An Objective Assessment of the Contribution of Dental Esthetics and Facial
Attractiveness in Men via Eye Tracking

THESIS

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Abstract

Recently a greater emphasis has been placed on smile esthetics in dentistry, but the question remains at what point a malocclusion becomes noticeable to a lay person, and in what way can this be assessed in an objective manner in men? Eye tracking has been used to objectively evaluate attention to the dentition (mouth) in female models with varying levels of esthetics quantified by IOTN aesthetic component level. Objective: To ascertain the visual attention to the mouth in men with varying dental esthetics (IOTN-AC levels) and background attractiveness, for both male and female raters, using eye-tracking.

Methods: Male facial images rated as unattractive, average, and attractive were digitally manipulated and paired with validated oral images, IOTN levels 1 (no treatment need), 7 (borderline definite treatment need) and 10 (definite treatment need). Following the completion of a power analysis and IRB approval, sixty-four participants meeting the inclusion criteria were included in the data analysis. Each participant was calibrated in the eye tracker and randomly viewed the composite images for 3 seconds, twice for reliability.

Results: Reliability was good-excellent at the eye, nose, and mouth (ICC: 0.6-0.9). Significant interactions were observed with factorial repeated measures ANOVA and the Tukey Kramer method, for density and duration of fixations in the interactions of:

model attractiveness by area of the face ($p < 0.0001$, 0.0001), dental esthetics (IOTN) by area of the face ($p < 0.0001$, 0.0001), and rater gender by area of the face (p : 0.0166 , 0.0290). For area by attractiveness, the hierarchy in unattractive and attractive models was eye, mouth, and then nose. For average attractiveness however the mouth exceeded eye and nose, and there was a significant difference of visual attention to the mouth versus unattractive and attractive men. For dental esthetics by area, at IOTN7, the mouth had significantly more visual attention than at IOTN1 and became significantly more than the nose. At IOTN 10, the mouth again received significantly more visual attention than IOTN7, as well as surpassing the nose and eye. These findings were not considering facial attractiveness levels. For rater sex by area, In density women showed significantly more attention to the eye than men, and only men showed more attention to the mouth over the nose. Overall, findings were inconsistent with studies in women which showed that the most visual attention to the mouth was in models of the highest facial and lowest dental attractiveness. In men more attention was given to the lowest dental attractiveness even to a greater degree than in women, and this was irrespective of facial attractiveness.

Conclusions: 1.) In men of average facial attractiveness the hierarchy of visual attention diverged from convention (eye, mouth, nose) and was mouth = eye, nose. Visual attention to the mouth was the greatest in men of average facial attractiveness. 2.) In borderline dental esthetics (IOTN7) the eye and mouth are statistically indistinguishable, but in the most un-esthetic dental attractiveness level (IOTN10), the mouth exceeds the eye. Thus, a significant malocclusion does significantly attract and affect visual attention in men. 3.) Male and female raters showed differences in their

visual attention to male faces. 4.) Lay people have significant visual attention attracted to poor dental esthetics in men, and this is irrespective of background attractiveness, which is counter to what is seen in women.

Dedication

This thesis is dedicated to my loving husband, daughter, and parents for all of their support and understanding throughout all of the years in my academic career.

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Table of Contents

Abstract.....	ii
Dedication	v
Acknowledgments	vi
Vita.....	vii
Table of Contents.....	viii
List of Tables	ix
List of Figures.....	x
Chapter 1: Introduction.....	1
Chapter 2: Materials and Methods.....	21
Chapter 3: Manuscript	33
Chapter 4: Conclusions	61
Appendix A: Tables and Figures	62
Complete References	81

List of Tables

Table 1. Reliability of Measures- Areas of Interest.....	66
Table 2. ANOVA Summary for Density (Total # of Fixations)	67
Table 3. ANOVA Summary for Duration (Total Fixation Time)	68
Table 4. Density- Attractiveness by Area -Differences of Least Squares Means.....	69
Table 5. Density- Attractiveness by Area- Raw and Log Summary Data	70
Table 6. Density- Dental Esthetics by Area- Differences of Least Squares Means.....	71
Table 7. Density- Dental Esthetics by Area- Raw and Log Summary Data.....	72
Table 8. Density- Area by Rater Gender- Differences of Least Squares Means.....	73
Table 9. Density- Area by Rater Gender- Raw and Log Summary Data.....	74
Table 10. Duration- Attractiveness by Area- Differences of Least Squares Means.....	75
Table 11. Duration- Attractiveness by Area- Raw and Square Root Summary Data.....	76
Table 12. Duration- Dental Esthetics by Area- Differences of Least Squares Means.....	77
Table 13. Duration- Dental Esthetics by Area- Raw and Square Root Summary Data....	78
Table 14. Duration- Area by Rater Gender- Differences of Least Squares Means.....	79
Table 15. Duration- Area by Rater Gender- Raw and Square Root Summary Data.....	80

List of Figures

Figure 1. Example of IOTN-AC rating and validation slide	63
Figure 2. Example of Composite image	64
Figure 3. Example of Composite image mapped with eye tracking data	65
Figure 4. Example of eye tracker setup	66
Figure 5. Density- Area by Facial Attractiveness	69
Figure 6. Density- Dental Esthetics by Area	71
Figure 7. Density- Area by Rater Gender	73
Figure 8. Duration- Area by Facial Attractiveness	75
Figure 9. Duration- Dental Esthetics by Area.....	77
Figure 10. Duration- Area by Rater Gender	79

Chapter 1: Introduction

In recent years an increased emphasis has been placed on esthetics in dentistry. Samorodnitzky-Naveh et al. in a 2007 study on patient satisfaction with dental esthetics, concluded that dentists should plan treatment that not only considers functional but also esthetic objectives, as most participants indicated that they were interested in improving the appearance of their teeth.¹ This increased emphasis on esthetics can translate into increased attention and awareness of the dentition by the lay population. With the general population becoming more aware of the dentition, the question arises as to the importance of the teeth in the overall context of an individual's personal interactions.

Shaw and Shaw et al. were some of the first to try to understand the effect of dental esthetic alterations and malocclusions, and the way in which it would affect how people are judged. They conducted a series of studies asking, what influence does dentofacial appearance have on the social attractiveness of young persons? The first in 1981, looked at perceptions of peers and adults on 11 year old children with missing incisors, prominent incisors, crowded incisors, a repaired cleft lip, and normal incisors. The questions asked were based on the perceptions of these modified images in regards to their ability to be a friend, good looking, intelligent, or be aggressive and start fights. What he showed was that in general those with normal incisors were judged to be more desirable as friends, better looking, more intelligent and less aggressive. They concluded

that “there is evidence to suggest that dentofacial anomalies of sufficient severity can mar a child’s facial attractiveness and represent an important social disadvantage. It is therefore reasonable for a parent to have concern over correcting dentofacial anomalies in their children”.²

In the second 1985 study, they looked at the same dental conditions, but with young adults. Here they showed that while background facial attractiveness was more important than the dental condition, young adults with a normal dental appearance (normal incisor relationship) were judged more socially attractive over a range of personal characteristics (friendly, extrovert, social class, compliant, popular, fun, honest, kind, intelligent, and sexually attractive).³ These studies support the influence of dental esthetic issues on the way in which people are judged. One must have some caution in this interpretation and its generalizability across cultures as this study was done in a British population.

Despite this however, if we consider why people seek treatment it has been shown that most individuals seek orthodontic treatment primarily to improve esthetics. Wedrychowska-Szulc and Syrynska in 2010 examined patient’s and parents motivation for seeking treatment and showed that improvements in dental esthetics was the main motivation for children, parents and adults seeking treatment.⁴

Historically, a survey study by Linn in 1966 with a 13 year old male found that 80% of respondents across different social classes would have the parents pay to straighten his teeth rather than buy a house they had been saving for.⁵ Another study by Lewit in 1968 showed that 50% of patients in a good occlusion group still had a high

desire for orthodontic treatment based on feeling their teeth were “crooked” or “buck”, and parents motivation for treatment was the most powerful single factor in the desire for treatment.⁶ A questionnaire study in a British population by Fleming investigating the motivation for orthodontic treatment showed that 87% of patients were concerned about the appearance of their teeth, with the chief complaint being the “crookedness” of the incisors.⁷ Although a longitudinal study by Tatarunaite et al. in 2005 showed that orthodontic treatment improves dental appearance, it does not necessarily make a person more attractive in the long term. They do however place merit on the positive effect of orthodontic treatment, especially in males with lower levels of facial attractiveness in childhood.⁸ Overall it is clear that the general population feels that dental esthetics are important, and they also have an influence on psychosocial judgements. This makes understanding ideal dental esthetics a key to a practitioner being able to deliver the most esthetic result for their patient.

Over the years numerous studies have been conducted to explain what is an esthetic and visually pleasing smile. Generally speaking however, these studies have been subjective, meaning they directed the raters’ attention to the dentition. They have also used a specific perspective (lower face only, mouth only, or full face views) with one of several rating groups (lay persons, dental professionals, and different sexes, etc.).⁹⁻¹² The aims in these studies have been to determine what the raters found most esthetic and what deviations from ideal were acceptable.

Ong et al. in 2006 looked at numerous anterior dental esthetic characteristics (alignment, color, shape, size, tooth and dentition proportions, and gingival contour and

color) as rated by peers to determine which features impacted dental attractiveness. They showed that no single feature determined overall dental attractiveness, but that crown shape had the highest impact, while tooth and gingival color had the lowest impact.⁹

Ker et al. in 2008 used laypersons as raters, a lower face view, and a sexually neutral model to reliably determine ideal dental characteristics in a multitude of dental esthetic areas. They uncovered ideal thresholds for smile arc, buccal corridor, gingival display, canine and posterior crown torque, maxillary midline to face, maxillary to mandibular midline, overbite, maxillary central and lateral gingival height discrepancies, maxillary central to lateral incisal step, maxillary central crown width to height ratio, maxillary central to lateral ratio, and occlusal cant. Interestingly, this study was done on the east coast, west coast, and the midwest of the United States, with minimal U.S. geographic influence on esthetic preferences (except for the west coast preferring a broader smile).¹⁰

Witt in 2011 conducted a review on layperson's preferences of tooth related factors, and provided some insight as to ideal anterior tooth size, shape, angulation, overbite and the absence of a diastema. What was also important to note here was that there was a model gender effect. This was demonstrated by differences in the esthetic preferences for male and female models with certain dental characteristics, like unworn small teeth in women, and larger teeth in men.¹¹

A study by Geron in 2005 also provided evidence on the effect of model gender in the rating of dental features (gingival display and incisal plane inclination), but also brought attention to the fact that the gender of the rater may also be influential on the way

in which dental features are judged. In general, female models were judged more critically by both male and female raters, and they suggested that based on this finding female patients are held to a higher level of dental esthetic expectations.¹²

Vallittu studying a Finnish Population in 2006 showed that the overall appearance of a person's own teeth was more important to women than men. Additionally, they demonstrated differences based on age, with younger populations placing more weight on the appearance and color of their teeth.¹³ This study again brought into question the effect of culture/nationality on the perception of dental esthetics, as it was in a Finnish population. While a review by Langlois et al. in 2000 concluded that there is strong agreement both within and across cultures about who is and is not attractive based on facial esthetics¹⁴, dental esthetics may or may not follow this same convention.

