

The Esthetics of the Nasolabial Fold and Age in the Elderly Via Eye-Tracking

Abstract

Background: Facial aging is associated with the loss of soft tissue fullness. Perioral signs of facial aging can add years to individuals' appearances and even affect their facial expressions in smiling and nonsmiling images. **Aims:** To evaluate the influence of the nasolabial fold on the visual perception of esthetics and age in the elderly, eye-tracking and a visual analog scale were used. **Material and Methods:** This study applied a cross-sectional study using 40 laypeople. Facial images of an elderly woman were modified to include facial expression lines such as nasolabial folds and marionette lines with no folds, intermediate, and accentuated depths folds. Eye tracking was implemented to measure the average number of fixations. Heat maps and dot maps were generated using eye-tracking software. A visual analog scale of attractiveness and age perception questionnaire were also incorporated into the study. Statistical analysis was performed using a significance of ($P < 0.05$). **Results:** The majority of visual attention was paid to the eye and mouth areas. In the images with no folds, the right eye attracted a greater degree of fixation. In the images in which nasolabial folds were accentuated, the mouth area served as an area of high fixation. No statistical difference was observed between the groups in which smiling images were viewed. Nonsmiling images demonstrated significant differences between groups for variables including time until first fixation, complete fixation time, and number of fixations on the eyes and hemifaces. Old age and diminished attractiveness were associated with attenuated nasolabial folds, especially in nonsmiling images. **Conclusion:** The facial lines and expressions of elderly female individuals were assessed by laypeople using eye-tracking, showing that the deeper one's nasolabial folds, the more aged and less attractive one appears, especially in nonsmiling images. Smiling pictures were perceived to be more attractive and youthful; these perceptions should be considered in the search for improved esthetic results, whether in dental or facial esthetic treatments.

Keywords: Esthetics, eye-tracking technology, perception

Introduction

Wellness, health, and appearance play crucial roles in self-esteem and social interactions.^[1] Age-related oral changes are often visible in the oral hard and soft tissues.^[2] As the world's population ages, facial esthetics become more and more important for many individuals, especially women.^[3]

Facial aging is associated with the support loss of soft tissue in certain areas – such as the periorbital, frontal, malar, temporal, mandibular, mental, and perioral areas – and fat persistence or hypertrophy in others, such as nasolabial folds and marionette lines.^[4] Chronological age and facial age correspond to one another for up to 30 years; later, facial age may begin to exceed chronological age.^[5]

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There is evidence to suggest that wrinkles and folds on the face interfere with emotional expression. As subtle as it can be, this interference is sufficient to pose potential problems for routine interactions in which the reception of subtle social signals is imperative. Thus, the older one becomes, the more emotion on the face is perceived by others due to the appearance of wrinkles and folds.^[6]

It is therefore important to consider the effects of aging on the smile and face, as aging causes changes within the perioral region.^[7] For Python *et al.*, people with ideal smiles according to esthetic standards are judged to be more intelligent by others.^[8] Apparent age determines how individuals are treated in society, and different facial ages attract different stereotypical attitudes based on perceived age groups.^[9] In general, those who look youthful benefit

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from stereotypes that favor younger people, while elderly members of society are often judged to be weak, dependent, and less attractive.^[10]

Treatments in the healthcare field and/or alternative procedures have been developed to attenuate morphological changes caused by the aging process.^[11] New procedures, materials, and techniques in dentistry and medicine can improve elders' quality of life and self-esteem.^[12,13]

Eye-tracking technology has been used in recent studies to address subjects such as visual perceptions of facial and dental structures.^[14,15] The use of this technology may serve as a complementary tool to the visual analog scale (VAS), supplementing our understanding of esthetics through psychosocial analysis. Exploring perceptions of age and attractiveness may help us to better comprehend the impact of facial esthetic treatments on individuals' appearance.

Thus, the purpose of this study is to evaluate the influence of nasolabial folds on visual perceptions of esthetics and age in female elderly faces using eye-tracking metrics and a VAS.

Materials and Methods

This cross-sectional study was approved by (name was omitted) of the Committee of Human Ethics and Research. Informed consent was obtained from all study observers.

Photo specifications

Images for this study were obtained using a digital camera (Rebel T6, Canon, Tokyo, Japan). Two facial frontal photos, one smiling and one nonsmiling were taken with the camera in portrait orientation, with the head positioned within the Frankfort plane parallel to the floor, and without lateral tilt or rotation.

