

Article

Influencing Factors on Aesthetics: Highly Controlled Study Based on Eye Movement and the Forensic Aspects in Computer-Based Assessment of Visual Appeal in Upper Front Teeth

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Abstract: First impressions are formed by the external appearance and, in this respect, essentially by an examination of the face. In the literature, the teeth, especially the maxillary front, are among an eye-catching and sensitive area that plays a significant role in the overall evaluation of appearance. In this study, the first eye fixation of 60 subjects with different levels of dental training (layperson, trained layperson, dental student, and dentist) is recorded using an eye-tracking system, and their subsequent evaluation of the images is recorded. Ten unedited original photographs of different maxillary anterior teeth and ten subsequently edited photographs will be used to evaluate forensic aspects such as the effect of symmetry and color on the overall evaluation. The results will be used to determine which areas of the maxillary anterior are demonstrably viewed and whether knowledge of dental esthetics influences evaluation and viewing.

Keywords: eye-tracking; aesthetics; golden ratio; forensics

1. Introduction

Aesthetics is an outstanding topic in dentistry and sometimes determines essential aspects of therapy, as patients often desire an optical benefit from a dental intervention. Therefore, the selection of tooth color and shape, as well as the correction of tooth position plays a major role. To follow the light-colored and straight teeth, particularly in the anterior region [1]. This is performed by teeth whitening-bleaching-and, for example, by veneers, which are thin shells bonded to the enamel and can correct discoloration, surface irregularities, but also slight tooth misalignments and asymmetries. Another growing area of the (aesthetic dentistry) industry is the treatment of misaligned teeth with orthodontic aligner therapies. Crowns or modifications of the anterior teeth out of cosmetic aesthetics, are treatments of choice for patients who want to optimize their external appearance through dental therapy. Since the introduction of aligner therapy in 1997, there has been an increased demand for this non fixed treatment in cosmetic dentistry [2–4]. The empirical literature tries to determine criteria associated with beauty and searches for the therapy of a perfect smile. In this context, the assessment of the most frequently exposed teeth in smiling, maxillary anterior teeth region 13–23, is outstanding in the literature [1,5–7]. Hereby, the central incisor plays the dominant role for an esthetic smile. The ideal relationship between the central incisor and the lateral incisor is discussed widely in the literature. The lateral

incisor should be 1.5 mm longer, and the height of the gingival margin should be 0.5 mm below that of the canine [5]. Furthermore, the condition of the gum, the symmetrical course and the color of the gingiva are included in the assessment of an attractive external appearance, since conclusions can be drawn about the health status of the oral cavity [7]. Based on the literature another dominant criteria is the tooth color [8]. A self-report based study among young adults showed that tooth color is the decisive factor in the subjective perception of their oral health [9]. This also correlates with the increased demand for dental aesthetic corrections such as bleaching and veneer treatment. Over 77% of general practitioner's patients demanded tooth whitening and over 54% wanted a veneer treatment in recent years due to the media influence. In addition, both the color correction by a bleaching procedure and the correction by ceramic shells adhesively bonded to the natural enamel have become very popular [10]. The influence of appearance by exposing the maxillary anterior teeth during social interaction leads to an evaluation of the person vis-à-vis. Hereby, the maxillary anterior teeth give rise to an overall impression, which has been highly investigated both from a sociological as well as population-based point of view [11–13]. These results highlight the importance of oral health in terms of external appearance and potential stigma and association with social status, for example, in the case of missing teeth [8,14,15]. In order to be able to respond to the needs of the patient, generally valid criteria are sought that are perceptible to the environment and are perceived as beautiful. In this context, the assessment of a beautiful smile by laypersons, i.e., the environment of a patient, is decisive and the subject of the literature. In a systematic review of 6032 studies laypeople's assessment of smile aesthetics was analyzed to identify the most important criteria. Hereby, the central incisor and the canine were again identified as the most important teeth for an esthetic smile [16–18]. Important aspects such as symmetry and tooth positions were also noted, which, with slight deviations, nevertheless resulted in an overall positive evaluation [1,19]. The assessments of the gingiva by laypersons were inconsistent, however a high smile line with a so-called "Gummy Smile" tended to score worse [20,21]. Which regions thereby fell first into the field of vision of the laymen and which characteristics of a smiling person were crucial "in the eye fall" was not reported nor worked out in these studies.

