# Eye fixations when viewing faces

**Lynnsay Hickman, DDS, MS; Allen R. Firestone, DDS, MS; F. Michael Beck, DDS, MA; Shari Speer, PhD, MA**


## ABSTRACT

**Background.** There is disagreement in the literature about the relative importance of the mouth and the teeth to facial attractiveness. Few investigators use objective measures for quantifying which facial features are important and their order of importance. Objective measures of the relative importance of a facial feature are in what order, for how long and how often viewers look at it. The authors conducted a study to determine the hierarchy and length of time study participants spent viewing features in facial images.

**Methods.** The participants were 50 young adults. The authors used a pupillary-corneal reflection technique to measure viewers' eye movements when they were viewing images of faces after orthodontic treatment was completed. The authors took the measurements again after a two-week interval. They quantified eye fixations for six areas of interest: eyes, ears, nose, mouth, chin and other. The variables measured were the location of the first fixation, the location of the area of maximum fixation duration and the location of the area receiving the maximum number of fixations.

**Results.** Intraobserver variability among the participants was high for most of the variables assessed ($\kappa < 0.30$). For the smile image, first fixation, the most frequent and the longest fixations were other, eye, nose, mouth, ear and chin, in that order. The mouth, even the smiling mouth, received less than 10 percent of the viewers' visual attention.

**Conclusion.** Viewers' visual fixations on images of well-balanced faces do not preferentially go to any single facial feature. The mouth attracts only a small part of visual attention in well-balanced faces.


**Key Words.** Face; orthodontics; smile; esthetics.
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Efforts to improve facial attractiveness often are stigmatized as cosmetic, and they have the connotation of being superficial, shallow and of no true value or importance. There is, however, evidence that facial attractiveness has evolutionary importance, and it has been associated with reproductive success in humans living in an industrialized setting in the late 20th century.[1]

There is considerable interest in the use of dental procedures to optimize the position, size and shape of improve facial appearance.[2-4] Because patienteeth and associated soft tissues to ts seek orthodontic and other dental treatment to improve dental and facial appearance,[5] dentists need to understand what role the mouth and teeth have in overall facial attractiveness. There is interest about which components contribute to the attractiveness of the smile.[6] However, the nature of the relationship between the smile and facial attractiveness remains unclear.

In the mid-1970s, Terry and colleagues[7-9] conducted a series of studies in which they assessed facial attractiveness. They found that participants consistently assigned major importance to the mouth and eyes, followed by hair, nose and facial structure. These findings, however, are not uni-

When this article was written, Dr. Hickman was a resident, Division of Orthodontics, College of Dentistry, Health Sciences Center, The Ohio State University, Columbus. She now is in private practice, Columbus, Ohio.
Dr. Firestone is an associate professor, Division of Orthodontics, College of Dentistry, Health Sciences Center, The Ohio State University, 4088 Postle Hall, 305 W. 12th Ave., Columbus, Ohio 43210-1267, e-mail "firestone.17@osu.edu". Address reprint requests to Dr. Firestone.
Dr. Beck is an associate professor, Division of Orthodontics, College of Dentistry, Health Sciences Center, The Ohio State University, Columbus.
Dr. Speer is a professor, Department of Linguistics, College of Humanities, The Ohio State University, Columbus.

versal. In 2005, Tatarunaite and colleagues[10] reported that overall facial attractiveness does not depend on any single facial feature and that the features least associated with the overall facial attractiveness score were nose and teeth. In the 1980s, Shaw and colleagues[11,12] found data indicating that background facial attractiveness was more important than were dentofacial features—even unattractive dentofacial features—in determining favorable perceptions of a person. Questions remain about which features contribute most to overall facial attractiveness.

Attractive faces have an innate ability to draw a person's gaze. A group of newborns—some of whom were younger than 24 hours—and a group of 6-month-old infants gazed longer at attractive faces than at unattractive faces.[13,14] If facial attractiveness can draw a viewer's gaze, then measures of the importance of a facial feature in determining attractiveness might be the order in which features are viewed and the amount of time spent viewing them. In one report based on the results of a poll, when people were asked, "What facial features draw your glance and hold your attention?," they responded eyes (62 percent), hair (22 percent) and mouth (8 percent).[15]