That question was further addressed by McLeod et al. in 2011. This study used the same protocol as the study by Ker et al.¹⁰ to determine esthetic thresholds of different dental features but applied this in a Canadian population and compared the outcome to the U.S. population. They provided evidence that there were cultural differences in the perceptions of dental esthetics.¹⁵

Consideration must also be given to the dental experience of the raters in these experiments. Are there differences between the perceptions of the lay population and dental or orthodontic professionals regarding dental esthetics? Kokich et al., in a series of studies in 1999 and 2006, addressed this question. They investigated initially symmetric dental alterations, where they showed that laypersons tended to not recognize these alterations.¹⁶ In the follow up study with asymmetric dental alterations they

showed that in some areas like crown length, orthodontists were the most discriminating, followed by dentists and laypersons. Overall though, the asymmetric dental alterations were deemed unattractive to the dental professionals and the laypersons. They also demonstrated that in general, female raters were more critical, although the sex effect was not statistically significant here.¹⁷ In 2007 Pinho et al. added further support for different perceptions in different groups with asymmetric dental alterations, for maxillary central incisor gingival margins, and a dental midline shift. Again, the orthodontists and prosthodontists were less tolerant of these deviations than the layperson.¹⁸

It is interesting to see, however, that some esthetic areas may not be viewed differently by dentists and laypersons. For example, Parekh et al. in 2006 showed that when looking at a dental only view, both laypersons and orthodontists preferred minimal buccal corridors and a smile arc that paralleled the lower lip. Additionally, he showed that there were slight differences for the model gender in the ratings, but again there were no significant differences between male or female, orthodontist or layperson raters.¹⁹ Zange et al. in 2011, on the other hand, showed that with laypersons and orthodontists evaluating buccal corridors in long and short faced models, there was a difference in the preferences of laypersons versus orthodontists, and that overall like Kokich¹⁷ showed, female evaluators were more critical.²⁰ In this study with long and short faced individuals, the factor of the full face in the esthetic perceptions may be the reason that different results were seen. Overall, it appears that the level of dental knowledge (layperson versus dentist) and rater and model sex may play a role in dental esthetic preferences, but the question still remains how the rest of the face factors into this puzzle.

The studies by Kokich¹⁷, Pinho¹⁸, and Parekh¹⁹ looked at dental only or circum-oral views, while Zange²⁰ was looking at the whole face perspective. Interestingly, Zange showed a different result than Parkeh for similar esthetic components (buccal corridors), suggesting the full face view does have an impact on the perception of dental esthetics. Further support for this fact can be seen in a 2004 study by Flores-Mir et al. where they showed that in a lay population, the esthetic impact of the dentition was greater in a dental only view versus a full facial view. They also showed that the gender of the rater had an impact with again men being consistently less critical than the female raters.²¹ This study however was conducted with a Canadian population, and as McCleod's study in 2011 showed¹⁵ there is a potential cultural effect on dental esthetic ratings. In a study with a US population by Springer et al. in 2011 they compared many dental esthetic variables to the study by Kerr et al.¹⁰ and showed no clinically meaningful differences in a full face versus lower face view. Additionally, there were no statistically significant differences in any of the areas, except upper to lower midlines, between the ratings of male and female raters.²²

As the full face perspective is considered, the last key to the equation that must be investigated is the background attractiveness of the model, and its possible effect on dental esthetic perceptions. Springer²² used only models considered to be of average attractiveness to try to control for this potential confounding factor. In the study by Flores-Mir²¹ the background attractiveness of the models was not quantified. Chang et al. in 2011 looked again at many dental esthetic variables (buccal corridor, smile arc, maxillary gingival discrepancy, gingival display, incisal edge display, overbite, cant,

central incisor gingival margin discrepancy, maxillary midline to face, and maxillary to mandibular midline). This study demonstrated that there were different preferences for models of different facial attractiveness, for dental variables that had a facial context- specifically, smile arc, gingival display and maxillary midline to face. Furthermore, they showed that rater gender did not have an effect, but the gender of the model did have an effect on dental esthetic preferences in the full face perspective.²³

We can see that there are definitely differences in esthetic perceptions and that dental esthetics can be influenced by a multitude of factors: culture¹⁵, background attractiveness²³, age¹³, model^{11,12,23} and rater^{12,13,21} gender, facial perspective²¹, and dental knowledge (dentist versus laypersons)^{16,18,20}. Accordingly, these are all important factors to take into consideration when investigating this subject. Additionally, a concern with many of the studies in this area has been that the subject is having their attention directed to the mouth and teeth, as the questions are regarding the mouth and teeth directly. With the goal of understanding the role of the teeth in the context of the full face, one would ideally seek a means to undertake this investigation in a more objective manner, without directing the subject's attention to the mouth and teeth, while controlling for all of these influential factors.

In order to achieve an objective measure of a person's visual attention to the face, eye tracking can be employed to record where a person is looking when they view a face. Eye tracking, or originally the study of visual attention, has been investigated for over a century.²⁴ Historically, it can be divided into three eras, the first from 1879-1920 involved the discovery of many basic eye movement features, notably size of the

perceptual span, as well as saccadic suppression and saccade latency. The second from 1930-1958 brought about more of an applied research focus along with the behaviorist movement in experimental psychology, and finally 1970 and onward saw improvements in eye movement recording systems allowing for more accurate and easily obtainable recordings.²⁵

Generally speaking, eye trackers are able to provide a quantitative measure of real time overt attention.²⁵ Based on neurophysiological and psychophysical literature the human field of view involves brief fixations over small areas of interest. These brief fixations give the perception of detail through the fovea, which can be further described by the visual angle. The visual angle allows perception through the central fovea at 1-5 degrees, allowing for detail of only a small portion of the total visual field (This would encompass 3% of a 21 inch computer screen viewed at a 60 cm distance). The majority of viewing time is spent in fixations (90%) while the remaining portion involves saccades, which are the fast eye movements to reposition the fovea, and occur when visual attention is directed to a new area.²⁴

One important assumption to remember with any purely eye tracking experiment is that attention is composed of both low level and high level functions, and people have the ability to voluntarily dissociate attention from the foveal direction of gaze. Therefore, it is assumed that attention is linked to foveal gaze direction, but understood that it may not always be.²⁴ The flow of visual information from the retina to the brain are known as visual pathways. The important neural regions in these visual pathways are the primary visual cortex (V1), which is involved in the detection of the range of stimuli, involving

orientation selection and possibly color perception. The superior colliculus, which is involved in programming eye movements and contributes to target selection for both saccades and smooth pursuits, or simply the relocation of attention. The posterior parietal complex, which is involved in fixations and the disengagement of attention. Finally, the pulvinar which helps to enhance or engage attention.²⁴

A study by Dorris et al. in 2004 looked at primates and their relationship to humans in the subjective desirability of decision making, through a behavioral task, and suggested that neurons in the area of the posterior parietal cortex (lateral intraparietal area or LIP) encode the subjective desirability of saccadic eye movements.²⁶ The activity in the LIP of the posterior parietal cortex in implementing oculomotor decisions was again supported in 2016 by Sugrue et al. They provided further support for LIP being responsible for value based choices through combining and representing a variety of information to guide eye movements or change the area of visual attention.²⁷ Simply speaking, with eye tracking we are recording the visual attention, and making the assumption that this is the area of interest that is being actively processed by the brain. Subsequently, this can be extrapolated into decision making processes by the observer as this activity in the brain can be correlated with these events.^{26,27}

Eye tracking cameras typically capture images of the eye at a sampling rate of 30 to over 1000 frames per second. Video processing software tracks the pupil with infrared or near infrared light, effectively increasing the contrast between the iris and the pupil. The location of the pupil can be very sensitive to head position, so corneal reflection along with the center of the pupil (pupil-center-corneal-reflection) are currently used to

record the relative position of the visual attention. Viewers are calibrated in the computer program to several predetermined positions by being asked to observe these areas. Typically these calibrations range from 2 point in infants and up to 9-16 point in older children.²⁸

When the data are analyzed typically it is the fixation that is used to determine visual attention. According to Salvucci and Goldberg in 2000, since little or no visual processing can occur during a saccade, and any small eye movements that occur within a fixation (drifts tremors, flicks) are irrelevant to high level analyses, fixation identification is therefore a good method to minimize the complexity of the data. This method maintains the most essential information, the fixation, for understanding cognitive and visual processing behavior.²⁹

Applications for eye tracking spread across multiple disciplines and areas of research from usability research where users are interacting with a product or service in computer software, to entertainment, online services and products^{30,31}, consumer marketing, product selection³², and even reading.³³ In a review by Liversedge and Findlay, they concluded that it has been shown through investigators of low level aspects of eye movements and reading that the “where” and “when” to look can be separate processes both psychologically and physiologically. Furthermore, even areas we do not normally relate to visual processing like auditory language processing can be studied with eye tracking, and that future research will reveal more of the cognitive processes that can be found in eye movement patterns.³³

Eye tracking and its relationship to dentistry has been a recently evolving area due to its advantage of objectivity. One of the first studies was by Hickman et al. in 2010 which looked at orthodontically treated patients with eye tracking to determine what areas of the face garner the most visual attention. What they found was that in well balanced faces of treated patients, no single area had a significantly greater amount of visual attention, and that the mouth was only a small part of the visual attention at 10%.³⁴ As Hickman only looked at patients with near ideal occlusions and profiles, no mention of background attractiveness or the gender of the models was made. Subsequently, the eye tracking attention characteristics of females with different levels of dental esthetics and background attractiveness, was reported by Richards et al. in 2015. They showed that in female models, the eyes were the most observed area followed by the mouth. As the dental attractiveness worsened, the visual attention to the mouth became statistically indistinguishable from that of the eyes. In accordance with other studies that suggested women were judged more critically,^{11,12,23} they showed that lower dental attractiveness received more attention as the facial attractiveness of the model increased.³⁵ This study looked at only 3 different dental esthetic levels as rated by the Index of orthodontic treatment need aesthetic component (IOTN-AC). These levels, 1,7, and 10 represent respectively, no treatment need, borderline treatment need, and definite treatment need.

