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Evaluation of the perception of smile esthetics, in frontal view, with mandibular laterognatism, through the eye-tracking technique

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Abstract:

OBJECTIVES: To evaluate the perception of esthetics and the attractiveness of the smile, in frontal view, with mandibular asymmetry, through the eye-tracking.

MATERIALS AND METHODS: OGAMA software and The Eye Tribe Tracker hardware were used to obtain eye tracking in certain areas of interest on the face. To simulate asymmetry, Photoshop® image editing software was used to create a vertical reference line to the midline of the face and make it symmetrical with control of the angulation relative to another horizontal reference line passing through the vertices. Then, the lower third of the face added asymmetries or deviations, starting from zero, with increments of 2 by 2 degrees up to 6 degrees. The study included 60 laypeople, 30 males and 30 females, without any knowledge about the study, showing good vision, and not having used drugs with the possibility of influencing cognitive or motor skills.

RESULTS: From the heat map in cases of mandibular asymmetry, it is possible to visualize that for both sexes the evaluators evaluated with a certain degree of similarity mainly when the deviations presented with 6 degrees. The trajectory of the male and female gaze in cases with asymmetry shows that in cases with a magnitude of 6 degrees, the raters traced mainly in the region of the mouth with little transition in the eye region and mainly in the areas of interest considered as “other.” In the images presented with a magnitude of up to 4 degrees, they were traced in the general image.

CONCLUSIONS: The perception of laypeople from mandibular asymmetry to the right in females presented a higher perception when compared to males with mandible asymmetry to the left.

Keywords:

Eye-tracking, facial asymmetry, smile esthetics

Introduction

Dentofacial appearance is one of the main determinants of physical attractiveness.^[1,2] During interpersonal interaction, the focus of individuals is mainly on the eyes of the other person,^[3] the most important feature in facial attractiveness.^[1] Facial symmetry can be explained as a steady state in which the two

sides of the face are of the same size, shape, and position.^[4]

Mandibular asymmetry is common among surgical patients, being diagnosed in almost 50% of patients with skeletal Class III,^[5] and in these patients, the mandible is usually the most severe asymmetric facial structure^[6] and is easily perceptible both by surgeons and patients.

With the focus on facial esthetics, the assessment of patients' frontal symmetry is

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an increasingly important factor in orthodontic diagnosis. Unlike a patient's profile, it is a perspective that he or she sees regularly and is judged by others during face-to-face encounters.^[7] This perception of beauty depends on individual preference and is influenced by a number of factors, such as the social and cultural environment in which the individual is inserted.^[8]

When deciding whether a face is beautiful, subjectivity is dominant, beauty seems to be directly related to facial symmetry,^[8] and, curiously, a perfectly symmetrical face is not always considered beautiful, whereas large asymmetries directly and negatively affect the facial attractiveness.^[9] Individuals with a smile and a harmonically favorable face are considered to be smarter, having a better chance of finding good jobs.^[10]

Skeletal laterognatism occurs when there is a mandibular deviation to one side of the median line of the face. Laterognatism is diagnosed through clinical facial examinations, which assess facial proportions and homologous facial structures, and generally, indicate where the asymmetry is located.^[11]

Eye-tracking studies explore visual perception from a variety of perspectives, as a renewed approach to traditional assessment methods. These studies addressed issues such as the visual perception of facial and dental structures^[9] and the evaluation of orthodontic treatment.^[12]

Several studies that evaluate human esthetics use visual perception as the main method of analysis and indicate that the way to observe and evaluate the face and/or smiles changes according to the observer, and this is one of the most attention-grabbing points of researchers to evaluate esthetics in dentistry.

Hence, the importance of this esthetic evaluation and the attractiveness of those who look and judge a smile, as well as the diagnosis of facial asymmetries relating the altered transverse positioning under the optics of visual perception. The present study aims to evaluate the perception of smile esthetics, in frontal view, with mandibular laterognatism, through the eye-tracking technique.

Materials and Methods

Before starting this qualitative and observational study, approval was granted by the Research Ethics Committee of the University (registry number: 2,235,302).