Extensive research has been conducted regarding human eye movements and the information a viewer receives as his or her eyes move across a scene or picture. Eye gaze is characterized by a series of jerky, rapid jumps known as saccades and by stops known as fixations. Visual information is acquired during fixations, although small eye movements can occur during this phase. Information that can be used for perceptual or cognitive analysis cannot be acquired during a saccade phase.[16,17]

Shepherd and colleagues[18] proposed that the most direct and simple method of assessing which facial features are most important to the viewer is to examine his or her eye movements. Eye-tracking methods, in which the viewer's eye movements are tracked and recorded while he or she views photographs or images, can be an objective tool for measuring facial attractiveness components. Eye fixations reflect the allocation of attention in a direct manner.[19] If the viewer's eyes are drawn consistently to particular features of the face, one can assume that those features are of greatest interest to the viewer.[20] Also, objects or features that are more interesting to a viewer are likely to lead to longer gaze duration when he or she views those particular objects or features.[21]

Although eye tracking has been used frequently in studies involving facial recognition or memory tasks, eye-tracking methods have been used infrequently in facial attractiveness research. In one study, investigators used an eye-tracking camera to measure directly the relative amount of time participants spent looking at particular facial features on photographs during a social impression–formation task.[22] The results indicated that 43 percent of participants' visual inspection time was spent looking at the eye region, and only 13 percent of their time was spent looking at the mouth region. However, investigators in only a few studies have tracked eye movements while asking viewers to look at facial images without attempting to recognize or memorize what they were viewing.[22,23]

We conducted a study to determine the location, order and duration of viewers' visual fixations on facial features in images of people who had completed orthodontic treatment and whose jaw relationships were within the range of normal (that is, neither protrusive nor retrusive).

## PARTICIPANTS, MATERIALS AND METHODS

**Participants.** Our research protocol was reviewed and approved by The Ohio State University Behavioral and Social Sciences Institutional Review Board, Columbus. We posted advertisements in classroom buildings on the main campus of The Ohio State University, away from The Ohio State University Medical Center, to recruit 50 students (25 men, 25 women) aged 18 through 30 years. All participants were compensated monetarily for their participation at the end of the study.

Our inclusion criteria were that participants be 18 to 30 years old at the time of enrollment in the study, have unimpaired vision with or without corrective lenses and be willing to attend two eye-tracking sessions of 15 to 30 minutes each scheduled two weeks apart. We excluded dental students from participating because they might be predisposed to look preferentially at the mouth and teeth.

**Materials.** ***Eye-tracking system.*** We used a pupillary-corneal reflection technique in conjunction with a head-mounted eye-tracking device to measure participants' eye movements when viewing facial images (Figure). The system uses the position of light reflected off of the retina onto the cornea to track eye position. The eye-tracking system software we used was equipped with data

