces: an eye-tracking study. Ophthalmology. 2009;116:355–60.
10. Frank K, Zeng R, Sedlbauer S, Prantl L, Giunta R, Cotofana S, et al. The influence of scar patterns after reduction mammoplasty on eye movement and gaze pattern: an eye-tracking investigation. Aesthet Plast Surg. 2024;48:250–8.
11. Zeng R, Glaue E, Moellhoff N, Alfertshofer M, Cotofana S, Knoedler S, et al. Eye-tracking insights into the perception of buttocks. Aesthet Plast Surg. 2024;48(19):1–9.
12. Zeng R, Moellhoff N, Cotofana S, Giunta R, Wiggenhauser S, Glaue E, et al. A gaze into the eyebrow standards of Asian versus caucasian women. Aesthet Plast Surg. 2024;48(23):1–10.
13. Richler JJ, Gauthier I. A meta-analysis and review of holistic face processing. Psychol Bull. 2014;140:1281.
14. Ugradar S, Kim JS, Massry G. A Review of Midface Aging. Ophthalmic Plast Reconstr Surg. 2023;39:123–31.
15. Tower JI, Gordon NA, Paskhover B. Deep cheek fat volumes and midfacial aging. Aesthet Surg J. 2020;40:467–75.
16. Lambros V. Observations on periorbital and midface aging. Plast Reconstr Surg. 2007;120:1367–76.
17. Mendelson B, Wong C-H. Changes in the facial skeleton with aging: implications and clinical applications in facial rejuvenation. Aesthet Plast Surg. 2012;36:753–60.
18. Mendelson BC, Hartley W, Scott M, McNab A, Granzow JW. Age-related changes of the orbit and midcheek and the implications for facial rejuvenation. Aesthet Plast Surg. 2007;31:419–23.
19. Boutet I, Nelson EA, Watier N, Cousineau D, Béland S, Collin CA. Different measures of holistic face processing tap into distinct but partially overlapping mechanisms. Atten Percept Psychophys. 2021;83:2905–23.
20. Bombari D, Mast FW, Lobmaier JS. Featural, configural, and holistic face-processing strategies evoke different scan patterns. Perception. 2009;38:1508–21.
21. Epihova G, Cook R, Andrews TJ. Global changes in the pattern of connectivity in developmental prosopagnosia. Cereb Cortex. 2024;34:bhae435.
22. Wang X, Zhen Z, Song Y, Huang L, Kong X, Liu J. The hierarchical structure of the face network revealed by its functional connectivity pattern. J Neurosci. 2016;36:890–900.
23. Tsao DY, Livingstone MS. Mechanisms of face perception. Annu Rev Neurosci. 2008;31:411–37.
24. Hinojosa J, Mercado F, Carretié L. N170 sensitivity to facial expression: a meta-analysis. Neurosci Biobehav Rev. 2015;55:498–509.
25. Gao C, Conte S, Richards JE, Xie W, Hanayik T. The neural sources of N170: understanding timing of activation in face-selective areas. Psychophysiology. 2019;56:e13336.
26. Frank K, Ehrl D, Bernardini F, Walbrun A, Moellhoff N, Alfertshofer M, et al. How we look at mature faces—an eye-tracking investigation into the perception of age. Aesthet Surg J. 2023;43:115–22.
27. Guo K, Smith C, Powell K, Nicholls K. Consistent left gaze bias in processing different facial cues. Psychol Res. 2012;76:263–9.
28. Vaid J, Singh M. Asymmetries in the perception of facial affect: is there an influence of reading habits? Neuropsychologia. 1989;27:1277–87.
29. Lyu A, Abel L, Cheong AM. Effect of habitual reading direction on saccadic eye movements: a pilot study. PLoS ONE. 2023;18:e0286801.