For the accomplishment of this work, a male model and a female model with satisfactory occlusion were selected, and both models signed the free informed

consent form to participate in the present study. Both models were photographed as follows: frontal facial photo in the portrait direction for the Canon Rebel XTI camera (Canon, Tokyo, Japan), with the head positioned parallel to the ground without any inclination in the three planes of space.

The proposed images were standardized and produced with the help of Photoshop® (Adobe Systems Inc., San Jose, California) and used only extraoral images that show the face of a smiling person. The Photoshop® program was also used to remove imperfections from the face that could divert the attention of the observer and focus the project objective (e.g., scars, props, spots on the skin).

Then, to simulate the laterognatism, Photoshop® image editing software was used to create a vertical reference line to the midline of the face and make it symmetrical with the angulation control in relation to a horizontal reference line passing through the oral commissures. From this, with the rectangular marking tool of Photoshop®, the lower third of the face was angled to add the asymmetries or deviations, with a shift to the left in the male model and to the right in the female model, starting from zero, with increments of 2 degrees up to the amplitude of 6 degrees [Figure 1].

To obtain eye-tracking, the Eye Tribe Tracker® hardware (The Eye Tribe Aps, Copenhagen, Denmark) was used in conjunction with the OGAMA software (Freie Universität, Berlin) to observe the ocular movement of each rater in a given area of interest (AOI). In the evaluation, 13 AOIs were created in the images, with Target 1 being fixed in the right eye, Target 2-left eye, Target 3-nose, Target 4-right eyebrow, Target 5-left eyebrow, Target 6-right cheek, Target 7-left cheek, Target 8-mouth, Target 9-chin, Target 10-right ear, Target 11-left ear, Target 12-hair, Target 13-forehead [Figure 2].

Raters consisted of 60 laypeople (30 men and 30 women) with no prior notice of the purpose of the study. The average age of raters in this research was 25.2 years. The average age of males was 23.06 years and females was 27.5 years. All the raters signed a consent form in which they affirm to have good vision, not to be using medicines that could disturb the cognitive or motor abilities.

Raters were instructed to sit comfortably in a chair 60–90 centimeters from the Dell P2317H 17-inch monitor (Dell Inc. Round Rock, Texas) upright as recommended by the manufacturer with images projected onto a monitor in the vertical position to maintain its actual size. The Eye Tribe hardware was positioned just below the monitor, according to the manufacturer's recommendations. In the experiment itself, eight

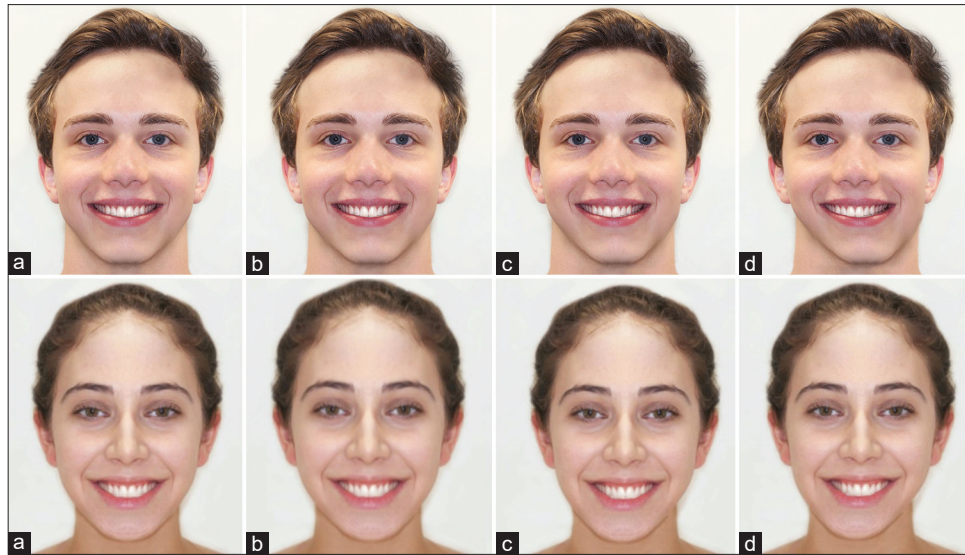


Figure 1: Male and female: (a) Original, (b) 2 degrees, (c) 4 degrees, (d) 6 degrees