Therefore, the aim, of the present investigation deals with the question of whether dentists, trained laypersons and laypersons have different ways of looking at teeth and, accordingly, view and evaluate the 20 images of smiling patients in different ways. It is further investigated whether a predictability of the look is possible, since the assumption is made that the expert degree has substantial influence on the way of looking and evaluating a smile. Therefore, it can be hypothesized that dentists see the problem zones that have to be treated first, whereas laypersons always look at the center.

2. Materials and Methods

2.1. Subject Group

The study included a group of sixty adults containing 15 laymen, 15 trained laymen, 15 dental students in the clinical study section and 15 dentists/experts. The group of laypersons did not show any dental reference in the professional profile.

In a 12-page power point presentation, the trained laypersons were shown basics of dental esthetics regarding gingiva, proportions and size relationships. The dental students were all at the clinical study stage and had clinical experience. The group of experts consisted of dentists who were licensed to practice dentistry.

2.2. Design

Twenty images were available for viewing and evaluation by the subjects. They were composed as follows (Figure 1):



Figure 1. Images for viewing and evaluation by the subjects.

Eleven unedited original photos of persons who had agreed to have their anterior teeth photographed were used. In each case, the region 13–23 including the gingiva was depicted and recognizable. The photos were taken using a cheek retractor, contrastor, camera (Nikon D5200, micro Nikkor Lens 105 mm, Nikon®, Tokyo, Japan) and macro flash (R1C1).

Nine edited photos: b,d,f,h,k,l,o,q,t. Picture b,j,k,q,t mirrored photos from original images a,i,p,f,h,k,l,o and and brightened photos from original images e,g,l,n (yellow saturation: 70% yellow brightness: +50%, general brightening: +5); picture d = golden section from original images c,k,o brightened and mirrored from original image n.

Each subject was placed individually and with the help of a chinrest in a fixed position in front of the viewing monitor. Calibration of the Eye Tracking System (NYAN 2.0 Eye Tracking Data Analysis Suit, LC Technologies, Inc., Fairfax, VA, USA) was performed for 15 s at a time. After a successful detection of eye movements and pupil recognition, the image sequence started automatically. The sequence always showed the unedited photo first.

Each image was projected for 8 s and the subjects' viewing patterns were recorded. Subsequently, the subjects were presented with an evaluation form containing a rating from 0–10 (VAS–visual analog scale), where 0 stood for very bad and 10 for very good. The images were played again in the same order but without a time limit for evaluation. The analysis program of the eye tracking system evaluated the first fixation point of each subject. Four points were defined (1 = central incisor, 2 = lateral incisor, 3 = canine, 4 = gum and 0 = outside the regions).

Consequently, 1200 initial fixation points and 1200 evaluations of the images were created.

2.3. Statistical Analysis

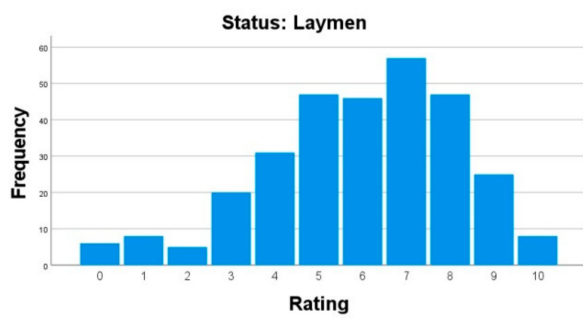
The analysis was performed with SPSS 27 (IBM, Munich, Germany) and after descriptive statistics with Kendall's tau, a regression calculation was applied to be able to determine the predictability of the first eye fixation depending on expert level, age and gender.