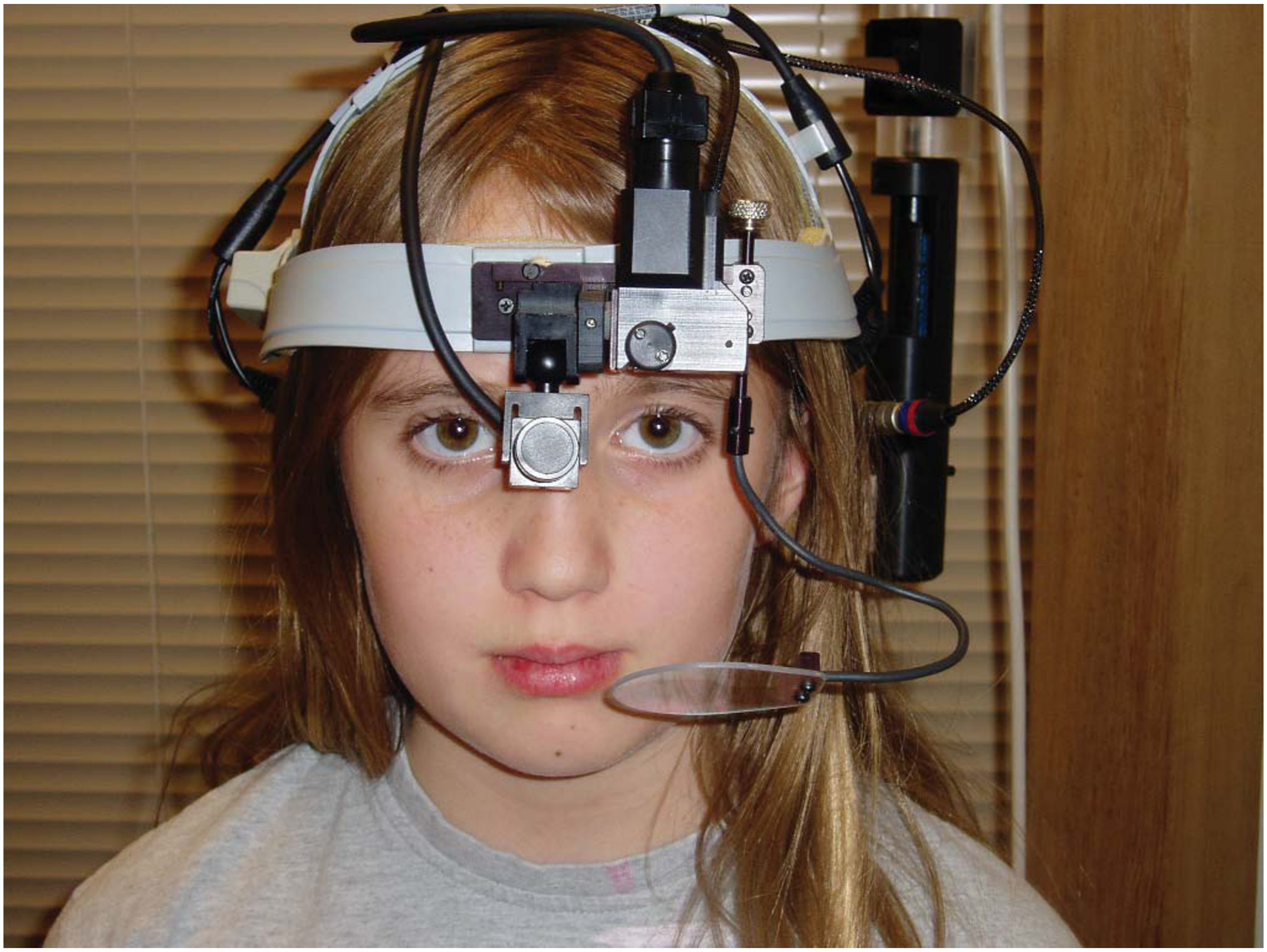

**Figure.** A child (not a study participant) wearing a head-mounted, eye-tracking device.

analysis routines that identified the location and duration of eye movements with respect to defined areas of interest within the viewed images. The software program also recorded the participant's fixations as his or her eyes moved across images displayed on the video monitor. To be recorded as a fixation, the participant's eye had to remain still for 83 milliseconds. We listed the fixations in the order in which they occurred.

We obtained the facial images we used in our study from an archival database of patients who had completed comprehensive orthodontic treatment at the Graduate Department of Orthodontics in the College of Dentistry at The Ohio State University. We chose 20 images of patients (10 male, 10 female) with acceptable Class I profiles (that is, neither retrognathic nor prognathic). The patients had well-aligned teeth after treatment with no apparent malocclusions or distracting restorations. Their soft-tissue profiles were within normal limits with no indications of protrusive or retrusive jaw relationships. The patients' ages ranged from 12 to 39 years. Each of the patients was shown in nonsmiling profile (profile image), smiling frontal view (smile image) and nonsmiling frontal view (nonsmile image), for a total of 60 images. All images were photographs taken after orthodontic appliances were removed from the patients. No visible retention appliances were in place in any of the images. We also screened the images and excluded any photographs with unusual facial expressions, unusual hairstyles, facial hair, eyeglasses and any other distracting features such as jewelry, piercings and blemishes. We cropped the images so that only the patients' heads and necks were included, and we standardized them to a resolution of 95 pixels per inch by using photo-editing software.

All facial images viewed in this study had five features designated as areas of interest for data analysis: eyes, ears, nose, mouth and chin. We delineated areas of interest as boxes with top, bottom, left and right boundaries, which were visible only when we analyzed the data in the software program; the boundaries did not appear on the video monitor as participants were viewing the images. We recorded all fixations as x, y coordinates. If a participant's fixation was located within the boundaries of one of the areas of interest, we considered it to be within that particular area of interest. We recorded any fixation that did not occur within the boundaries of one of these five areas of interest as "other" (included forehead, cheeks, hair, throat and neck, and background).