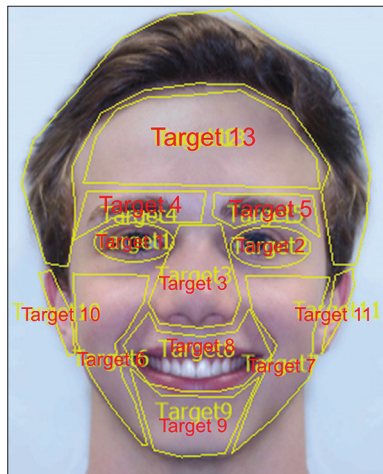


Figure 2: Areas of interest. (a) Male

images were projected, four images of the female model simulating laterognatism to the right and four images of the male model with laterognatism to the left. Each image was visible for 3 seconds and, between the exchange of images, a green transition slide was placed for 1 second, to avoid fatigue displaying each image.

The first 200 milliseconds (ms) of the previous image was set to be ignored so that the last image fixation point did not interfere with the first attachment point of the next image, so as to “zero out” the observer’s focus. The order of the images was drawn before the experiment through the <randomizer.org> website “accessed on 03/29/2019” and followed the same for all raters.

In conjunction with the Eye Tribe Tracker® hardware, OGAMA software was used to obtain eye-tracking data. The tracking generated data on heat maps and trajectory of the gaze. Heat maps provided information as to which

areas were most observed by raters in the selected AOI from a color scale ranging from cold colors to warm colors (green to red, respectively), and the warmer the color, the more fixations occurred at this point, as well as information from other areas will be considered as “other” and will not be analyzed. The trajectory of the look provided information on the tracing of the tracking by laypeople.

Statistical analysis

The ANOVA was used to analyze the time until first fixation or number of fixations and the AOI against the magnitude of the laterognatism and the sex of the model [Table 1]. Time until first fixation or number of fixations and the AOI against the sex of the observer are shown in [Table 2], and the magnitude of the laterognatism and sex of the model against the sex of the rater are shown in [Table 3].

The results obtained with the visual analog scale (VAS) were used to measure the facial attractiveness of each image individually in a printed form, in which the scores were from 0 to 10, and the closer to 0, the less attractive, the closer to 10, the more attractive, and the data of eye-tracking were tabulated in Microsoft Excel and later analyzed with SPSS software version 25 (IBM Corp., Armonk, NY).

The dependent variables studied were time to first fixation (ms), i.e., the number of fixations, and VAS. The independent variables were the AOIs and the laterognatism of the mandible separated by sex of the model.

The one-way ANOVA test was performed, and statistically significant differences were observed ($P < 0.05$) in

Table 1: Comparison within laterognatism

Variables	Mean Grade (±SD)								P
	Male				Female				
	0 degree	2 degrees	4 degrees	6 degrees	0 degree	2 degrees	4 degrees	6 degrees	
Time until 1 fixation Right Eye (ms)	1368 (±829)	1156 (±675)	1467 (±893)	1127 (±857)	1173 (±755)	1084 (±872)	959 (±745)	1017 (±819)	0.578
Time until 1 fixation Left Eye (ms)	1055 (985)	470 (±794)	558 (±980)	859 (±986)	1159 (±772)	773 (±848)	1143 (±961)	766 (±1003)	0.09*
Time until 1 fixation in Mouth (ms)	755 (±543)	791 (±527)	783 (±572)	812 (±701)	1120 (±706)	1064 (±736)	985 (±603)	858 (±761)	0.172
Number of fixations at Right Eye	1.41 (±0.796)	1.14 (±0.363)	1.21 (±0.419)	1.08 (±0.277)	1.50 (±0.618)	1.23 (±0.528)	1.50 (±0.816)	1.20 (±0.414)	0.259
Number of fixations at Left Eye	1.38 (±0.752)	1.35 (±0.629)	1.12 (±0.332)	1.14 (±0.359)	1.40 (±0.681)	1.43 (±0.662)	1.33 (±0.594)	1.16 (±0.375)	0.356
Number of fixations in Mouth	1.75 (±1.107)	1.71 (0.902)	2.00 (±1.206)	1.95 (±1.138)	1.31 (±0.592)	1.59 (±0.911)	1.32 (±0.612)	1.91 (±1.040)	0.02*
VAS	7.27 (±2.189)	7.18 (±1.797)	6.56 (±1.771)	5.63 (±2.285)	8.02 (±1.703)	7.52 (±1.657)	7.48 (±1.790)	6.18 (±2.287)	0*