3. Results

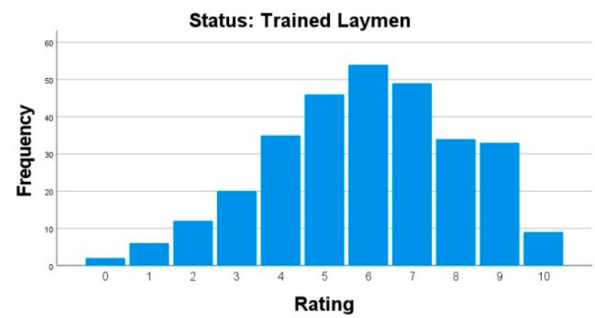
3.1. Descriptive Analysis

In the group of dentists and dental students, as among laypersons, the rating 7 was given most frequently. Overall, this rating was given 243 times out of 1200 evaluations (20.3%). The trained laypersons most frequently assigned the rating 6. This rating was the second most frequent overall (201 times, 16.8%). The group of trained laypersons showed the most stringent evaluation and chose the evaluation between 0 and 4 with 25% most frequently in the overall comparison. Only 14.3% of the dental students chose to rate the photos in the score range of 0–4, and overall, they most frequently rated the photos with above-average points (mean 6.42).

The top score of 10 was given most frequently by dental students (10 times) and least frequently by laypersons and dentists (8 times). All four groups considered image s to be the worst aesthetically (eight times 0, twelve times 1) and image o to be the most beautiful (ten times 10, nineteen times 9) with dental students giving the best rating to image number a (three times 10, two times 9). For further detail see Figures 2–4. However, no significant differences in the evaluation between the individual groups could be determined ($p = 0.013$, see Table 1). Likewise, no gender-specific significances were found. In the group of dental students and dentists, a tendency towards a better rating was found among the women; in the group of untrained laypersons, there was a reverse tendency (see Table 1).

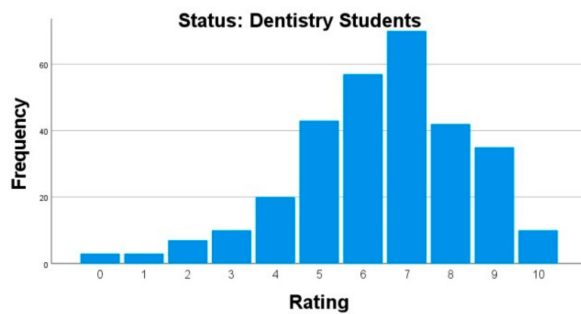


(a)

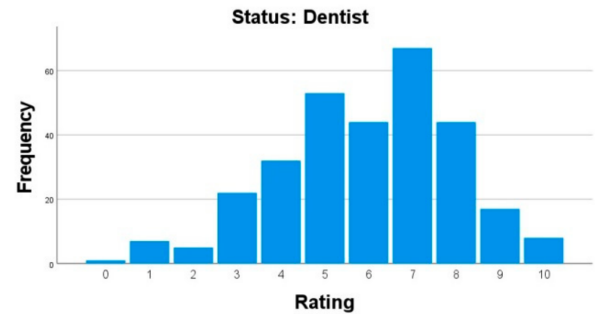


(b)

Figure 2. Evaluation of (a) laymen and (b) trained laymen.

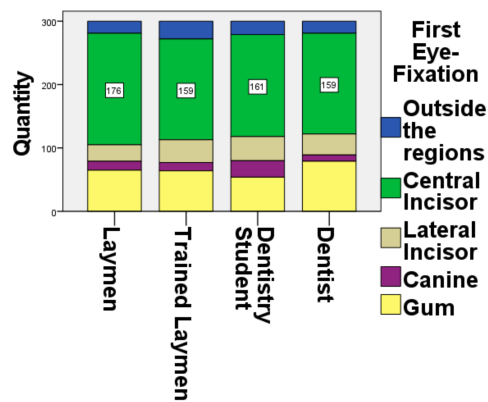


(a)