Johnson et al. looked at some of the esthetic borderline treatment need levels (IOTN-AC levels, 3,4,5,6,7) to try and determine where the “tipping point” was for attention to move from the eyes to the mouth using a similar study design to Richards with female models. They showed that viewer sex, background facial attractiveness, and

dental attractiveness had a combined effect on the amount of attention paid to a particular facial area. The most apparent changes in attention to the mouth were found around IOTN 7 in only the attractive female faces. Again, as shown in many other studies, female raters were more discerning. They showed more significant differences in fixation duration (total fixation time) and density (total number of fixations) between the borderline levels in the attractive female models, and that viewers were more likely to focus on the mouth than the eyes at the higher IOTN levels (lower dental attractiveness). Finally, gradually increasing attention was paid to the mouth as the IOTN approached level 7, however these differences were not statistically significant.³⁶

Most recently, Wang et al. in 2016 published an article using eye tracking to evaluate orthodontic treatment need and treatment outcome from a lay person perspective. They looked more closely at the pattern of the scanpaths from the eye tracking data, and used a support vector machine to improve the accuracy of assessing treatment need and treatment outcome by modeling eye movement characteristics. This technology was used to generalize unseen data and make data driven predictions in an effort to boost diagnostic accuracy. They looked at the scanpaths for normal or control patients, and then pre and post treatment malocclusion patients. They showed that there is a significant deviation in the scanpath of pretreatment patients compared to normal and posttreatment patients, and thus that orthodontic treatment normalizes the scanpath.³⁷

This study examined male models in the same manner that was achieved for females by Richards et al. and Johnson et al.^{35,36} This was completed in an objective manner using eye tracking. The specific aim of this project was to ascertain if there is a

point on the esthetic index of orthodontic treatment need when the severity dental esthetics between IOTN 1,7 and 10, will be enough to begin to attract visual attention in male faces of different background attractiveness. In regards to visual attention, we looked at the area of the most frequent fixations (density), and the area of the greatest duration of fixations (duration). We investigated if the background attractiveness level, attractive, average, or unattractive had any effect on the visual attention to dental esthetics. Also, we looked at if the sex of the rater had any effect on visual attention. Finally, we made comparisons to previous studies with female models and borderline IOTN levels to see if there were any differences for male models. Future research in this area could help to make the connection between the potentially negative judgements made of people based on a significantly un-esthetic occlusion and the visual attention to the malocclusion.

Hypotheses:

Ho1: The level of dental attractiveness (IOTN 1,7,10) will not affect the visual attention in males via eye-tracking, as determined through both the duration of fixations (total time) and the density of fixations (total number) to the mouth.

Ho2: The background attractiveness of the model will not affect the visual attention via eye-tracking to the mouth as determined through density and duration of fixations.

Ho3: When compared with existing data on females the sex of the model (male versus female) will not affect the visual attention via eye-tracking to the mouth as determined through density and duration of fixations.

Ho4: The sex of the rater will not affect the visual attention via eye-tracking to the face of male models as determined through density and duration of fixations.

Ho5: When looking at previous data for males of borderline dental attractiveness (IOTN 3,4,5,6), these borderline levels will have no effect on the visual attention via eye-tracking to the mouth as determined through density and duration of fixations.

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Chapter 2: Materials and Methods

Preliminary steps:

The first step for the development of this project was to obtain models for background facial images to be used in the study. Potential models were recruited in a University setting populated by numerous students, and any individual who was willing to volunteer to participate was allowed to do so. Those who volunteered completed a photograph release consent form. Two frontal full face images were obtained for each consenting individual (Canon EOS DIGITAL REBEL XT camera, Melville, New York), one social smile where the participants did show the teeth and one with no teeth visible. This enabled background attractiveness to be rated from the image without teeth, to avoid the potential that the facial attractiveness of the model would be affected by their dentition. The second smiling image would be used if the model was selected for the experimental portion of the study.

After images were collected, the inclusion criteria for the study were used to select the images to be used for the next step, the background facial attractiveness ratings. Models that were judged by the researchers to have a significant distraction, such as a facial tattoo, extreme facial hair or hairstyle, asymmetry, abnormal piercing, etc. were not included. The models were eighteen to thirty year old white males. Eighteen to thirty year old models were included so that this study would involve assessment by a peer

group for the experimental portion. Only white male models were used in an attempt to eliminate the variable of ethnicity, and control for sex. For ethnicity, Sharma et al. showed that different ethnicities, specifically U.S. Whites and U.S. Asian Indians, and Asian Indians, show different preferences for multiple dental esthetic features.¹ For model sex, many studies have shown an association between esthetic preferences and sex, so this factor was also controlled.²⁻⁴ Additionally, a previous study looked at female models only with similar methodology.⁵ In total 109, eighteen to thirty year old white male facial images were collected and included for overall facial attractiveness ratings.

The 109 facial images showing no teeth, were rated by peer young adults who had no background or formal education in dentistry (lay persons). Facial photos with no teeth visible were used to avoid any dental factor having an influence on the attractiveness rating of the individual. They rated these images as attractive, average, or unattractive or 3, 2, and 1 respectively. Reliability was determined by having all of the images repeated in a random order during the same rating session. Twenty raters evaluated the images and reliability was good for intrarater (weighted kappa: 0.67, 95%CI 0.64-0.70), but poor for interrater reliability (weighted kappa: 0.35, 95% CI 0.34-0.37).⁶ The poor reliability for interrater could be explained by the subjective nature of attractiveness ratings.

The images were selected based on the mean value of the ratings. The three images with the highest mean, closest to 3 were selected as attractive, the three closest to 2 were selected for average, and finally the lowest three image means were selected as the unattractive images.

The next step in the preliminary experimental procedure involved gathering the images of various levels of dental attractiveness. These were gathered by searching the database of a university orthodontic clinical archive. Frontal intraoral photos were obtained from the database. The selected images were classified in accordance with the Aesthetic Component (AC) of the Index of Orthodontic Treatment Need (IOTN) by researchers. The IOTN-AC is based on ten levels of malocclusion defined by esthetic impairment, a method that has been tested for reliability and validity by Richmond⁷ and described by Borzabadi-Farahani.⁸ Level 1 represents the least treatment need, level 7 the borderline need, and level 10 a clear need for treatment based on esthetic grounds.^{7,8} To verify the researchers' classification of the IOTN-AC level, experienced orthodontists, (15 full and part time university faculty) were surveyed to verify agreement with the level of malocclusion as defined by the IOTN-AC. The experienced orthodontists were provided a page with the standard IOTN image at the top for levels 1, 7, and 10. Six images below the standard were provided with 5 images that the researchers felt were representative of that level, and 1 image that was obviously not consistent with the IOTN level given to act as a distractor. The experienced orthodontists were then asked to eliminate any image or images that they felt were not representative of the given level (Figure 1). All images were rated twice to determine reliability. The malocclusion ratings were completed by and are as reported by Richards et al. The intrarater kappa statistic was 0.72 with 91.7% agreement and the interrater was 0.56 with 83.1% agreement for all of the images.⁵

The next step involved combining the selected background attractiveness model facial smiling images with the verified IOTN malocclusion levels. The models for each background attractiveness level were randomly combined with one of the three IOTN malocclusion levels, 1,7, and 10. In the study by Richards et al.⁵ with female images, an occlusal level for a repaired cleft lip was also included to give a factor known to draw visual attention. This was shown by Shaw in a social attractiveness study, where a repaired cleft lip consistently received the lowest ratings, making it a feature that is noticed by observers.⁹ Richards et al.⁵ however, showed that the dental esthetics levels were capable of drawing visual attention, and no further significant information was uncovered from the cleft level, so it was eliminated from this study. The composite images were created using Photoshop Elements 11 software (Adobe Systems; San Jose, CA) by removing the models existing dentition and creating a new layer for the IOTN verified esthetic level, with adjustments made for scale and color as needed. The backgrounds of all of the images were standardized with a basic gray hue, and the scale of the models head in the background was visually standardized between all of the images. In total 9 composite images were generated for each malocclusion and attractiveness level: Attractive-IOTN1, Attractive-IOTN7, Attractive-IOTN10, Average-IOTN1, Average-IOTN7, Average-IOTN10, Unattractive-IOTN1, Unattractive-IOTN7, Unattractive-IOTN10 (Figure 2). Additionally, in the previous study⁵ for female facial images, there were 2 different models for each level, to test for reliability within each dental esthetic-facial attractiveness level. In the data analysis for that study there were no significant differences for the two models at the same level. Accordingly, for this male

study only one image per level was used, as adequate reliability was established in the female study.⁵

Experimental Steps:

The 9 generated composite images, were loaded into Experiment Builder (SR Research, Mississauga, Ontario Canada) and interest areas were defined. Many interest areas were mapped including: eyes, nose, mouth, ears, eyebrows, chin, hair, and cheeks (Figure 3). To simplify the analysis the areas were classified as: eye, nose, mouth, chin, ear and other (including, hair, eyebrows, cheeks, etc.).

The eye tracking camera utilized for the experiment, Eyelink 1000 (SR Research, Mississauga, Ontario) has a reported average accuracy of 0.25 to 0.5 degrees¹⁰ for this reason, when the interest areas were mapped, some space was left between the areas, to allow for this degree of error.

IRB approval was gained before beginning the experimental part of the study (Behavioral Sciences IRB #2012B0414). Subjects were recruited on a university campus through the Department of Psychology Research Education Program (REP). The subjects recruited through the REP program were Ohio State University students enrolled in the introductory psychology course, and received credit for participating in experiments within the department (0.5 credits / 30 minutes). The goal of the program is to give them experience with a variety of techniques and procedures used in the field of psychology. They had the option to instead receive this credit through reading and writing reports on psychology research papers.

Inclusion criteria for participants were set as follows: eighteen to thirty years, able to understand English, no known neurological conditions, normal or corrected to normal color vision (no hard contact lenses), willing to attend 20-25 minute eye tracking session, no recent consumption of drugs or alcohol, no current medications that could affect cognitive abilities, and no mascara or willing to remove it as needed for the session. Dental professionals and dental students were also excluded from the study, with the intent of a lay person perspective for the study.

Written informed consent was obtained for all participants, with the option to withdraw at any time. Deception was used so the subjects were not more prone to look at the mouth, as they may if they were aware that this was a dental study. Participants were informed that this was a study to look at the way in which individuals view faces, and a debriefing form was given after the study to inform the participants of the actual nature of the study. Additionally, a short questionnaire was given which inquired about the participants, age, ethnicity, and sex.