Participants: 60 Laypeople, *Statistically significant at $\alpha=0.05$

Table 2: Comparison between male and female using ANOVA

	Mean (±SD)		P
	Male	Female	
Time until first fixation on right cheek (ms)	1952 (±843)	1279 (±896)	0.046*
Time until first fixation on the nose (ms)	385 (±753)	450 (±674)	0.482
Number of fixations on the nose	1.7 (±1.01)	1.46 (±0.70)	0.034*
Number of fixations on the right cheek	1.23 (±0.43)	1.0 (±0.00)	0.038*

Source: search data. *Statistically significant difference ($P<0.05$)

Table 3: Mean of VAS scale by class of observer

	Mean Grade (±SD)		P
	Male	Female	
0-degree Male	5.43 (±1.85)	7.53 (±1.90)	1
2-degree male	6.83 (±1.74)	7.30 (±1.48)	1
4-degree male	6.23 (±1.81)	7.10 (±1.72)	0.93
6-degree male	5.43 (±1.85)	5.63 (±2.18)	1
0-degree female	7.53 (±1.90)	8.47 (±1.36)	0.82
2-degree female	7.30 (±1.48)	7.72 (±1.80)	1
4-degree female	7.10 (±1.72)	7.84 (±1.79)	0.82
6-degree female	5.63 (±2.18)	6.69 (±2.29)	0.98

Participants per group: 30 male; 32 female; 62 total. *Statistically significant at $\alpha=0.05$

relation to time to the first fixation on right cheek, nose, left eye, right eye, and mouth and number of fixations on the right cheek, left cheek, right eye, left eye, and mouth with the sex of the evaluator [Table 2]. In addition, the ANOVA test was performed within the magnitude of the laterognatism when compared with the dependent variables [Table 1]. Therefore, the results analyzed in the present study will be of the AOIs of nose, right cheek, mouth, and eyes. Mouth and eyes will be analyzed because previous studies show that they are the areas with the highest perception; in addition, the qualitative

data demonstrate a high degree of fixation near these areas.

The Levene’s test observed the homogeneity of variances and then the post hoc Tukey HSD 2-by-2 multiple parametric comparisons were performed for the homogeneous results ($P > 0.05$) and the Games–Howell 2-by-2 multiple parametric comparison test for heterogeneous results ($P < 0.05$).

Pearson’s correlation test was used to verify the correlation between dependent and independent variables [Table 4].

Results

According to the ANOVA test within the magnitude of the laterognatism, the male and female there were no statistically significant differences concerning the time and number for first fixation on the eyes and mouth [Table 1].

The results of the one-way ANOVA showed statistically significant differences in relation to time variables—until the first fixation on the right cheek and number of fixations in the nose and the right cheek [Table 1]; in addition, the ANOVA performed within the magnitude of the laterognatism compared with the dependent variables showed statistically significant differences ($P > 0.05$) [Table 3]. Regarding the time to the first fixation on the eyes and mouth and number of fixations, there were no statistically significant differences.

From a descriptive analysis of the results, it is possible to observe that women were faster to observe the AOI and first observed the right eye, while the men observed the left eye, but with regard to the number of fixations on the mouth, AOI was higher in males [Table 2].

The results of the visual analog scale did not show significant differences between male and female raters [Table 2]. However, according to the descriptive data, the values of the female observers were smaller than for the male observers.