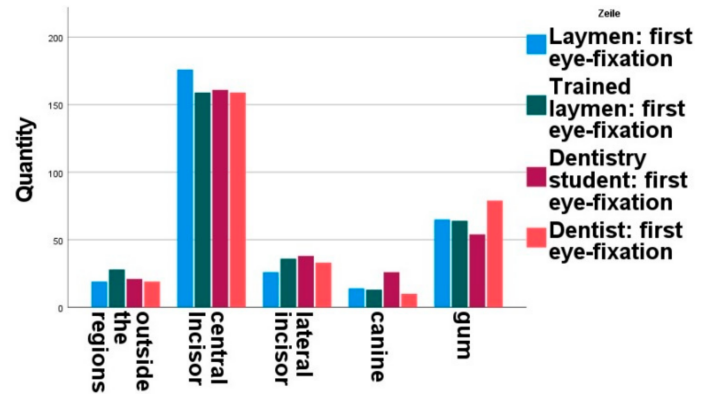


(b)

Figure 3. Evaluation of (a) dental students and (b) dentists.



(a)



(b)

Figure 4. Quantity of first eye fixation illustrated in (a) expert level group (x-axis) and (b) first eye-fixation point (x-axis).

Table 1. Kendall tau correlation.

		Correlations				
		Rating	Gender	Status	Age	First_Eyefixation
Kendall-Tau-b	Rating	Correlation coefficient	1000	−0.006	0.013	* −0.069
		Sig. (two-sided)	-	0.815	0.57	0.003
		N	1200	1200	1200	1200
	Gender	Correlation coefficient	−0.006	1000	* 0.226	* 0.212
		Sig. (two-sided)	0.815	-	<0.001	<0.001
		N	1200	1200	1200	1200
	Status	Correlation coefficient	0.013	* 0.226	1000	* −0.27
		Sig. (two-sided)	0.57	<0.001	-	<0.001
		N	1200	1200	1200	1200
	Age	Correlation coefficient	* −0.069	* 0.212	* −0.27	1000
		Sig. (two-sided)	0.003	<0.001	<0.001	-
		N	1200	1200	1200	1200
	First_Eyefixation	Correlation coefficient	* −0.069	0.023	0.033	−0.028
		Sig. (two-sided)	0.003	0.391	0.173	0.266
		N	1200	1200	1200	1200

* The correlation on level 0.01 is significant (two-sided).

3.2. Ordinal Regression

The ordinal regression should provide information on how the variables behave depending on the first point of view. Therefore, a step wise regression model was performed. The first fixation point as the dependent variable was compared with the independent variables, gender, age and status. The regression model is not significant ($p = 0.076$) and thus the null hypothesis cannot be rejected (Table 2). The corrected R-squared is $R = 0.003$, and only age shows significance with negative correlation ($p = 0.03$). Consequently, older subjects predictably looked more often at the regions outside the displayed structures ($=0$).

Table 2. Regression.

	Non-Standardized Coefficients		Standardized Coefficients		95.0% Confidence Intervals for B		
	Reg. Coefficient B	Std.-Mistake	Beta	T	Sig.	Lower Limit	Upper Limit
Constant	1.875	0.172	-	10.874	<0.001	1.537	2.213
Gender	0.117	0.085	0.043	1.379	0.168	−0.05	0.284
Status	−0.013	0.041	−0.011	−0.302	0.763	−0.094	0.069
Age	−0.067	0.031	−0.075	−2.176	0.03	−0.128	−0.007

Dependent variable: First_Eyefixation.