***Questionnaire.*** To assess the congruence of the participants' responses to questions about visual attention with their actual behavior, we administered a brief, two-item questionnaire to the participants after they completed the second viewing session. The questions were multiple choice and asked the participants to choose the facial feature at which they looked first when meeting someone for the first time and the facial feature at which they looked longest when meeting someone for the first time. Possible responses were the six areas of interest (including other).

**Methods.** Participants attended two eye-tracking sessions of 15 to 30 minutes each that took place two weeks apart. At the beginning of each session, we fitted participants with the head-mounted eye tracker and instructed them to look at the images as they appeared on the screen; we gave no further instructions. Participants viewed two practice facial images to familiarize themselves with the eye-tracking system. We did not include these first two images in the data analysis. Participants then viewed the 60 facial images presented in random order for six seconds each on a computer screen while we recorded their eye movements. After a participant completed the questionnaire, we debriefed him or her about the nature of the research project.

**Statistical analysis.** For us to obtain an $\alpha$ risk of .05, a confidence interval of 0.2 and a predicted observed agreement of 0.85, we needed a sample size of 49 participants.

The dependent variables we measured for each six-second image-viewing session were the location of the first fixation in all six areas of interest including other (first), the location of the area of maximum fixation duration in all six areas (most frequently) and the location of the area receiving the maximum number of fixations in all six areas (longest). The independent variable was the image type (profile, smile, nonsmile). We conducted pairwise comparisons between each of the areas of interest for all images pooled and for the smile images by using the Holm-Bonferroni correction.[24] We considered results to be significant if the corrected $P$ value was less than .05.

**TABLE 1**

**Values for area of first fixation, area of maximum number of fixations and area of maximum fixation duration for all areas of interest, according to image type.**

| VARIABLE (IMAGE TYPE) | ALL AREAS (INCLUDING OTHER) ($\kappa$) |
|---|---|
| **Area of First Fixation** | |
| All images* | 0.18 |
| Smile image | 0.09 |
| **Area of Maximum Number of Fixations** | |
| All images | 0.20 |
| Smile image | 0.11 |
| **Area of Maximum Fixation Duration** | |
| All images | 0.21 |
| Smile image | 0.13 |

* Smile, nonsmile and profile images.

We evaluated reliability for dependent variables by using a simple $\kappa$ statistic with a 95 percent confidence interval. For the frontal view images—both smile and nonsmile—we combined the data for the left and right ear, as well as for the left and right eye.

## RESULTS

All 50 participants participated in both sessions. The mean age of the participants was 22.6 years (standard deviation [SD] ± 3.0 years) for female participants and 22.7 years (SD ± 3.4 years) for male participants. The results indicate that the participants did not look consistently at an individual facial feature when viewing nonsmile, smile or profile images of faces with good occlusion ($\kappa < 0.3$) (Table 1). All $\kappa$ values were statistically different from zero owing to the large sample size used.

For all images combined and for the smile images, participants looked first, most frequently and longest at other (everything except the five areas of interest) (Tables 2, 3 and 4 [page 45]). For the smile image alone, the participants looked first, most frequently and longest at eyes, nose, mouth, ears and chin, in that order, after other. For all images combined, the results were similar, except that for the area of longest fixa-

**TABLE 2**

**Number of first fixations in an area of interest and percentage of total first fixations for all images* and for smile image alone for all participants.**

| AREA OF INTEREST | FIRST FIXATIONS FOR ALL IMAGES (NO.) | % FIRST FIXATION FOR ALL IMAGES (95% CL†) | FIRST FIXATION FOR SMILE IMAGE (NO.) | % FIRST FIXATION FOR SMILE IMAGE (95% CL) |
|---|---|---|---|---|
| **Ears** | 291 | 9.7 (8.7, 10.8) | 9 | 0.9 (0.4, 1.7) |
| **Eyes** | 664 | 22.1 (20.7, 23.7) | 328 | 32.8 (28.9, 35.8) |
| **Mouth** | 66 | 2.2 (1.7, 2.8) | 27 | 2.7 (1.7, 3.9) |
| **Nose** | 491 | 16.4 (15.1, 17.7) | 237 | 23.7 (21.1, 26.5) |
| **Chin** | 8 | 0.3 (0.1, 0.5) | 2 | 0.2 (0.02, 0.7) |
| **Other** | 1,480 | 49.3 (47.5, 51.1) | 397 | 39.7 (36.7, 42.8) |
| **TOTAL** | **3,000** | **100.0** | **1,000** | **100.0** |

* Smile, nonsmile and profile images.
† CL: Confidence limit.