The tracing generated data on the heat map and trajectory of the gaze. The heat map provided information such as which were the areas most observed by the raters in the AOI selected from a color scale ranging from cold colors to warm colors (green to red, respectively), and the warmer fixings occurred at this point. The gaze trajectory provided tracking order information by observer category, heat maps [Figures 3 and 4], and scan paths [Figures 5 and 6].

Table 4: Pearson’s Correlation between VAS and time to first fixation in mouth

	VAS	Time to first fixation in mouth (ms)
VAS	1	0.132*

*Correlation is significant at the level of 0.05 (2 extremities). Pearson’s correlation coefficient measures the degree of association between the two variables.

The results, for the female model, for the heat maps were concentrated on the eyes in mandibular right-angled magnitudes up to 4 degrees showing a certain normality in the observer pattern of the layperson, suggesting that the laterognatism was not perceptible. When the magnitude of laterognatism was 6 degrees, the rater started to observe the AOI and presented a high level of fixation density, and consequently, the eyes had a low level of fixation density, suggesting that the raters when the magnitude of mandibular right-handedness increased to the right, the lay evaluators were able to perceive it [Figure 3].

In the left lateral laterognatism in the male, the raters focused on eyes and mouth region more effectively when compared with the images in the female model. In addition, it is possible to evaluate that the raters presented high density of fixation in the deviation of 4 degrees in the AOI and when exposed to the deviation of 6 degrees focused with a high density of fixation only on the mouth with a low density of fixation in the region of the eyes and other regions [Figure 4].



Figure 3: Female heat map. (a) Original; (b) 2 degrees; (c) 4 degrees; (d) 6 degrees

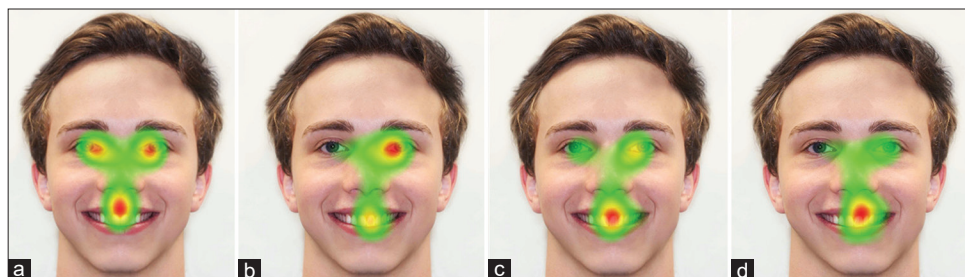


Figure 4: Male heat map. (a) Original; (b) 2 degrees; (c) 4 degrees; (d) 6 degrees

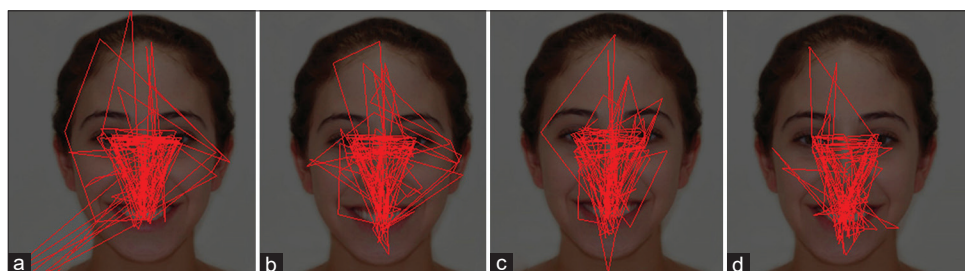


Figure 5: Scanpath of the female gaze. (a) Original; (b) 2 degrees; (c) 4 degrees; (d) 6 degrees

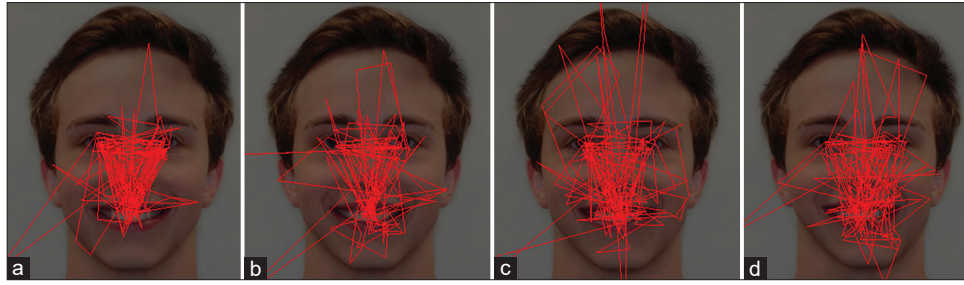


Figure 6: Scanpath of the male gaze. (a) Original; (b) 2 degrees; (c) 4 degrees; (d) 6 degrees