The images were selected, standardized, and modified with the software Adobe Photoshop® (Adobe Systems Inc., San

Jose, California), primarily using the dissolve, stamp, and rectangular sign tools. Alterations were made to the depths of the nasolabial folds on the elderly model [Figure 1]. In both the smiling and nonsmiling images, these depths were assigned to three categories: No folds, intermediate folds, and accentuated folds. Features that could significantly impact perceptions (e.g., scars and nevi) were also removed.

The Eye Tribe Tracker® (The Eye Tribe ApS, Copenhagen, Denmark) hardware was used in conjunction with OGAMA software (Freie Universität, Berlin) to obtain eye-tracking results. To classify the ocular movements of each study participant into discrete facial regions, areas of interest (AOI) were mapped onto the images as follows: AOI 1– right eye; AOI 2– left eye; AOI 3– right hemiface; AOI 4– left hemiface [Figure 2].

Observers

Forty adult observers (60% females, $n = 24$; 40% males, $n = 16$) between 18 and 70 years of age were recruited for this study. The mean age of observers was 35.14 years. Each participant signed a consent form that explained the risks and benefits of the study, in addition to asking them to confirm that they had no visual impairments or psychological problems and had not used medications that could affect cognitive abilities within 24 h of the test.

Once recruited, these observers were required to participate in an eye-tracking session and subsequently answer a subjective VAS attractiveness assessment and age perception question. In the first part of the session, observers were taken individually to a quiet room in which only one researcher and one participant could simultaneously reside. The observers were instructed to sit comfortably in a chair within 60 centimeters of a 17-inch Dell P2317H monitor (Dell Inc. Round Rock, Texas). To ensure the accuracy and reliability of the eye-tracking technology, a 9-point calibration was performed. The observer was instructed not to start the experiment until the software confirmed that the results of the calibration were “perfect.”



Figure 1: Depth of the nasolabial folds. Nonsmiling and smiling: (a and d) no folds; (b and e) intermediate folds; (c and f) accentuated folds



Figure 2: Area of interest

Data collection

The monitor, onto which the images were projected, was placed in an upright position. The Eye Tribe hardware (The Tribe Aps, Copenhagen, Denmark) was placed below the monitor according to the manufacturer's recommendations. The observers were allowed to freely view the images, and all six images were displayed in a randomized order for 7 s each. The order of the images was generated before the experiment using the website randomizer.org. All observers received the images in the same sequence.

The eye-tracking software collected numerical gaze data, such as the time until the first fixation, allowing to acknowledge the first AOI and the time to the first visualization in every area, the complete fixation time, providing the average time which every AOI were viewed, and number of fixations, explaining how many times a given AOI was stared, as well as qualitative information using heat maps and dot maps. A heat map was used to assess the areas in which fixations occurred most frequently. Fixation amounts were represented using a color scale ranging from cool (green) to hot (red) colors; the hotter the color at a given point, the more frequently observers fixated on that point during the study. The dot maps represented fixation data using points. Every time a fixation was registered in a specific area, a point was placed in that spot on the map.

The VAS for attractiveness and the age perception questionnaire was administered as a printed form. At this point in the study, the observers were presented with the images in full-size print, arranged in an album in the same order as they appeared in the eye-tracking software. The observers were asked to assign ages to each image as well as grades for attractiveness in the form of scores ranging from 0 to 10, with 0 indicating the least attractive faces and 10 indicating the most attractive.

Statistical analysis

The results obtained from the eye-tracking study, VAS, and age perception questionnaire were tabulated in Microsoft Excel (Microsoft-LOCAL), exported, and analyzed with SPSS software, version 25 (SPSS Inc., Chicago, IL, USA). The dependent variables studied were time until first fixation, number of fixations, complete fixation time, VAS score, and age perception mean value. Sex, age, and AOI were the independent variables.

A one-way ANOVA was performed to identify differences in the mean values of the dependent variables between groups of images. Levene's variance homogeneity test was also conducted. When heterogeneous variances occurred, a Games-Howell ($P < 0.05$) test was used to perform comparisons, and Tukey's honestly significant difference was performed when homogeneous variances arose ($P < 0.05$). Pearson's correlation tests were performed on both the VAS score and age perception mean value. The level of significance adopted was 0.05.



Figure 3: Heatmaps in nonsmiling and smiling: (a and d) no folds; (b and e) intermediate folds; (c and f) accentuated folds

Results

The heat maps [Figure 3NS] and the dot maps [Figure 4NS] of the nonsmiling images showed that fixations occurred most frequently in the right eye area for the image with no nasolabial folds [Figures 3 and 4a]. However, the images with intermediate and accentuated folds [Figure 3b and c] demonstrated increases in observers attention to the folds as they became more severe. Examining the dot maps [Figure 4b and c] confirms this observation; the greater the depth of the folds, the higher the density of points in the nasolabial fold area.