4. Discussion

This study investigated the first point of view of the four groups of subjects in order to identify a possible difference in the approach and definition of aesthetics between laypersons and experts in this field. The methodology used was the eye-tracker described in the literature, which is non-invasive and harmless to the health of the subjects due to corneal reflection using infrared light [22,23]. In the study by Yamamoto et al. [24], 47 laypersons were shown intraoral images of teeth with and without restorations and the gaze points and duration of each were evaluated with an eye-tracker. The restorations were subsequently inserted into photographs of the mouth-closed and mouth-opened condition using an editing program. This was done only on one side in each of the four quadrants and did not fit aesthetically into the overall image. Consequently, a sequence of images was created, showing unprocessed photos and photos with non-aesthetic restorations. The first fixation point in the images shown with restorations was significantly more often detectable first on the restoration and the viewing of the restoration was additionally of longer duration. No difference in viewing time was observed in the photos without non-esthetic restorations [24]. In contrast in the present study design, also the identification

of the difference between laypersons and experts, who could have different approaches to the observation due to their level of experience, should be performed. The hypothesis that experts pay more attention to the “problem area” and laypersons primarily look at the central incisor cannot be confirmed.

The literature, on the other hand, shows a clear tendency for the dominant viewpoint, regardless of gender and age, to be the anterior region, with particular emphasis on the central incisor [25,26]. In our study, the photos did not allow any conclusions to be drawn about the gender of the model, whereas in the study by Baker et al. [23], only male faces, showing the whole face, were provided for the viewing analysis and a difference was found between women and men when viewing. Women were significantly more likely to have viewing points in the eye region, whereas men had viewing points in the mouth region [23]. No gender difference could be identified in the results of the study presented here. In general, the central incisor could be identified as the dominant first consideration point in all four subject groups, which is reflected in the literature [26]. The evaluation of the images also confirmed the literature, which places an emphasis on color in dental esthetics, with white teeth being perceived as significantly more beautiful [5,8]. The highest rated photo, number o, was subsequently lightened. Only the group of dental students also showed outstandingly good ratings for image number a, which was not lightened but corresponded to the unprocessed original. Photo number s, on the other hand, which was rated the worst of all the groups of test subjects, showed a prosthetic restoration in the region of the central incisor in region 21. Compared to tooth 11, this crown appeared incisally shortened and heavily discolored in the area of the crown margin.

Consequently, the literature results are confirmed, which entails an immediate focus of the eye in esthetically restrictive restorations [24]. The overall socio-psychological image of a person is clearly influenced by the oral area and especially the teeth and their aesthetics. Furthermore, teeth play a crucial role in the well-known first impression. The present study was able to show that the assessment and evaluation of aesthetics takes place independently of experience level, gender, or age and no occupational context needs to exist to perceive certain oral characteristics positively or negatively and to fix them visually. The clinical aspect in the treatment of anterior teeth should have a focus on symmetry and color, which is associated with more positive evaluations as proven in our study. The esthetically sensitive facial area of the maxillary anterior region requires special consideration regarding the selection of the restoration and its design.

Both an accomplished expert and laypersons make quick evaluations based on presumed universally valid criteria. An appearance associated with “health” is also proven to be a factor for positive evaluation, reflected in healthy gingiva and a light tooth color. This is also shown in the literature and implies a positive effect considering the first appeal [27]. The dwell time of the eye gaze, as well as a uniform subject selection in gender and age, as well as experience level in the occupational field, would be worth considering for follow-up studies.

5. Conclusions

The evaluation of the data shows that there is no demonstrable difference in the approach and evaluation at different expert levels. The null hypothesis that dentists have a different approach to the evaluation or assessment of their counterpart can therefore not be confirmed. A general focus in the first eye fixation can be detected on the central incisor, which is in line with the existing literature. Overall, a generally valid ideal of beauty can be derived in the evaluation of the 20 images, which places color and symmetry in the foreground, despite differing levels of knowledge depending on the expert level. Lighter and symmetrical anterior teeth tend to be rated better. Individual deviations from the golden ratio are nevertheless perceived as aesthetic and still allow the statement that beauty is in the eye of the beholder.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data from this study were part of the dissertation paper from F.B. Data can be seen in Tables 1 and 2.

Conflicts of Interest: The authors declare no conflict of interest.

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