All consenting participants were positioned in a table mounted, head stabilizing device equipped with the Eyelink 1000 eye tracking camera (Figure 4).¹¹ Each participant was calibrated on a 9 or 5 point calibration with the eye tracker, and instructed how the program would run. The eye tracking data throughout the experiment was captured using Data Viewer software (SR Research, Mississauga, Ontario Canada) which allowed for extraction of the data for first fixation, location of the longest duration, and the greatest number of fixations (density).

The nine composite male images were viewed, with 5 sample images viewed before the experimental images. The sample images were shown to give the participant a chance to familiarize themselves with the program and how it would run before any data were collected. The images were all repeated a second time in a random order for reliability. In between each image a cross was displayed in a random changing location on a blank screen to eliminate the possibility that the location of the gaze was fixed from one image to the next. Each participant viewed 23 total images for 3 seconds each

A total of 87 individuals were consented for the experiment, and 23 were excluded. 8 were excluded for the inability to calibrate them in the eye tracker, 1 was excluded for not completing the survey and demographic information, and 14 were excluded for being of a different ethnicity than Caucasian. This gave a total of 64 participants meeting the inclusion criteria, 41 of these were male, and 23 were female. The participants viewed the 5 sample images, which were not tracked, and then the 9 composite images in a random order, for 3 seconds each image. The images were all repeated a second time in a random order for reliability. In between each image a cross was displayed in a random changing location on a blank screen to eliminate the possibility that the location of the gaze was fixed from one image to the next.

Independent variables:

- Level of dental esthetics – For the experimental portion of this study, three levels of dental esthetics were selected from the Index of Orthodontic Treatment Need-Aesthetic Component (IOTN-AC). These levels 1, 7, and 10 were selected as they represented the least need for treatment at IOTN1, the highest level of borderline need at IOTN 7, and a clear need for treatment on esthetic grounds at IOTN-10.⁷
- Background facial attractiveness of the model– Non-smiling facial photographs were rated for attractiveness as, un-attractive 1, average 2, or attractive 3, as described above in the preliminary work.
- Model Sex – For this study male models were used. Female images were completed in a previous study.⁵ We used the previous study to evaluate what affect the sex of the model played in viewing faces and the effect of different malocclusions on these observations.
- Rater Sex– There have been previous studies that show some effect on the way in which male and female dental esthetic features were viewed.²⁻⁴ For this reason the sex of the rater was analyzed to see if this affected the way faces were viewed by different sexes.
- Area of observation- Six different areas were mapped and recorded: eye, nose, mouth, ear, chin and other. Other contained hair, cheeks, eyebrows, and forehead.

Dependent Variables:

- Total fixation time (Duration) – The duration of all of the fixations in each of the six interest areas (eye, nose, mouth, chin, ears, and other) in ms were recorded. Fixation times can vary depending on the task being performed, and it has been shown that longer mean fixation times can be found in more difficult tasks, but generally individual fixations last from 50 to 700 ms.¹² If multiple fixations occurred within the three second viewing time the results were cumulative, as well as with bilateral structures like the eyes or ears, the total time in ms was summed for both structures.
- Total number of fixations (Density) –The total number of times a fixation occurred in one of the interest areas was recorded. These again were summed for bilateral structures, and for the duration of the three second viewing period.

Statistical Analysis and sample size determination

Sample size and power analysis were completed. For male composite images, sample size and power were determined using data from the Richards et al.⁵ study as follows: two outcome variables were of interest: area of maximum number of fixations (density); and area of maximum duration (duration). Assuming a correlation of 0.4, for area of maximum number of fixations (density), assuming a standard deviation of 2.178 observations⁵, a sample size of 64 subjects would enable detection of a mean difference of 1.0 with a power of 0.91. With a sample size of 64 subjects and assuming a standard deviation of 687.3 milliseconds⁵, a difference of 300 milliseconds could be detected for area of maximum duration with a power of 0.88. All power calculations were based on a non-directional alpha risk of 0.05

The results were analyzed with factorial repeated measures Analysis of Variance (ANOVA). This analysis was used to reveal statistically significant interactions ($p < 0.05$) between the independent variables: level of dental attractiveness (three levels: IOTN1, 7, 10), background attractiveness (three levels: unattractive, average and attractive), rater sex (two categories: male and female), and area of the face (3 categories in 2, 3 and 4-way analyses: eye, mouth, and nose). Tukey-Kramer post hoc testing was used for multiple comparisons. A log scale was used for density means, and square root for duration means to transform the data and achieve a better fit of the respective models.

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Chapter 3: Manuscript

An objective assessment of the contribution of dental esthetics and background facial
attractiveness in men via eye tracking

Robin S. Baker

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Abstract

Recently a greater emphasis has been placed on smile esthetics in dentistry, but the question remains at what point a malocclusion becomes noticeable to a lay person, and in what way can this be assessed in an objective manner in men? Eye tracking has been used to objectively evaluate attention to the dentition (mouth) in female models with different levels of dental esthetics quantified by the IOTN aesthetic component.

Objective: To ascertain the visual attention to the mouth in men with different levels of dental esthetics (IOTN-AC levels) and background facial attractiveness, for both male and female raters, using eye-tracking.

Methods: Male facial images rated as unattractive, average, and attractive were digitally manipulated and paired with validated oral images, IOTN levels 1 (no treatment need), 7 (borderline of definite treatment need) and 10 (definite treatment need). Sixty-four raters meeting the inclusion criteria were included in the data analysis. Each rater was calibrated in the eye tracker and randomly viewed the composite images for 3 seconds, twice for reliability.

Results: Reliability was good-excellent at the eye, nose, and mouth (ICC: 0.6-0.9). Significant interactions were observed with factorial repeated measures ANOVA and the Tukey Kramer method, for density and duration of fixations in the interactions of: model facial attractiveness by area of the face ($p < 0.0001$, 0.0001), dental esthetics (IOTN) by area of the face ($p < 0.0001$, 0.0001), and rater gender by area of the face (p : 0.0166 , 0.0290). For area by facial attractiveness, the hierarchy of visual attention in unattractive and attractive models was eye, mouth, and then nose. In the hierarchy for

men of average attractiveness, however, the mouth exceeded eye and nose. There was a significant difference in visual attention to the mouth in average versus unattractive and attractive men. For dental esthetics by area, at IOTN7, the mouth had significantly more visual attention than at IOTN1 and became significantly more than the nose. At IOTN 10, the mouth again received significantly more visual attention than IOTN7, as well as surpassing the nose and eye. These findings were irrespective of facial attractiveness levels. For rater sex by area in visual density, women showed significantly more attention to the eye than men, and only men showed significantly more attention to the mouth over the nose. Overall, findings were inconsistent with studies in women where the most visual attention to the mouth was in models of the highest facial and lowest dental attractiveness. In men, more visual attention was given to the lowest dental attractiveness even to a greater degree than in women, and this was irrespective of facial attractiveness.

Conclusions: 1.) Visual attention to the mouth was the greatest in men of average facial attractiveness, irrespective of dental esthetics. 2.) In borderline dental esthetics (IOTN7) the eye and mouth are statistically indistinguishable, but in the most un-esthetic dental attractiveness level (IOTN10), the mouth exceeds the eye. Thus, the most un-esthetic malocclusion does significantly attract and affect visual attention in men. 3.) Male and female raters showed differences in their visual attention to male faces. 4.) Lay persons have significant visual attention attracted to poor dental esthetics in men, and this is irrespective of background facial attractiveness, which is counter to what is seen in women.

Introduction

In recent years, an increased emphasis has been placed on esthetics in dentistry. It has been suggested that dentists should plan treatment that not only considers functional but also esthetic objectives, as most participants indicated that they were interested in improving the appearance of their teeth.¹ This emphasis on esthetics can translate into increased attention and awareness of the dentition by lay persons.

Shaw and Shaw et al. were some of the first to begin to understand the effect of dental esthetic alterations and the way in which it would affect how people were judged. They showed that in general, 11 year old children with normal incisors were judged to be more desirable as friends, better looking, more intelligent and less aggressive.² In a second study with young adults they showed that while background facial attractiveness was more important than the dental condition, young adults with a normal dental appearance (normal incisor relationship) were judged more socially attractive over a range of personal characteristics.³

“Does having a less than ideal smile affect the way people act and live?” This question was examined by the American Dental Association’s Health Policy Institute in 2015.⁴ Using an online survey conducted by the Harris Poll, 14,962 responses from a randomly selected study group of individuals, ages 18 and older were analyzed. Twenty-nine percent of low income adults and 28% of young adults (18-34) believed the appearance of their mouth and teeth affects their ability to interview for a job. Twenty-five percent of all adults avoid smiling, 23% feel embarrassed and 20% experience anxiety due to the condition of their mouth and teeth. Low income and young adults

were shown to feel the greatest impact with a minimum of 30% in each of these two groups indicating a problem very often or occasionally. Finally, 82% of all responders agreed, “It is easier to get ahead in life if I have straight, bright teeth.” Overall, it is clear that the general population feels that dental esthetics are important,⁴⁻⁷ and they also have an influence on psychosocial judgements.^{2,3,8,9} This makes understanding ideal and acceptable dental esthetics a key to a practitioner being able to deliver an esthetic result for their patient.

Other studies have been conducted to explain what is an esthetic and visually pleasing smile. The aims in these studies have been to determine what the raters found most esthetic and what deviations from ideal were acceptable. They have used a specific perspective (circumoral only, lower face only, or full face views) with one of several rating groups (lay persons, dental professionals, and different sexes).¹⁰⁻¹³ Generally speaking however, these studies may have been biased because they directed the raters’ attention to the dentition.

Through these studies many important confounding factors have been uncovered. A model sex effect has been shown that affects different preferences in dental esthetic characteristics.^{12,14} Also, In general, female models have been shown to be judged more critically.¹³ Further, the sex of the rater may also be influential on the dental esthetic ratings made.^{13,15,16}

Consideration must also be given to the dental experience of the raters in these experiments. A number of studies have demonstrated that dental professionals tend to be more critical of dental esthetic aberrations than the lay population,¹⁷⁻¹⁹ although this is not

always the case.^{20,21} Additionally, the perspective that the raters are viewing the model in may be important.^{16,22}

When a full face perspective is used the background facial attractiveness of the model, and its possible effect on dental esthetic perceptions must also be considered. Chang et al. in 2011 looked at many dental esthetic variables and demonstrated that there were indeed different preferences for models of different facial attractiveness for dental variables that had a facial context.¹⁴

It is evident that there are individual differences in esthetic perceptions and that dental esthetics are influenced by a multitude of factors. With the goal of understanding the role of the teeth in the context of the full face, one would ideally seek a means to investigate this issue in a more objective manner.