A different pattern of attention was observed in the heat maps [Figure 3] and the dot maps [Figure 4] of the smiling images in which the attention remained balanced between the eyes and the smile regardless of the depth of the nasolabial folds [Figure 4d and e].

No statistical differences were observed in terms of time until first fixation, complete fixation time, and number of fixations between changes in the nasolabial folds of the smiling images [Table 1].

The right hemiface was the most revealing of all of the AOIs. In the nonsmiling photos, higher average fixation times were measured in this area. Furthermore, the higher the degree of modification, the more time observers spent fixating on the region on average. In the smiling images, the right hemiface attracted more attention from the observers in photos displaying intermediate folds and demonstrated similar fixation values to the left hemiface in photos displaying accentuated and no folds [Figure 5].

Conversely, significant differences in eye-tracking variables between nonsmiling images were found ($P < 0.05$) [Table 2]. The degree of photo manipulation influenced the VAS scores

and age perception values for both smiling and nonsmiling images [Table 3]. The nonsmiling images scored lower on attractiveness and higher on age perception values. Pearson's correlation test displayed a negative correlation between VAS and age perception values ($P = -0.525$), indicating that the higher the VAS score, the lower the perceived age of the subjects in the images evaluated.



Figure 4: Dot maps in nonsmiling and smiling: (a and d) no folds; (b and e) intermediate folds; (c and f) accentuated folds

These results confirm the observations from the descriptive results, in which deepened nasolabial folds resulted in an image that appeared more aged and less attractive to observers. According to the age perception results, smiling images appeared younger to observers than nonsmiling images. In addition, nonsmiling images with no folds scored 4.3 years younger than the nonsmiling images with accentuated folds and were considered more attractive [Table 3].

Discussion

This study aims to evaluate the influence of nasolabial folds through the use of eye-tracking technology and how people perceive images of a female elderly model with regards to attractiveness and age perception depending on the depths of her facial folds. Our findings show that nasolabial folds have a negative esthetic impact on the elderly female face.

During interpersonal interaction, individuals mainly focus on the eyes and mouth of the other person, paying little attention to other facial features.^[16] In the opinion of the public, the only features more important to facial attractiveness than the smile are the eyes.^[17] Thus, the results of the present study primarily concentrated on the AOI surrounding the eyes and mouth, in accordance with the observations of Miller that these are the areas found most attractive to others during personal interaction.^[18]



Figure 5: Average number of fixations per AOI in nonsmiling and smiling: (a and d) no folds; (b and e) intermediate folds; (c and f) accentuated folds

Table 1: Comparison between smiling images using ANOVA

	With accentuated Nasolabial Folds Mean ($\pm$ SD)	Intermediate Nasolabial Folds Mean ($\pm$ SD)	Without Nasolabial Folds Mean ($\pm$ SD)	<i>P</i>
Time until first fixation at Right Eye (ms)	1372,22 ($\pm$ 353,29)	1670,96 ($\pm$ 322,42)	2422,83 ($\pm$ 456,94)	0.142
Time until first fixation at Left Eye (ms)	2362,62 ($\pm$ 389,37)	2487,82 ($\pm$ 453,31)	2733,04 (304,20)	0.778
Time until first fixation at Right Hemiarth (ms)	1101,29 ($\pm$ 305,42)	1270,05 (319,31)	1456,16 ($\pm$ 316,11)	0.721
Time until first fixation at Left Hemiarth (ms)	2248,38 ($\pm$ 426,67)	2269,27 ($\pm$ 370,91)	1249,06 ($\pm$ 330,74)	0.161
Complete fixation time at Right Eye (ms)	968,15 ($\pm$ 109,97)	964,36 ($\pm$ 132,82)	998,00 (153,86)	0.981
Complete fixation time at Left Eye (ms)	736,88 ($\pm$ 140,24)	699,37 ($\pm$ 109,56)	745,43 ($\pm$ 149,44)	0.972
Complete fixation time at Right Hemiarth (ms)	1556,90 ($\pm$ 211,77)	1553,38 ($\pm$ 170,15)	1490,22 ($\pm$ 158,04)	0.957
Complete fixation time at Left Hemiarth (ms)	1085,08 ($\pm$ 200,40)	807,55 ($\pm$ 141,36)	999,10 ($\pm$ 175,52)	0.505
Number of fixations at Right Eye	2,59 ($\pm$,28)	2,44 ($\pm$,28)	2,39 ($\pm$,32)	0.881
Number of fixations at Left Eye	1,65 ($\pm$,16)	1,95 ($\pm$,25)	1,65 ($\pm$,16)	0.494
Number of fixations at Right Hemiarth	3,19 ($\pm$,29)	3,34 ($\pm$,32)	3,22 ($\pm$,30)	0.935
Number of fixations at Left Hemiarth	2,21 ($\pm$,62)	2,18 ($\pm$,30)	2,19 ($\pm$,29)	0.997