**TABLE 3**

**Number of maximum duration of fixations in an area of interest and percentage of total maximum duration fixations for all images* and for smile image alone for all participants.**

| AREA OF INTEREST | MAXIMUM DURATION OF FIXATION (NO.) | % MAXIMUM DURATION OF FIXATION (95% CL†) | MAXIMUM DURATION OF FIXATION FOR SMILE IMAGE (NO.) | % MAXIMUM DURATION OF FIXATION FOR SMILE IMAGE (95% CL) |
|---|---|---|---|---|
| **Ears** | 108 | 3.6 (3.0, 4.3) | 13 | 1.3 (0.7, 2.2) |
| **Eyes** | 1,040 | 34.7 (33.0, 36.4) | 463 | 46.3 (43.2, 49.5) |
| **Mouth** | 241 | 8.0 (7.1, 9.1) | 35 | 3.5 (2.5, 4.8) |
| **Nose** | 229 | 7.6 (6.7, 8.6) | 108 | 10.8 (8.9, 12.9) |
| **Chin** | 14 | 0.5 (0.3, 0.8) | 2 | 0.2 (0.02, 0.7) |
| **Other** | 1,368 | 45.6 (43.8, 47.4) | 379 | 37.9 (34.9, 41.0) |
| **TOTAL** | **3,000** | **100.0** | **1,000** | **100.0** |

* Smile, nonsmile and profile images.
† CL: Confidence limit.

tion the order was eyes, mouth, nose, ears and chin, after other (Table 3). There was no statistically significant difference between the number of times that the mouth and nose were viewed longest. The mouth was viewed first, most frequently or longest in less than 10 percent of the 3,000 image viewings. This also was true for the smile images (Tables 2-4).

All pairwise comparisons were statistically significant except for mouth and nose in the area of longest fixation as noted above, and in the smile images for chin and ear in first fixation and ear and mouth in maximum fixation duration.

The responses to the questions differed from the objective measurements (Table 5). For the first question, which asked which facial feature of the six areas of interest the participant looks at first when meeting someone for the first time, 82 percent of the participants said eyes. Objective measurements of eye movement indicate that eyes were viewed second to other. For the second question, which asked which facial feature the participant looks at the longest when meeting someone for the first time, 68 percent of the participants said eyes. Again, objective measurements of eye movements showed that eyes were viewed second to other. In addition, the participants underestimated how soon and how long they looked at the nose and overestimated how soon and how long they looked at the mouth.

## DISCUSSION

Humans make esthetic judgments of others from the first interaction and thereafter.[25] Mueser and colleagues[26] reported that the face was a more powerful predictor than the body of overall attractiveness. There is, however, disagreement about which facial features are important in evaluating overall facial attractiveness.[7-10] The results from our study indicated that participants did not consistently view any single feature first, most frequently or longest when viewing nonsmile, smile or profile images of well-balanced faces. This finding is in agreement with the results of other studies in which investigators used different methods and found that the mouth and teeth were not primary determinants of facial attractiveness.[10-12]

The six-second duration we chose for each image display does not seem to be a source of error. Voluntary eye movements and fixations made while scanning a display take approximately 250 milliseconds per saccade, including the fixation.[27] Therefore, about four eye movements are possible in a one-second observation phase; much shorter viewing phases have been reported.[27] Therefore, we determined that six seconds of viewing time per image would be adequate for participants to fixate on interesting areas and return to interesting fixations.

The between-methods reliability of different eye-tracking methods has been verified in schizophrenia research,[28] thus, the method is reliable. In our study, however, the participants did not consistently fix their gazes on any facial feature when viewing the three standard facial views. Although all κ values were significantly different from zero, none of the κ values approached those indicating at least moderate agreement, which is 0.41 and higher (Table 1).[29] We hypothesized that in well-balanced heads and faces after orthodontic treatment is completed, there are no salient features that consistently attract the viewer's gaze.

Most studies involving eye-tracking methods in which faces are viewed involve recognition and memorization tasks. For memorization and later recognition of faces, the first two fixations almost always were the eyes or nose and rarely the mouth or forehead.[30] In a study in which investigators used an eye-tracking method to measure directly the relative amount of time participants spent looking at particular facial features on photographs, they found that participants spent almost four times as much time looking at eyes as at mouths.[22] The results of both these reports are in agreement with the results of our study.

