Visual attention during the evaluation of facial attractiveness is influenced by facial angles and smile

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ABSTRACT
Objective: To examine the changes in visual attention influenced by facial angles and smile during the evaluation of facial attractiveness.

Materials and Methods: Thirty-three young adults were asked to rate the overall facial attractiveness (task 1 and 3) or to select the most attractive face (task 2) by looking at multiple panel stimuli consisting of 0°, 15°, 30°, 45°, 60°, and 90° rotated facial photos with or without a smile for three model face photos and a self-photo (self-face). Eye gaze and fixation time (FT) were monitored by the eye-tracking device during the performance. Participants were asked to fill out a subjective questionnaire asking, “Which face was primarily looked at when evaluating facial attractiveness?”

Results: When rating the overall facial attractiveness (task 1) for model faces, FT was highest for the 0° face and lowest for the 90° face regardless of the smile (P < .01). However, when the most attractive face was to be selected (task 2), the FT of the 0° face decreased, while it significantly increased for the 45° face (P < .001). When facial attractiveness was evaluated with the simplified panels combined with facial angles and smile (task 3), the FT of the 0° smiling face was the highest (P < .01). While most participants reported that they looked mainly at the 0° smiling face when rating facial attractiveness, visual attention was broadly distributed within facial angles.

Conclusions: Laterally rotated faces and presence of a smile highly influence visual attention during the evaluation of facial esthetics. (Angle Orthod. 2018;88:329–337.)

KEY WORDS: Face; Perception; Smiling; Eye movement; Esthetics

INTRODUCTION
Improvement of facial esthetics as well as occlusion is one of the main treatment objectives of esthetic dentistry. Individual perception of facial esthetics and attractiveness is influenced by combined factors including anatomic features, psychosocial states such as self-esteem, cultural background, and age; and three-dimensional movements such as facial expressions. However, unlike the daily perception of facial features, clinicians commonly diagnose and analyze facial esthetics based on reliable static anatomic features such as balanced facial ratios and symmetry. Especially, lateral cephalometrics and lateral profiles are accepted as gold standards to set esthetic goals in dentistry.

In the field of cognitive psychology, it is known that a slightly laterally rotated face is preferred and better recognized than a frontal face or the lateral profile, indicating that the judgment of facial attractiveness can be influenced by facial angle. Similarly, most faces presented in well-known classical portraits or paintings are slightly rotated laterally, and rotation of the
face to about 45° was recognized as the most attractive and preferred angle to take selfie photos among photos from a social network service.21 In addition, facial expression such as the smile is reported as a better predictor of facial attractiveness than an expressionless (neutral) face or the lateral profile,22 while dental attractiveness during a smile can change the level of visual attention.23 However, objective investigation of the direct influence of facial angle and smile during the perception of facial attractiveness is limited.

Facial attractiveness and beauty are determined quickly—within the first few seconds of seeing the face.24 In particular, eye gaze both reflects and influences the process of making decisions regarding more attractive faces.25 An eye tracker is a device that records the movement of the eye using the reaction of the pupil as a physiological index.26 By using this system, instant changes in visual attention can be quantified, making it possible to detect “what” viewers perceive and “how” they perceive the face.4,27

The objective of this study was to examine the influence of various facial angles and presence of a smile during the exploration of facial attractiveness. By using photo stimuli to induce behavioral changes, such as to rate facial attractiveness, changes in eye gaze pattern were monitored and analyzed with the eye-tracking system.

MATERIALS AND METHODS

Participants

This study was approved by the Institutional Review Board (3-2016-185). A total of 33 young adults without visual impairment (15 women, 23.3 ± 3.1 years of age; 18 men, 21.3 ± 2.4 years) were recruited. In addition, six models (three women and three men) with normal occlusion volunteered to provide only facial photos as model photos.

Stimuli Preparation

Standardized facial photographs were taken at horizontally rotated facial angles of 0° (frontal), 15°, 30°, 45°, 60°, and 90° (lateral profile), encompassing from the chin to the hairline without hair ornaments or glasses, using a digital camera (SONY NEX-5T; Sony, Tokyo, Japan) in an orthodontic clinic photo room with a rotatable chair. Adobe Photoshop CS6 software (Adobe Systems Inc, San Jose, Calif) was used to standardize face size among participants and develop panels.

For the first task stimuli, each participant’s photographs of neutral or smiling faces at angles from 0° to 90° were arranged and presented in a circular form in random order. To eliminate placement bias, the same six photo sets were used to make three separate panels with different photo positions and arrangement orders. The panels of both the neutral (three panels) and smiling face (three panels) were made separately (Figure 1A). In addition, model panels were made using model photos.

For the second task stimuli, three panels of the neutral or smiling face were composed of the participant’s photographs as in task 1. Two additional photo panels for the neutral and smiling face were made with individually labeled 0° to 90° photos as a set arranged in a row (Figure 1B).