In order to achieve an objective measure of a person's visual attention to the face, eye tracking can be employed to record where a person is looking when they view a face. Eye trackers are able to provide a quantitative measure of real time overt visual attention.²³ The majority of viewing time is spent in fixations (90%) while the remaining portion involves saccades, which are the fast eye movements to reposition the fovea, and occur when visual attention is directed to a new area.²⁴

Eye tracking cameras use video processing software to track the pupil with infrared or near infrared light, and corneal reflection along with the center of the pupil (pupil-center-corneal-reflection) is used to record visual attention. Viewers are calibrated to several predetermined positions prior to viewing the images.²⁵ When the data are analyzed typically it is the fixation that is used to determine visual attention. This

method maintains the most essential information, the fixation, for understanding cognitive and visual processing behavior.²⁶

Eye tracking, and its relationship to dentistry has been a recently evolving area due to its advantage of objectivity. Hickman et al. in 2010 showed that in well balanced faces of orthodontically treated patients, no single area had a significantly greater amount of visual attention, and that the mouth was only a small part of the visual attention at 10%.²⁷ Subsequently, the eye tracking characteristics of female models with different levels of dental esthetics and background facial attractiveness, were reported by Richards et al. in 2015.²⁸ As a follow up to this study, Johnson et al. looked at some of the esthetic borderline IOTN treatment need levels in women.²⁹

Wang et al. in 2016 showed that there was a significant deviation in the scanpath of pretreatment patients compared to normal and posttreatment patients, and that orthodontic treatment normalizes the scanpath.³⁰

The current study examined male models in the same manner as Richards et al and Johnson et al.,^{28,29} using eye tracking. The specific aim of this study was to ascertain if there was a point on the Index of Orthodontic Treatment Need- Aesthetic Component (IOTN-AC) when the severity of dental esthetics would be enough to attract the majority of visual attention in male faces. A secondary aim was to determine whether background facial attractiveness level, (attractive, average, or unattractive) or the sex of the rater, had any effect on the visual attention to dental esthetics.

Materials and Methods

Preliminary steps:

The first step for the development of this project was to obtain models for background facial images to be used in the study. Potential models were recruited in a university setting. Two frontal full face digital images were obtained for each consenting individual (Canon EOS DIGITAL REBEL XT camera, Melville, New York), one social smile where the participants did show the teeth and one with no teeth visible. Facial attractiveness was rated from the image with no teeth visible, to avoid the potential that the facial attractiveness of the model would be affected by their natural dentition.

Model images were excluded that were judged by the researchers to have a significant distraction, such as a facial tattoo, extreme facial hair or hairstyle, asymmetry, abnormal piercing, etc. Models were eighteen to thirty year old white men. Only white male models were used in an attempt to eliminate the variable of ethnicity,³¹ and control for sex.¹²⁻¹⁴ In total 109, eighteen to thirty year old white male facial images were collected and included for the background facial attractiveness ratings.

The images showing no teeth, were rated by peer young adults who had no background or formal education in dentistry (lay persons). They rated the images as attractive, average, or unattractive or 3, 2, and 1 respectively. Reliability was determined by having all of the images repeated in a random order during the same rating session. Twenty raters evaluated the images and reliability was good for intra-rater (weighted kappa: 0.67, 95% CI-0.64-0.70), and poor for inter-rater (weighted kappa: 0.35, 95% CI-0.34-0.37).³²

The images were selected based on the mean value of the ratings. The three images with the highest mean closest to 3, were selected as attractive; the three closest to 2 were selected for average and finally the lowest three image means were selected as the unattractive images. This provided the greatest spread between the images for the level of facial attractiveness.

Frontal facial images of various levels of dental esthetics were then selected from the database of a university orthodontic clinical archive. The selected images were classified in accordance with the Aesthetic Component (AC) of the Index of Orthodontic Treatment Need (IOTN) by researchers. The IOTN-AC is based on ten levels of malocclusion defined by esthetic impairment, a method that has been tested for reliability and validity by Richmond³³ and described by Borzabadi-Farahani.³⁴ Level 1 represents the least treatment need, level 7 the upper limit of borderline need, and level 10 a clear need for treatment based on esthetic grounds.^{33,34} To verify the researchers' classification of the IOTN-AC level, experienced orthodontists, (15 full and part time university faculty) were surveyed to verify agreement with the level of malocclusion as defined by the IOTN-AC. All images were rated twice to determine reliability. The details of this method have been previously described.²⁸ The intra-rater kappa statistic was 0.72 with 91.7% agreement and the inter-rater was 0.56 with 83.1% agreement for all of the images.²⁸

Next, the selected background facial attractiveness model smiling images were combined with the verified IOTN dental esthetic level images. The models for each background attractiveness level were drawn randomly for combination with one of the

three IOTN malocclusion levels, 1,7, and 10. Composite images were created using Photoshop Elements 11 software (Adobe Systems; San Jose, CA) by removing the models existing dentition and creating a new layer for the IOTN verified esthetic level, with adjustments made for scale and color as needed. The backgrounds of all of the images were standardized with a basic gray hue, and the scale of the models head in the background was visually standardized between all of the images. At each level of facial attractiveness, one image was created for each of the three levels of dental esthetics, for a total of 9 composite images. In a previous study with female facial images, reliability within each dental/facial attractiveness level was established, thus for this male study only one image per level was used.²⁸

Experimental Steps:

Interest areas for the 9 composite images, were defined (Experiment Builder-SR Research, Mississauga, Ontario Canada). The areas mapped were: eyes, nose, mouth, ears, eyebrows, chin, hair, and cheeks (Figure 2). To simplify the analysis the areas were classified as: eye, nose, mouth, chin, ear and other (including, hair, eyebrows, cheeks, etc.).

The eye tracking camera utilized for the experiment, Eyelink 1000 (SR Research, Mississauga, Ontario) has a reported average accuracy of 0.25 to 0.5 degrees.³⁵ For this reason, when the interest areas were mapped, some space was left between the areas, to allow for this degree of error.

IRB approval was gained before beginning the experimental part of the study (Behavioral Sciences IRB #2012B0414). Raters were recruited on a university campus.

Inclusion criteria for raters were set as follows: eighteen to thirty years old, able to understand English, no known neurological conditions, normal or corrected to normal color vision (no hard contact lenses), willing to attend 20-25 minute eye tracking session, no recent consumption of drugs or alcohol, no current medications that could affect cognitive abilities and no mascara or willing to remove it as needed for the session. Dental professionals and dental students were also excluded from the study, with the intent of a lay person perspective for the study.

Written informed consent was obtained for all raters. Deception was used so the raters were not more prone to look at the mouth. Raters were informed that this was a study to look at the way in which individuals view faces, and a debriefing form was given after the study to inform the participants of the actual nature of the study. Additionally, a short questionnaire was given which inquired about the rater's age, ethnicity, and sex.

Raters were positioned in a table mounted, head stabilizing device. Each rater was calibrated on a 9 or 5 point calibration with the eye tracker, and instructed how the program would run. The eye tracking data throughout the experiment was captured using Data Viewer software (SR Research, Mississauga, Ontario Canada) which allowed for extraction of the data- duration of fixations (total time in milliseconds spent viewing each interest area), and the density of fixations (total number of fixations in each interest area) (Figure 2).

The nine composite male images were viewed, with 5 sample images viewed before the experimental images. The sample images were shown to give the participant a chance to familiarize themselves with the program and how it would run before any data

were collected. The images were all repeated a second time in a random order for reliability. In between each image a cross was displayed in a random changing location on a blank screen to eliminate the possibility that the location of the gaze was fixed from one image to the next. Each participant viewed 23 total images for 3 seconds each.

A total of 87 individuals were consented for the experiment, and 23 were excluded. Eight were excluded for the inability to calibrate them in the eye tracker, 1 was excluded for not completing the demographic information, and 14 were excluded for being of a different race than white. This gave a total of 64 participants meeting the inclusion criteria, 41 of these were male, and 23 were female.

Statistical Analysis and sample size determination

Sample size and power were determined using data from the Richards et al.²⁸ study as follows: two outcome variables were of interest: area of maximum number of fixations (density); and area of maximum duration (duration). Assuming a correlation of 0.4, for area of maximum number of fixations (density), assuming a standard deviation of 2.178 observations,²⁸ a sample size of 64 subjects would enable detection of a mean difference of 1.0 with a power of 0.91. With a sample size of 64 subjects and assuming a standard deviation of 687.3 milliseconds and a correlation of 0.4,²⁸ a difference of 300 milliseconds could be detected for area of maximum duration with a power of 0.88. All power calculations were based on a non-directional alpha risk of 0.05

The results were analyzed with factorial repeated measures Analysis of Variance (ANOVA). The independent variables were: level of dental attractiveness (three levels:

IOTN 1, 7, 10), background attractiveness (three levels: unattractive, average and attractive), rater sex (two categories: male and female), and area of the face (3 categories: eye, mouth, and nose). Tukey-Kramer post hoc testing was utilized for multiple comparisons. A log scale transformation was used for density, and square root transformation for to achieve a better fit of the respective models.

Reliability was evaluated by repeating all of the images during the viewing session. The first viewing of the image was used for the data analysis, and the second was for the evaluation of reliability. Intrarater and interrater reliability was evaluated through Intraclass Correlation (ICC).

Results

Density was the measure of the total number of fixations in an interest area, and duration was the total time in milliseconds the observer spent viewing a given interest area. Reliability was assessed as ICC <0.40 as poor, 0.40-0.59 as fair, 0.60 and 0.74 as good, and >0.75 as excellent.³² Intra-rater and inter-rater reliability was good-excellent in the areas of eye, nose, and mouth for both density and duration of fixations (Table 1). For this reason these were the areas included in the data analysis. The reliability for the areas of chin, ear and other, had poor reliability in either density or duration, and were eliminated from the data analysis.

Density

For density, significant interactions ($p < 0.0500$), were seen for the variables of model facial attractiveness and area of the face ($p < 0.0001$), dental esthetic level and area of the face ($p < 0.0001$), and finally, area of the face and rater sex ($p = 0.0166$).

Additionally, the main effects of dental attractiveness and area of the face were also significant ($P < 0.0001$, $p < 0.0001$) (Table 2). As a reminder, model facial attractiveness was described as unattractive, average, or attractive. For dental esthetic level, IOTN 1 was no treatment need, IOTN 7 was borderline treatment need, and IOTN 10 was definite treatment need based, on the IOTN-AC.