Dental health care providers might question the lack of salience of the mouth and smiling mouth in the hierarchy of the participants' visual attention. However, this is not an isolated finding and may reflect a dichotomy between dentists' professional focus and the lay public's interest.[31]

The responses of the participants in our study to the questionnaire are in agreement with the responses of people asked which facial features draw and hold their attention.[15] One can question if this attention to eyes is the person recounting his or her behavior or providing an expected, socially acceptable response. In either case, there was a lack of congruence between the questionnaire response and actual behavior. We hypothesize that social rules (for example, to look a conversational partner in the eye) may determine the response to the questions. When determining why the nose received so few responses in the questionnaire and more visual attention, we hypothesize that it may not be socially acceptable to admit to looking at someone's nose; in contrast, eyes, mouths and perhaps hair (color or style) are socially acceptable objects of our attention. Our

**TABLE 4**

**Number of maximum number of fixations in an area of interest and percentage of total maximum number of fixations for all images* and for smile image alone for all participants.**

| AREA OF INTEREST | MAXIMUM NO. OF FIXATIONS | % MAXIMUM NO. OF FIXATIONS (95% CL†) | MAXIMUM NO. OF FIXATIONS FOR SMILE IMAGE | % MAXIMUM NO. OF FIXATIONS FOR SMILE IMAGE (95% CL) |
|---|---|---|---|---|
| Ears | 95 | 3.2 (2.6, 3.9) | 10 | 1.0 (0.5, 1.8) |
| Eyes | 1,009 | 33.6 (31.9, 35.4) | 472 | 47.2 (44.1, 50.4) |
| Mouth | 154 | 5.1 (4.4, 6.0) | 17 | 1.7 (1.0, 2.7) |
| Nose | 223 | 7.4 (6.5, 8.4) | 101 | 10.1 (8.3, 12.1) |
| Chin | 6 | 0.2 (0.1, 0.4) | 0 | 0.0 |
| Other | 1,513 | 50.4 (48.6, 52.2) | 400 | 40.0 (37.0, 43.1) |
| **TOTAL** | **3,000** | **99.9** | **1,000** | **100.0** |

* Smile, nonsmile and profile images.
† CL: Confidence limit.

**TABLE 5**

**Results from questionnaire asking "When you meet someone for the first time, which facial feature do you ..." (N = 50).**

| FACIAL FEATURE | LOOK AT FIRST (%) | LOOK AT LONGEST (%) |
|---|---|---|
| Eyes | 82 | 68 |
| Ears | 2 | 0 |
| Nose | 2 | 4 |
| Mouth | 14 | 24 |
| Chin | 0 | 0 |
| Other | 0 | 4 |

participants' responses to the two questions seem to support this interpretation of the results.

Our findings raise the issues of whether all questionnaire data in the field of facial attractiveness should be reassessed or whether there is reason to accept the data from the questionnaires instead of that from objective measurement of attention. One can hypothesize that the perception of beauty is different from where the gaze goes and lingers. However, data from newborns and infants indicate that their gazes are drawn to attractive faces.[13,14] The results of our study suggest that, although it is possible by asking a question to force a decision about the most pleasing parameters of occlusion and gingival architecture in the arrangement of a smile, the impact on facial attractiveness should be assessed more behaviorally.[6,10]

We offer the hypothesis that the results of our study were due to the use of static images of well-balanced faces after orthodontic treatment was completed. We speculate that without a marked deviation of some facial feature from the norm, visual attention in a nonsocial setting is not directed to any particular facial feature. Variations in oral presentation—that is, occlusion and gingival architecture—are so minor in well-balanced faces after orthodontic treatment as to warrant only cursory attention.

Finally, the results from our study might have been influenced by the use of static images. Sarver and colleagues[32] have proposed that digital videography be a component of orthodontic records used in treatment planning. Dynamic interactions and facial expressions could be examined in future research by tracking eye movements while participants viewed video displays.

## CONCLUSION

Viewers' first visual fixation on static images of well-balanced faces after orthodontic treatment was completed do not preferentially go to any single facial feature. The mouth, even in smile images, attracts only a small part of visual attention when viewers look at images of well-balanced faces. ■

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