For the third task stimuli, a combination panel was made with 0°, 45°, and 90° photos with a mixture of neutral and smiling faces (Figure 1C). Similar to task 1, the same six photos in a set were used to make three separate panels, with different photo positions and arrangement orders.

Task Setting for the Eye Tracking

The participants were positioned in front of a 23-inch monitor connected to the eye-tracking system, SMI RED 120 eye-tracker (SensoMotoric Instruments, Teltow, Germany). This eye-tracking device measured the movement of the pupil using an infrared camera and eye movement. The eye movement and behavior data of each participant were recorded during the task performance (Figure 1D).

For task 1, the participants were asked to “rate the overall facial attractiveness” by looking at the photo panels (4.5 seconds/panel) using a descending scale from 4 for most attractive to 1 for least attractive (2 seconds/panel). The scores were not used as results since they were only questions to induce the act of observing the face. One participant was presented with six self-photo panels (three neutral, three smiling) and 18 model photo panels (from three models of same gender), resulting in a total of 24 stimuli panels.

Task 2 was designed to induce active exploration behavior by asking participants to “select the most attractive face” among the photos. Similar to task 1, three panel sets were presented. Then, an additional panel with labeled photos was displayed for 5 seconds for the participants to press the most attractive face number on the keyboard. One participant was presented with four neutral and four smiling self-photo panels and 24 model-photo panels.

Task 3 was designed to evaluate and to confirm the interaction between facial angle and presence of a smile when rating facial attractiveness. The participants rated “the overall facial attractiveness” while looking at a combination panel similar to task 1. One participant was presented with three self-photo combi-
nation panels and nine model-photo combination panels from three models of same gender.

**Questionnaire Survey**

After the eye-tracking sessions, the participants were asked to fill out a multiple-choice questionnaire asking, "Which face did you mainly look at when deciding the facial attractiveness?" The answer was chosen from (1) neutral front face, (2) smiling front face, (3) neutral laterally rotated face, (4) smiling laterally rotated face, (5) neutral lateral profile, and (6) smiling lateral profile.

**Evaluation of Eye Gaze**

Eye-tracking results were analyzed using the Experiment Center 3.5, SMI iView X system, and SMI BeGaze software (SensoMotoric Instruments). The photos for each panel were set as six areas of interest (AOI). The time when eyes gazed for at least 80 milliseconds was defined as the fixation time (FT). The FT of each AOI was represented by the relative percentage of the total FT of the six AOI/panel. Heat map analysis was used to show the overall appearance of the FT.

**Statistical Analysis**

Linear mixed model followed by the Bonferroni test was used to compare FT (%) for AOI and to analyze the interactions among facial angle and smile. Significance was set at the 5% critical level ($P < .05$). SAS 9.2 software (SAS Institute, Cary, NC) was used for the evaluation.
RESULTS

Eye Gaze Influenced by Facial Angles and Smile When Rating the Overall Facial Attractiveness (Task 1)

Among neutral model faces, the 0° face showed the highest FT during the evaluation of overall facial attractiveness. The 0° face had significantly higher FT than any other angle, except for 30° ($P < .01$), while the 90° face showed a significantly lower FT than all other angles ($P < .01$; Figure 2A). For the smiling face, the 90° face had the lowest FT compared with other angles ($P < .05$; Figure 2B).

For the evaluation of the neutral self-face, the FT of the 90° face had the lowest FT compared with all other angles, except for 60° ($P < .05$; Figure 3A). For the
Eye Gaze Influenced by Facial Angles and Smile When Selecting the Most Attractive Face (Task 2)

When the most attractive face was to be selected among neutral model faces, the FT of the 30° and 45° face became higher and the 0° face became lower. Compared with the evaluation of overall facial attractiveness among neutral faces (task 1), the fixation time of the 0° face significantly decreased, while it significantly increased for the 45° face when rating the most attractive face (task 2; \( P < .001 \). Figure 4A). Similarly, the FT of 30° to 45° faces increased for the smiling face, but this was not statistically significant (Figure 4B).

For the self-face, the FT of 0° decreased while it increased for the laterally rotated faces for both neutral and smiling faces, but this tendency was not statistically significant (Figure 5A,B).

Interaction Between Facial Angles and Expressions When Rating Facial Attractiveness (Task 3)

For both model and self-faces, the FT was highest for the 0° face and lowest for the 90° face, regardless of the presence of a smile (\( P < .01 \)). For the model face, 0° smiling faces had significantly higher FT compared with the other conditions (\( P < .01 \)). However, for the self-face, a significant difference was not noted between the neutral or smiling face (Figure 6A,B).