For facial attractiveness by area of the face (Figure 3, Tables 3, 4) in men of average attractiveness, the mouth received significantly more visual attention than it did in unattractive ($p = 0.0006$) and attractive ($p < 0.0001$) men. For unattractive and attractive men the hierarchy for visual attention was the same- the greatest density at the eyes,

(attractive, $p<0.0001$ and unattractive $p=0.0061$, as compared to the mouth) followed by the mouth and finally the nose.

For dental esthetic level and area of the face (Figure 4, Tables 5, 6), with no treatment need (IOTN1) the eye received significantly more visual attention than the mouth ($p<0.0001$). For borderline dental esthetics (IOTN7), the mouth had significantly more visual attention than in IOTN1 ($p=0.0025$) and significantly more than the nose ($p=0.0075$), but was not statistically distinguishable from the eye ($p=0.3083$). At IOTN10, the mouth received significantly more visual attention than in the borderline models (IOTN7) ($p<0.0001$), and significantly exceeded the eye ($p<0.0001$) and the nose ($p<0.0001$).

For area of the face and rater sex (Figure 5, Tables 6, 7), both male and female raters showed significantly more visual attention to the eyes over the nose ($p<0.0001$, $p=0.0002$). Women showed significantly more visual attention to the eyes than men ($p=0.0225$). Male raters showed significantly more visual attention to the mouth than the nose ($p=0.0023$).

Duration

For duration, the pattern was the same as for density. Significant interactions were found in the same areas- model facial attractiveness and area of the face ($p<0.0001$), dental esthetic level and area of the face ($p<0.0001$), and area of the face and rater gender ($p=0.0290$). Additionally the main effects of dental esthetics (occlusion) and area of the face were significant ($p<0.0001$, $p<0.0001$) (Table 8).

For facial attractiveness by area of the face (Figure 6, Tables 9, 10) again significant differences were seen in duration with average attractiveness men receiving more visual attention to the mouth than unattractive ($p=0.0024$) and attractive models ($p<0.0001$). Again, the hierarchy for unattractive and attractive men was eye, mouth, nose, with the eye receiving significantly more visual attention than the mouth ($p=0.0239$ unattractive)($p<0.0001$ attractive). For average men, the hierarchy was mouth, eye, and nose (but the eye and mouth were not significantly distinguishable here) ($p=0.4024$).

For dental esthetic level and area of the face (Figure 7, Tables 11, 12), at IOTN1 the eye received significantly more visual attention than the mouth and nose ($p<0.0001$, $p=0.0018$). At IOTN7, the mouth had significantly more visual attention than in IOTN1 ($p=0.0116$), and became significantly more than the nose ($p=0.0004$), and was statistically indistinguishable from the eye ($p=0.4853$). At IOTN10, the mouth received significantly more visual attention than in IOTN7 ($p<0.0001$), as well as significantly exceeded the nose ($p<0.0001$) and the eye ($p=0.0002$).

For rater sex by area of the face (Figure 8, Tables 13, 14), again a significant difference was shown for male and female raters giving more visual attention to eyes over the nose ($p<0.0001$, $p<0.0001$), with women showing this preference to a greater degree. Additionally, male ($p<0.0001$) and female ($p=0.0201$) raters also spent significantly more of their visual time on the mouth over the nose. Overall the hierarchy here was eye, mouth, nose, for both male and female raters.

Discussion

The specific aim of this study was to ascertain if there was a point on the aesthetic index of orthodontic treatment need (IOTN-AC) when the severity of dental esthetics would be enough to attract visual attention in men with varying background attractiveness levels. This was done in a manner that accounted for many potential confounding factors that have been identified in the literature. These include: background facial attractiveness and sex of the model, sex and dental knowledge of the rater, and facial perspective.

Dental esthetic ratings were based on the Index of Orthodontic Treatment Need Aesthetic Component (IOTN-AC). This method has been tested for reliability and validity.^{33,34,36} It has received some criticism in its validity and usefulness in the evaluation of dental esthetics and subsequent classification of treatment need.^{33,36} This is often due to its comparison to the dental health component (IOTN-DHC), as IOTN-AC scores and IOTN-DHC scores can differ for the “treatment need” of an individual.³⁷ For the purposes of this study we were only evaluating the esthetic perceptions from a frontal view, and not using this to directly evaluate dental health treatment need, thus the IOTN-AC was the most reliable and valid tool to evaluate dental esthetic levels.

In this study significant interactions were found between multiple independent variables in two-way interactions. For area of the face by attractiveness in density and duration (Figures 3 and 6) with attractive and unattractive models, the hierarchy of visual attention was as would be expected based on other studies with female models: eye, mouth, nose.^{28,29} We found, however, that in average male models visual attention to the

mouth significantly exceeded that of the eye regardless of dental esthetics, which begins to provide evidence of differences between male and female models. In the study by Richards et al.²⁸ visual attention to the mouth never significantly exceeded the eye in any female model. This raises the question as to why raters looked more to the mouth in average men? One could hypothesize that viewers are more fixated on the eyes on the ends of the attractiveness spectrum, and in the middle their attention moves more freely to the mouth. Interestingly, Chang et al.¹⁴ also found in a study looking at dental esthetic variables in the context of background facial attractiveness, differences in the perceptions for average models versus unattractive and attractive models.

The next area of consideration was area of the face by dental esthetic level. Here the results for density and duration (Figures 4 and 7) were initially similar to what has been shown with female models.^{28,29} As the dental attractiveness level decreased from no treatment need (IOTN1) to borderline (IOTN7) the visual attention to the mouth became significantly greater, but did not exceed the eye. What is different in the male model is that at the definite treatment need level (IOTN10), the visual attention to the mouth significantly exceeded the eye. This is true irrespective of background facial attractiveness. In women this is not the case, mean visual attention to the mouth did not exceed the eye in density or duration at IOTN10²⁸ (at any attractiveness level).

In the last two-way interaction for male models of rater sex by area of the face, our results are consistent with those that have supported the position that the sex of the rater has an effect on dental esthetic ratings.^{13,15,16,28} It can be seen that in duration and density (Figures 5 and 8) both men and women showed significantly greater visual

attention to eyes over noses, but women showed this to a greater degree. Additionally, only male raters showed a significantly stronger preference in the density of attention to the mouth over the nose. In density alone, women showed significantly more attention to the eyes than men. One could argue that the difference in number of male and female raters could affect these findings, as ideally they would be balanced as an independent variable. While an effort was made to balance these subjects, it was not possible through the consecutive volunteer nature of raters recruited for the study.

As the gender of the model has shown an effect on dental esthetic preferences in the full face perspective, the background facial attractiveness must therefore also be evaluated further. Interrater reliability in men was poor³² for facial attractiveness (weighted kappa 0.35, 95% CI 0.34-0.37). This shows that agreement between raters was not ideal. In women on the other hand, Richards et al.²⁸ reported better agreement for interrater reliability (weighted kappa 0.51, 95% CI 0.49-0.52). Attractiveness ratings in women are fairly consistent among raters. In men however, we have found that there is less agreement between raters as to which man is and is not attractive.

In the eye tracking studies with women,^{28,29} significant interactions were found for the three- way interaction of facial attractiveness, by area, by dental esthetics. The significant interactions here were found to be mostly among women of attractive facial esthetics. It was thus concluded that the disharmony between facial and dental esthetics (low dental esthetics and high facial esthetics) was the reason for the increased visual attention to the mouth in these attractive women. More attention is given to attractiveness in women and it has been shown that it can be evaluated across many raters with more

consistency.²⁸ The three-way interaction was not significant in men however. The lack of agreement between raters on facial attractiveness may explain why this interaction was not found in men. Male attractiveness is simply less well defined with the result being that all men could benefit from treatment when the treatment need was definite.

In contrast to reliability for facial attractiveness the reliability of the areas of the face were consistent with previous studies,^{28,29} with good-excellent reliability for the areas of eye, mouth, and nose. But reliability in men for density or duration at ear, chin, and other was poor and therefore not analyzed.

An earlier study implied the benefits of orthodontic treatment are greater in men of lower levels of facial attractiveness.³⁸ Those investigators concluded that a positive effect on facial attractiveness was observed in orthodontically treated men, especially those with lower initial facial attractiveness scores. A greater benefit was seen in men with lower facial attractiveness, which may imply that in men, the attention to an un-esthetic dentition is more pronounced, as it did not follow the disharmony in facial and dental esthetics like in women.^{28,29}

Kerosuo et al. has shown that with three grades of background facial attractiveness, like in the present study, incisal disarrangement corresponded to a one step drop in the facial attractiveness of the model, compared to the same face with a normal occlusion.³⁹ An argument could be made that the background attractiveness of the model was therefore modified within the experiment. Regardless of this however, our results show that background attractiveness did not play a factor in the increased visual attention

to the most unesthetic dentition (IOTN10), as this factor was not significant along with area of the face and dental esthetic level.

With recent increased awareness and concern over bullying in young children, new attention is being brought to the influence of the dentition. In a 2011 article by Seehra et al. the complex relationship between a malocclusion, bullying, self-esteem and oral health related quality of life were discussed.⁴⁰ In 2013, Seehra took this a step further by examining the effect of interceptive orthodontic treatment on the self-esteem and oral health related quality of life in patients with a history of bullying. They showed that following the beginning of treatment, 78% were no longer being bullied, and while self-esteem was not greatly impacted, there was a significant improvement in oral health-related quality of life in those no longer being bullied.⁴¹ The need to further understand the complex relationship between dental esthetics and the impact it has psychologically and psychosocially on an individual, begins with an understanding of visual attention to the dentition in an objective setting as we have presented.

The objective of this study was to uncover when deviations from the “ideal” esthetics would in fact be noticed by a lay peer observer unbiased toward looking at the mouth in men of different background facial attractiveness levels. Further, we wanted to compare to previous studies of similar methodology with female models. What was revealed was that there are indeed differences in the way in which both men and women look at the face of a man or a woman based on differing dental esthetics and background facial attractiveness. Attractiveness studies have shown that in general women are rated more critically, and previous eye tracking studies have supported this notion in attractive

women with un-esthetic dentitions.^{28,29} We have presented evidence that raters are more able to agree on attractiveness in women than they are in men. This may be why the interaction of area, attractiveness, and dental esthetics was found to be significant in attractive women but not in men. In men, the lowest dental esthetics (IOTN10) were significantly noticed, and even to a greater degree than in women²⁸, but the background facial attractiveness “disharmony” does not appear to be the reason for the attention in men as it is in women.^{28,29} While this study may only be generalizable to men in the 18-30 age range, children will eventually reach this age range. Therefore, from the evidence presented here, treatment for the most un-esthetic dentition could potentially benefit men at all levels of background facial attractiveness.