Participants: 40 laypeople. *Statistical Difference $P < 0,05$ Different letters=differ significantly

Table 2: Comparison between nonsmiling images using ANOVA

	Nasolabial folds, mean ($\pm$ SD)			<i>P</i>
	Accentuated	Intermediate	Without	
Time until first fixation at right eye (ms)	3390.86 ($\pm$ 393.02) ^a	2066.90 ($\pm$ 472.89)	1873.96 ($\pm$ 297.28) ^b	0.014*
Time until first fixation at left eye (ms)	2866.24 ($\pm$ 498.89)	2882.21 ($\pm$ 444.35)	2189.58 ($\pm$ 338.02)	0.425
Time until first fixation at right hemiarth (ms)	1509.12 ($\pm$ 344.20)	955.41 ($\pm$ 231.48)	1204.23 ($\pm$ 284.05)	0.431
Time until first fixation at left hemiarth (ms)	672.22 ($\pm$ 247.74) ^a	1984.67 ($\pm$ 431.37) ^b	2253.12 ($\pm$ 489.97) ^{a,b}	0.005*
Complete fixation time at right eye (ms)	639.14 ($\pm$ 86.47) ^a	831.10 ($\pm$ 128.96)	1096.56 ($\pm$ 134.35) ^a	0.031*
Complete fixation time at left eye (ms)	660.18 ($\pm$ 68.23)	659.00 ($\pm$ 110.13)	938.11 ($\pm$ 127.71)	0.112
Complete fixation time at right hemiarth (ms)	1765.77 ($\pm$ 211.58)	1843.05 ($\pm$ 202.70)	1378.54 ($\pm$ 233.51)	0.276
Complete fixation time at left hemiarth (ms)	1373.88 ($\pm$ 179.51) ^a	850.75 ($\pm$ 94.01)	707.24 ($\pm$ 100.94) ^b	0.006*
Number of fixations at right eye	1.48 ($\pm$ 0.14)	1.95 ($\pm$ 0.24)	2.70 ($\pm$ 0.29)	0.003*
Number of fixations at left eye	1.65 ($\pm$ 0.19)	1.58 ($\pm$ 0.17)	2.37 ($\pm$ 0.34)	0.055
Number of fixations at right hemiarth	3.62 ($\pm$ 0.38)	4.05 ($\pm$ 0.28)	3.27 ($\pm$ 0.35)	0.307
Number of fixations at left hemiarth	3.13 ($\pm$ 0.28) ^a	2.04 ($\pm$ 0.23)	2.06 ($\pm$ 0.27) ^a	0.006*

Participants: 40 laypeople. *Statistical difference $P < 0.05$. SD: Standard deviation. Different letters: Differ significantly

Table 3: Visual Analog Scale grade and mean age

	Mean ($\pm$ SD)		Pearson correlation
	VAS (grade)	Age	
Smiling with nasolabial folds	7.225 ($\pm$ 0.194)	62.35 ($\pm$ 0.601)	-0.525
Smiling with intermediate nasolabial folds	7.875 ($\pm$ 0.282)	59.6 ($\pm$ 0.629)	
Smiling without nasolabial folds	8.5 ($\pm$ 0.733)	58.05 ($\pm$ 0.615)	
Without smiling with nasolabial folds	6.325 ($\pm$ 0.249)	65.5 ($\pm$ 0.578)	
Without smiling with intermediate nasolabial folds	7.375 ($\pm$ 0.216)	61.45 ($\pm$ 0.577)	
Without smiling without nasolabial folds	8.15 ($\pm$ 0.197)	59.5 ($\pm$ 0.625)	

VAS: Visual Analog Scale; SD: Standard deviation

The present study shows that observers mainly focused on the eyes and mouth of the model in the images, although the folds and lines significantly impacted where they directed their attentions. Fortunately, the model's dental alignment was ideal, as Havens *et al.* observed that dental alignment is the most important factor in facial esthetics, even more so than the eyes.^[19] This could explain why the smiling photos received better scores on attractiveness

and lower age scores despite facial modifications and fold accentuations.