Questionnaire Survey Versus Eye Tracking

The self-reports to the question, “Which face did you mainly look at when deciding the facial attractiveness?” for the model faces was highest for the 0° smile (64.9%), followed by 0° neutral, 45° smile, 45° neutral, 90° neutral and smile. While most participants reported they looked mainly at the 0° smiling face, the FT of the 0° smiling face was 25.5%, with broad distribution among facial angles.
The responses for self-face was highest for 0° neutral (56.8%) followed by 0° smile, 45° neutral, 45° smile, and none for 90° neutral or smile. The FT was distributed among facial angles similar to the model faces (Table 1).

**DISCUSSION**

Facial angle and presence of a smile influenced visual attention during the exploration of facial attractiveness especially when evaluating faces other than one’s own. During evaluation of overall facial attractiveness, eye gaze was mainly focused toward the 0° face, whereas the 90° face received the least eye gaze. Interestingly, when an active form of behavior change was induced to differentiate the one most attractive face, visual attention was more focused toward the slightly rotated faces within facial angles of 30–45°.

In general, there is more information and interest in the areas that receive visual attention for longer periods of time. Thus, the increase in visual attention for the facial angle of 30–45° may indicate that the morphological features of the rotated face may also be a determinant factor when evaluating facial esthetics. Previous studies on cognitive psychology also reported that laterally rotated faces are better recognized, preferred in daily life, and that the 45° rotated face has the advantage of containing considerable information on both the two-dimensional facial features of the front face and the three-dimensional features of the lateral profile. Interestingly, most participants subjectively reported that they looked at the frontal face during the evaluation, while the objective evaluation of visual attention indicated by FT was similar between the frontal face and the 45° face, indicating an unconscious preference toward the laterally rotated face when deciding facial attractiveness.

It is noteworthy that the 90° face received the least attention when young adults determined facial attractiveness regardless of facial expression such as a smile or during the evaluation of self-face or others’ faces. Lateral cephalometry and the profile have been primarily used as the gold standards to diagnose facial esthetics in the field of dentistry, especially for orthodontic treatment or oral and maxillofacial surgery. However, the results suggest that diagnosis based solely on the lateral profile may not be appropriate or sufficient to determine the overall impression of appearance or facial esthetics.

![Figure 4](http://meridian.allenpress.com/angle-orthodontist/article-pdf/88/3/329/1394873/080717-528_1.pdf)

**Figure 4.** Visual attention is focused on laterally rotated faces when selecting the most attractive model face. For the neutral face, the FT of the 0° face significantly decreased, while it significantly increased for the 45° face (A). The tendency was similar for the smiling face (B). Data presented as mean ± standard error. *P < .05; **P < .01; ***P < .001.
People see the dynamic appearance of others in everyday life, and the smile per se is one of the most dynamic motions involved in facial expression. In general, visual attention for a smiling face was higher than for neutral expression during the evaluation of facial attractiveness, and subjective response for the 0° smiling face was the highest among the model faces. This also implies that dental attractiveness during a smile may also influence the perception of facial attractiveness.23 In this study, static facial images and posed smile photos were applied because of technical difficulties. Further evaluation using motion pictures or

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Figure 5. Changes in visual attention when evaluating the self-face. The FT of the 0° face decreased, while it increased on laterally rotated faces for both the neutral (A) and smiling face (B). Data presented as mean ± standard error. * P < .05; ** P < .01; *** P < .001.

Figure 6. Presence of a smile increases visual attention when rating model face attractiveness but not self-face. The FT was highest for the 0° smile face (S0°) among other conditions for the model face (A). However, it was not statistically significant for the self-face (B). N indicates neutral face; S, smiling face. Data presented as mean ± standard error. * P < .05; ** P < .01; *** P < .001.
video clips may be necessary to precisely discern the influence of smile dynamics on the perception of facial esthetics.

Increase in eye gaze reflects preference, but it also influences decision making in a cascade with positive feedback seconds before selecting a more attractive face. Facial attractiveness and trustworthiness reportedly can be fully assessed within 0.1 second. Viewers tended to fix the eye on the informative area within the initial 2 seconds, and facial attractiveness is determined within the first 2 seconds. Since the task stimuli panels used in this study presented six photos of the same model simultaneously, pilot studies were conducted to approximate the appropriate observation time for the tasks. As there was a possibility to include eye movements for searching unnecessary information as the observation time became longer, various time ranges were evaluated. Accordingly, 4.5 seconds and 5 seconds were selected for tasks 1 and 3, and task 2, respectively.

Determining facial esthetics is considered to be highly subjective, but facial angle and the presence of facial expression, such as a smile, highly influenced visual attention during the evaluation of facial attractiveness. In this study, models with normal occlusion were selected, and the participants were not classified according to their facial morphological features or occlusal condition. Considering that malocclusion may influence the self-perception of facial attractiveness and/or facial esthetics. Thus, to further establish customized diagnosis in esthetic dentistry, the objective morphological features observed at different facial angles and subjective perception studies according to different malocclusion patterns may be helpful in the future.

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