From the heat map, in cases of mandibular laterognatism, it is possible to visualize that for both sexes, the evaluators evaluated with a certain degree of similarity mainly when the deviations presented with 6 degrees [Figures 3c and 4c].

For the male and female scan paths in cases with laterognatism, it is observed that in cases with a magnitude of 6 degrees, the evaluators traced mainly in the region of the mouth with little transition in the eye region and mainly in the AOI considered as “others.” Being that in the images that presented with a magnitude of up to 4 degrees presented/displayed tracing in the general image [Figures 5 and 6].

Pearson’s correlation test showed a weak positive correlation between the mean grade of the VAS and time to the first fixation on the mouth at a statistical level of significance ($P > 0.05$). These results show that the higher the mean grade attributed to the images with the VAS, the higher the time the raters took to look to the laterognatism [Table 4].

Discussion

Dentofacial appearance is one of the main determinants of physical attractiveness. Thus, the search for dental and facial esthetics is the main motivation for patients seeking orthodontic treatment. In this study, facial tooth image was used because it is considered in the literature that the addition of the face in perception studies may alter the judgment on the mouth region.^[13]

The models were edited in Adobe Photoshop software, in which the face was bisected and mirrored so that the different magnitudes of laterognatism were the only difference between the images that could alter the perception of the evaluators, even if other articles state that this technique is not required for perception studies.^[14] The models were initially selected without a previous evaluation of the dental esthetic because it does not affect the attractiveness of the face^[15] and furthermore the smiles in this study have been edited.

The images were simulated and projected on the monitor, in which the observers positioned themselves 60–90 cm

away, thus simulating a conversational distance that is how people are seen during day-to-day life.^[16] The patient should be aware that in certain magnitudes of mandibular laterognatism, only the patient and orthodontist will know of deviations and up to 4 mm of laterognatism in the present study did not produce high density of fixations in the region.

Skeletal laterognatism occurs when there is mandibular deviation to one side of the midline of the face; it is diagnosed by means of complete extraoral clinical examinations, which assess facial proportions and homologous facial structures, and generally indicate where the asymmetry is located (Yamashiro *et al.*, 1998). Moreover, this type of asymmetry usually develops progressively until the end of the growth phase.^[17]

Recent studies, with the tracking of the look, addressed subjects such as the visual perception of facial and dental structures in the evaluation of orthodontic treatment.^[12]

The objective of this study was to evaluate the perception of the esthetics and the smile attractiveness of a group of 60 laypeople, 30 male and 30 female observers, and was based on other studies that also divided the evaluators.^[16] From the analysis of photos in frontal view with mandibular laterognatism through the tracking of the gaze, we obtained the results with the heat map and the trajectory of the gaze at the images, in which they presented mandibular laterognatism of 0, 2, 4, and 6 degrees in males and females.

In the evaluation of the images as a whole, it can be observed that the perception of laymen from the mandibular laterognatism to the right in the female presented with greater perception than the male with laterognatism jaw to the left, and with that it is possible to affirm that even untrained individuals can perform a good analysis of facial esthetics.^[12]

This study has clinical implications and is relevant to the diagnosis and treatment plan for the orthodontic treatment of the patient. As indicated by some smile variables, they make a clinical difference from the perspective of the face.^[18] We affirm that the present

study is not an attempt to dismiss the patients' concerns, but to try to calm them about the perceptions of laypeople in relation to mandibular laterognatism of different magnitudes in a real context.

Conclusions

The perception of laypeople from the right mandibular laterognatism in the female presented with greater perception than the male with laterognatism to the left.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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