Conclusions

- 1.) Visual attention to the mouth was the greatest in men of average facial attractiveness, irrespective of dental esthetics.
- 2.) In borderline dental esthetics (IOTN7) the eye and mouth are statistically indistinguishable, but in the most un-esthetic dental attractiveness level (IOTN10), the mouth exceeds the eye. Thus, the most un-esthetic malocclusion does significantly attract and affect visual attention in men.
- 3.) Male and female raters showed differences in their visual attention to male faces.
- 4.) Lay persons have significant visual attention attracted to poor dental esthetics in men, and this is irrespective of background attractiveness, which is counter to what is seen in women.

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Chapter 4: Conclusions

- 1.) Visual attention to the mouth was the greatest in men of average facial attractiveness, irrespective of dental esthetics.
- 2.) In borderline dental esthetics (IOTN7) the eye and mouth are statistically indistinguishable, but in the most un-esthetic dental attractiveness level (IOTN10), the mouth exceeds the eye. Thus, the most un-esthetic malocclusion does significantly attract and affect visual attention in men.
- 3.) Male and female raters showed differences in their visual attention to male faces.
- 4.) Lay persons have significant visual attention attracted to poor dental esthetics in men, and this is irrespective of background attractiveness, which is counter to what is seen in women.

Appendix A: Tables and Figures

IOTN-AC level 1

Figure 1. Example of IOTN-AC rating slide to validate IOTN-AC levels

Figure 2. Example of composite image (Attractive model, IOTN level 10)

Figure 3. Example of mapped interest areas, as well as eye tracking data plotted

Figure 4. Example of participant in an eye tracker (eye link 1000)⁴⁴

Reliability of measures							
Variable	Area	Intra-rater	LCB _{.95}	UCB _{.95}	Inter-rater	LCB _{.95}	UCB _{.95}
Density*	Chin	0.75	0.73	0.77	0.04	-0.03	0.11
	Ear	0.26	0.21	0.31	0.10	0.02	0.17
	Eye	0.88	0.87	0.89	0.79	0.76	0.82
	Nose	0.80	0.78	0.82	0.65	0.61	0.69
	Other	0.79	0.77	0.81	0.61	0.56	0.65
	Mouth	0.75	0.73	0.77	0.60	0.55	0.65
Duration*	Chin	0.77	0.75	0.79	-0.05	-0.12	0.02
	Ear	0.24	0.19	0.29	0.05	-0.02	0.12
	Eye	0.90	0.89	0.91	0.82	0.79	0.84
	Nose	0.89	0.88	0.90	0.79	0.76	0.82
	Other	0.66	0.63	0.69	0.38	0.32	0.44
	Mouth	0.77	0.75	0.79	0.64	0.59	0.68
*Intraclass correlation							

Table 1. Reliability of Measures- Areas of Interest

ANOVA Summary for Density				
Effect	Num DF	Den DF	F Value	Pr > F
ATRC	2	124	1.18	0.3109
OCCL	3	186	20.34	<.0001
ATRC*OCCL	6	372	1.04	0.4017
AREA	2	124	27.63	<.0001
ATRC*AREA	4	248	10.64	<.0001
OCCL*AREA	6	372	19.22	<.0001
ATRC*OCCL*AREA	12	744	1.1	0.3602
RGEND	1	62	3.45	0.068
ATRC*RGEND	2	124	0.69	0.5038
OCCL*RGEND	3	186	0.61	0.6122
ATRC*OCCL*RGEND	6	372	0.59	0.738
AREA*RGEND	2	124	4.24	0.0166
ATRC*AREA*RGEND	4	248	0.3	0.8794
OCCL*AREA*RGEND	6	372	0.84	0.5427
ATRC*OCCL*AREA*RGEND	12	744	0.73	0.7228

Table 2. ANOVA Summary for Density (Total # of Fixations)

ANOVA Summary for Duration				
Effect	Num DF	Den DF	F Value	Pr > F
ATRC	2	124	1.07	0.346
OCCL	3	186	16.98	<.0001
ATRC*OCCL	6	372	0.59	0.735
AREA	2	124	43.45	<.0001
ATRC*AREA	4	248	8.68	<.0001
OCCL*AREA	6	372	17.26	<.0001
ATRC*OCCL*AREA	12	744	0.77	0.68
RGEND	1	62	1.66	0.203
ATRC*RGEND	2	124	0.26	0.771
OCCL*RGEND	3	186	0.58	0.63
ATRC*OCCL*RGEND	6	372	0.41	0.872
AREA*RGEND	2	124	3.65	0.029
ATRC*AREA*RGEND	4	248	0.51	0.725
OCCL*AREA*RGEND	6	372	1.3	0.255
ATRC*OCCL*AREA*RGEND	12	744	0.57	0.871

Table 3. ANOVA Summary for Duration (Total Fixation Time)

Figure 5. Density: Area by Facial Attractiveness

Density:												
Attractiveness by Area	Attractiveness	Area	Attractiveness 2	Area 2	Estimate	Standard Error	DF	t Value	Pr > t	Adjustment	Adj P	
ATRC*AREA	Unattractive	EY	Unattractive	MO	0.1898	0.05021	248	3.78	0.0002	Tukey-Kramer	0.0061	
ATRC*AREA	Unattractive	EY	Unattractive	NO	0.2148	0.05021	248	4.28	<.0001	Tukey-Kramer	0.0009	
ATRC*AREA	Unattractive	EY	Average	EY	0.1186	0.05021	248	2.36	0.0189	Tukey-Kramer	0.3095	
ATRC*AREA	Unattractive	EY	Average	MO	-0.03013	0.05021	248	-0.6	0.5491	Tukey-Kramer	0.9996	
ATRC*AREA	Unattractive	EY	Average	NO	0.2621	0.05021	248	5.22	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	EY	Attractive	EY	-0.02678	0.05021	248	-0.53	0.5943	Tukey-Kramer	0.9998	
ATRC*AREA	Unattractive	EY	Attractive	MO	0.2488	0.05021	248	4.95	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	EY	Attractive	NO	0.2614	0.05021	248	5.21	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	MO	Unattractive	NO	0.02508	0.05021	248	0.5	0.6179	Tukey-Kramer	0.9999	
ATRC*AREA	Unattractive	MO	Average	EY	-0.07113	0.05021	248	-1.42	0.1579	Tukey-Kramer	0.8907	
ATRC*AREA	Unattractive	MO	Average	MO	-0.2199	0.05021	248	-4.38	<.0001	Tukey-Kramer	0.0006	
ATRC*AREA	Unattractive	MO	Average	NO	0.07233	0.05021	248	1.44	0.151	Tukey-Kramer	0.881	
ATRC*AREA	Unattractive	MO	Attractive	EY	-0.2165	0.05021	248	-4.31	<.0001	Tukey-Kramer	0.0008	
ATRC*AREA	Unattractive	MO	Attractive	MO	0.059	0.05021	248	1.17	0.2412	Tukey-Kramer	0.9611	
ATRC*AREA	Unattractive	MO	Attractive	NO	0.07166	0.05021	248	1.43	0.1548	Tukey-Kramer	0.8865	
ATRC*AREA	Unattractive	NO	Average	EY	-0.0962	0.05021	248	-1.92	0.0565	Tukey-Kramer	0.6034	
ATRC*AREA	Unattractive	NO	Average	MO	-0.245	0.05021	248	-4.88	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	NO	Average	NO	0.04726	0.05021	248	0.94	0.3476	Tukey-Kramer	0.9903	
ATRC*AREA	Unattractive	NO	Attractive	EY	-0.2416	0.05021	248	-4.81	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	NO	Attractive	MO	0.03392	0.05021	248	0.68	0.5	Tukey-Kramer	0.999	
ATRC*AREA	Unattractive	NO	Attractive	NO	0.04658	0.05021	248	0.93	0.3545	Tukey-Kramer	0.9912	
ATRC*AREA	Average	EY	Average	MO	-0.1488	0.05021	248	-2.96	0.0033	Tukey-Kramer	0.0795	
ATRC*AREA	Average	EY	Average	NO	0.1435	0.05021	248	2.86	0.0046	Tukey-Kramer	0.1046	
ATRC*AREA	Average	EY	Attractive	EY	-0.1454	0.05021	248	-2.9	0.0041	Tukey-Kramer	0.0947	
ATRC*AREA	Average	EY	Attractive	MO	0.1301	0.05021	248	2.59	0.0101	Tukey-Kramer	0.1956	
ATRC*AREA	Average	EY	Attractive	NO	0.1428	0.05021	248	2.84	0.0048	Tukey-Kramer	0.1082	
ATRC*AREA	Average	MO	Average	NO	0.2922	0.05021	248	5.82	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	MO	Attractive	EY	0.003349	0.05021	248	0.07	0.9469	Tukey-Kramer	1	
ATRC*AREA	Average	MO	Attractive	MO	0.2789	0.05021	248	5.55	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	MO	Attractive	NO	0.2915	0.05021	248	5.81	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	NO	Attractive	EY	-0.2889	0.05021	248	-5.75	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	NO	Attractive	MO	-0.01334	0.05021	248	-0.27	0.7908	Tukey-Kramer	1	
ATRC*AREA	Average	NO	Attractive	NO	-0.00068	0.05021	248	-0.01	0.9893	Tukey-Kramer	1	
ATRC*AREA	Attractive	EY	Attractive	MO	0.2755	0.05021	248	5.49	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Attractive	EY	Attractive	NO	0.2882	0.05021	248	5.74	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Attractive	MO	Attractive	NO	0.01266	0.05021	248	0.25	0.8011	Tukey-Kramer	1	

Table 4. Density-Facial Attractiveness by Area -Differences of Least Squares Means

Density- Attractiveness by Area	Area	# of Observations	Variable	N	Mean	Standard Deviation	Minimum	Maximum
Attractiveness								
Unattractive	Eye	256	# FIX	256	2.5859375	1.920079	0	10
			LOG VALUE	256	1.1198113	0.5889974	0	2.3978953
	Mouth	256	# FIX	256	2.1015625	1.7683041	0	7
			LOG VALUE	256	0.9492184	0.6341122	0	2.0794415
	Nose	256	# FIX	256	1.8515625	1.4007832	0	7
			LOG VALUE	256	0.921924	0.5202529	0	2.0794415
Average	Eye	256	# FIX	256	2.2929688	1.951397	0	10
			LOG VALUE	256	1.0026165	0.6428451	0	2.3978953
	Mouth	256	# FIX	256	2.7578125	2.0436265	0	12
			LOG VALUE	256	1.1697281	0.5812009	0	2.5649494
	Nose	256	# FIX	256	1.6953125	1.349269	0	8
			LOG VALUE	256	0.8651957	0.5175614	0	2.1972246
Attractive	Eye	256	# FIX	256	2.6171875	1.826262	0	7
			LOG VALUE	256	1.1302659	0.5988551	0	2.0794415
	Mouth	256	# FIX	256	1.90625	1.6986154	0	7
			LOG VALUE	256	0.8866533	0.6200257	0	2.0794415
	Nose	256	# FIX	256	1.7226563	1.410477	0	6
			LOG VALUE	256	0.867498	0.5293402	0	1.9459101