No perfectly symmetrical face exists, and excessive symmetry can lead to monotony. However, the presence of notorious asymmetries in primary esthetic areas can lead to an unfavorable appearance.^[20] Perceptions of disharmonies by the laypeople may have impacted their perceptions of age, given attractiveness scores, and eye motions. A general

practitioner may find these results useful in the planning of esthetic treatments.

Of all the characteristics of skin aging, expression lines are considered to be the most representative of emotion and have important social impacts.^[21] For Michaud *et al.*, facial expressions are integral parts of psychosocial interactions, and some propose that an assessment of skin aging's impacts on facial dynamics must be incorporated into an optimal treatment plan.^[22] In this study, images with accentuated facial lines received more attention to the folds in the eye-tracking segment of the experiment, earned lower scores on the attractiveness scale, and were perceived as older, especially in the nonsmiling images. The use of hyaluronic acid, botulinic toxin, and other filling agents to increase soft tissue have become popular esthetic procedures for patients who desire nonsurgical facial rejuvenation, and these may lead to satisfactory results when performed by a qualified professional.^[23]

The world's population is aging^[24] and the demand for facial esthetic treatment from the elderly population is growing along with the overall esthetics exigency. There are various reasons why people wish to appear younger. A common theme among these reasons is the desire to avoid social penalties that accompany aging, which can come in the form of discrimination, employment difficulties, lower rates of pay, and harassment.^[8,10] Our findings show that observers frequently focused on the nasolabial fold area, which is an area of great importance in demonstrating signs of age.^[25] Age perception, the judgment of another person's age by appearance, is imperative for achieving effective communication and navigating personal relationships, as stated by Imai and Okami.^[26]

The results of the present study confirm the importance of facial structures when determining age and attractiveness, since the right and left hemiface were the primary focus in all images. Overall, these AOI displayed lower times until first fixation, higher numbers of fixation, and higher complete fixation times.

Although facial appearance varies widely among individuals, common keys to age estimation are embedded in some facial features. Many researchers have sought to understand more about the features that determine and characterize the physical signs of facial aging. Some authors claim that certain facial features are correlated to the aging process, such as the mouth, eyes, and lower part of the face.^[25,26] McKenna *et al.* (2010) described a variety of oral changes that can be observed in elderly patients, such as reductions in total muscle mass, number of muscle fibers, muscle fiber size, and tissues. Merinville *et al.* (2015) observed the increased influence of wrinkles, sagging, and hyperpigmentation due to aging on the appearance of female models. To our knowledge, this is the first study to implement an age perception study in tandem with attractiveness metrics and eye-tracking technology to

identify esthetic challenges and changes commonly found within elderly populations.

Eye-tracking technologies applied to and the results obtained from the present study can be used in the planning of aesthetic surgeries in the face and/or filling agents in the future. It is important to consider the perspectives of individual laypeople during treatment alternatives.^[27]

The loss of structural support accentuating the appearance of the mandible and the nasolabial fold can cause changes in the perioral area, which can ascribe expressions of unpleasant sadness and aging to patients^[13] and were quite noticeable in the present study. For Fink *et al.*, both the distribution of skin color and the topography of the skin surface significantly influenced the perception of age, female facial health, and judgments of facial attractiveness in people,^[28] and many patients desire reassurance of a natural look when seeking facial esthetic treatments.

Limitations of this study may include the fact that we presented images only for a given period, a method often used in facial expression research.^[29] Observers in our study may have reacted differently to images on the screen than they would in front of faces at real social gatherings.

Another limitation of this study is the known subjectivity in the assessment of attractiveness and naturalness.^[13] Despite this concern, the results obtained from eye tracking were reliable because they formed a central triangle on the face, including the eyes, nose, and mouth, in agreement with the results of Warne *et al.*, who reported that these are the areas where the gaze most often resides when evaluating faces with and without deformities,^[30] although our findings also suggest that images with smiling faces were evaluated as more attractive and younger due to the morphology in the region of the facial folds and the thinness of lines while smiling.

Conclusions

In this study, the facial lines and expressions of elderly female individuals were assessed by laypeople using eye-tracking, showing that the deeper one's nasolabial folds, the more aged and less attractive one appears, especially in nonsmiling images. Smiling pictures were perceived to be more attractive and youthful; these perceptions should be considered in the search for improved esthetic results, whether in dental or facial esthetic treatments.

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Conflicts of interest

There are no conflicts of interest.

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