Table 5. Density- Facial Attractiveness by Area- Raw and Log Summary Data

Figure 6. Density- Dental Esthetics by Area

Density:	Dental Esthetics	Area	Dental Esthetics 2	Area 2	Estimate	Standard Error	DF	t Value	Pr > t	Adjustment	Adj P
Dental Esthetics by Area (IOTN)			(IOTN)								
OCCL*AREA	1	EY	1	MO	0.2794	0.05798	372	4.82	<.0001	Tukey-Kramer	0.0001
OCCL*AREA	1	EY	1	NO	0.1687	0.05798	372	2.91	0.0038	Tukey-Kramer	0.1421
OCCL*AREA	1	EY	7	EY	-0.1087	0.05798	372	-1.87	0.0617	Tukey-Kramer	0.7745
OCCL*AREA	1	EY	7	MO	0.0396	0.05798	372	0.68	0.4951	Tukey-Kramer	0.9999
OCCL*AREA	1	EY	7	NO	0.2631	0.05798	372	4.54	<.0001	Tukey-Kramer	0.0005
OCCL*AREA	1	EY	10	EY	0.02733	0.05798	372	0.47	0.6377	Tukey-Kramer	1
OCCL*AREA	1	EY	10	MO	-0.2663	0.05798	372	-4.59	<.0001	Tukey-Kramer	0.0004
OCCL*AREA	1	EY	10	NO	0.2502	0.05798	372	4.32	<.0001	Tukey-Kramer	0.0012
OCCL*AREA	1	MO	1	NO	-0.1108	0.05798	372	-1.91	0.0569	Tukey-Kramer	0.7524
OCCL*AREA	1	MO	7	EY	-0.3881	0.05798	372	-6.69	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	MO	7	MO	-0.2398	0.05798	372	-4.14	<.0001	Tukey-Kramer	0.0025
OCCL*AREA	1	MO	7	NO	-0.01634	0.05798	372	-0.28	0.7783	Tukey-Kramer	1
OCCL*AREA	1	MO	10	EY	-0.2521	0.05798	372	-4.35	<.0001	Tukey-Kramer	0.0011
OCCL*AREA	1	MO	10	MO	-0.5457	0.05798	372	-9.41	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	MO	10	NO	-0.02919	0.05798	372	-0.5	0.615	Tukey-Kramer	1
OCCL*AREA	1	NO	7	EY	-0.2773	0.05798	372	-4.78	<.0001	Tukey-Kramer	0.0002
OCCL*AREA	1	NO	7	MO	-0.1291	0.05798	372	-2.23	0.0266	Tukey-Kramer	0.532
OCCL*AREA	1	NO	7	NO	0.09441	0.05798	372	1.63	0.1043	Tukey-Kramer	0.8977
OCCL*AREA	1	NO	10	EY	-0.1413	0.05798	372	-2.44	0.0153	Tukey-Kramer	0.3836
OCCL*AREA	1	NO	10	MO	-0.435	0.05798	372	-7.5	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	NO	10	NO	0.08156	0.05798	372	1.41	0.1604	Tukey-Kramer	0.9618
OCCL*AREA	7	EY	7	MO	0.1483	0.05798	372	2.56	0.011	Tukey-Kramer	0.3083
OCCL*AREA	7	EY	7	NO	0.3717	0.05798	372	6.41	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	EY	10	EY	0.136	0.05798	372	2.35	0.0195	Tukey-Kramer	0.4462
OCCL*AREA	7	EY	10	MO	-0.1577	0.05798	372	-2.72	0.0069	Tukey-Kramer	0.2211
OCCL*AREA	7	EY	10	NO	0.3589	0.05798	372	6.19	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	MO	7	NO	0.2235	0.05798	372	3.85	0.0001	Tukey-Kramer	0.0075
OCCL*AREA	7	MO	10	EY	-0.01227	0.05798	372	-0.21	0.8325	Tukey-Kramer	1
OCCL*AREA	7	MO	10	MO	-0.3059	0.05798	372	-5.28	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	MO	10	NO	0.2106	0.05798	372	3.63	0.0003	Tukey-Kramer	0.0165
OCCL*AREA	7	NO	10	EY	-0.2357	0.05798	372	-4.07	<.0001	Tukey-Kramer	0.0034
OCCL*AREA	7	NO	10	MO	-0.5294	0.05798	372	-9.13	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	NO	10	NO	-0.01285	0.05798	372	-0.22	0.8247	Tukey-Kramer	1
OCCL*AREA	10	EY	10	MO	-0.2937	0.05798	372	-5.06	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	10	EY	10	NO	0.2229	0.05798	372	3.84	0.0001	Tukey-Kramer	0.0078
OCCL*AREA	10	MO	10	NO	0.5165	0.05798	372	8.91	<.0001	Tukey-Kramer	<.0001

Table 6. Density- Dental Esthetics by Area- Differences of Least Squares Means

Density- Dental Esthetics by Area	Area	# of Observations	Variable	N	Mean	Standard Deviation	Minimum	Maximum
Dental Esthetics	AREA	N Obs	Variable	N	Mean	Std Dev	Minimum	Maximum
Normal (IOTN1)	Eye	192	# FIX	192	2.5572917	2.0044059	0	10
			LOG VALUE	192	1.1000006	0.6095529	0	2.3978953
	Mouth	192	# FIX	192	1.6875	1.4053935	0	6
			LOG VALUE	192	0.8390762	0.5696337	0	1.9459101
	Nose	192	# FIX	192	1.9322917	1.4401131	0	7
			LOG VALUE	192	0.9532157	0.511069	0	2.0794415
Borderline (IOTN7)	Eye	192	# FIX	192	2.9114583	2.0149894	0	8
			LOG VALUE	192	1.1989645	0.6212823	0	2.1972246
	Mouth	192	# FIX	192	2.4635417	1.9679963	0	12
			LOG VALUE	192	1.0723644	0.6130609	0	2.5649494
	Nose	192	# FIX	192	1.6354167	1.3153925	0	6
			LOG VALUE	192	0.8387574	0.5269313	0	1.9459101
Unesthetic (IOTN10)	Eye	192	# FIX	192	2.3645833	1.7523046	0	7
			LOG VALUE	192	1.0558963	0.596111	0	2.0794415
	Mouth	192	# FIX	192	3.4583333	1.8974586	0	10
			LOG VALUE	192	1.38656	0.5012756	0	2.3978953
	Nose	192	# FIX	192	1.6822917	1.2524736	0	6
			LOG VALUE	192	0.8727529	0.4937969	0	1.9459101

Table 7. Density- Dental Esthetics by Area- Raw and Log Summary Data

Figure 7. Density: Rater Gender by Area

Density:												
Area by Rater Gender	Area	Rater Gender	Area 2	Rater Gender 2	Estimate	Standard Error	DF	t Value	Pr > t	Adjustment	Adj P	
AREA*RGEND	EY	FEMALE	EY	MALE	0.1723	0.05421	124	3.18	0.0019	Tukey-Kramer	0.0225	
AREA*RGEND	EY	FEMALE	MO	FEMALE	0.1878	0.04641	124	4.05	<.0001	Tukey-Kramer	0.0013	
AREA*RGEND	EY	FEMALE	MO	MALE	0.1955	0.05421	124	3.61	0.0004	Tukey-Kramer	0.0059	
AREA*RGEND	EY	FEMALE	NO	FEMALE	0.2729	0.04641	124	5.88	<.0001	Tukey-Kramer	<.0001	
AREA*RGEND	EY	FEMALE	NO	MALE	0.3304	0.05421	124	6.1	<.0001	Tukey-Kramer	<.0001	
AREA*RGEND	EY	MALE	MO	FEMALE	0.01551	0.05421	124	0.29	0.7753	Tukey-Kramer	0.9997	
AREA*RGEND	EY	MALE	MO	MALE	0.02321	0.03476	124	0.67	0.5055	Tukey-Kramer	0.9851	
AREA*RGEND	EY	MALE	NO	FEMALE	0.1006	0.05421	124	1.86	0.0659	Tukey-Kramer	0.4347	
AREA*RGEND	EY	MALE	NO	MALE	0.1581	0.03476	124	4.55	<.0001	Tukey-Kramer	0.0002	
AREA*RGEND	MO	FEMALE	MO	MALE	0.007708	0.05421	124	0.14	0.8872	Tukey-Kramer	1	
AREA*RGEND	MO	FEMALE	NO	FEMALE	0.08506	0.04641	124	1.83	0.0692	Tukey-Kramer	0.4486	
AREA*RGEND	MO	FEMALE	NO	MALE	0.1426	0.05421	124	2.63	0.0096	Tukey-Kramer	0.0976	
AREA*RGEND	MO	MALE	NO	FEMALE	0.07736	0.05421	124	1.43	0.1561	Tukey-Kramer	0.7106	
AREA*RGEND	MO	MALE	NO	MALE	0.1349	0.03476	124	3.88	0.0002	Tukey-Kramer	0.0023	
AREA*RGEND	NO	FEMALE	NO	MALE	0.05755	0.05421	124	1.06	0.2905	Tukey-Kramer	0.8955	

Table 8. Density- Area by Rater Gender-Differences of Least Squares Means

Density- Area by Rater Gender	Rater Gender	# of Observations	Variable	N	Mean	Standard Deviation	Minimum	Maximum
Area								
Eye	Female	276	# FIX	276	2.7572464	1.740152	0	8
			LOG VALUE	276	1.19461	0.5460708	0	2.1972246
	Male	492	# FIX	492	2.3536585	1.9756478	0	10
			LOG VALUE	492	1.0223114	0.639202	0	2.3978953
Mouth	Female	276	# FIX	276	2.2282609	1.7421195	0	8
			LOG VALUE	276	1.0068044	0.6063896	0	2.1972246
	Male	492	# FIX	492	2.2703252	1.9489653	0	12
			LOG VALUE	492	0.9990966	0.6332499	0	2.5649494
Nose	Female	276	# FIX	276	1.865942	1.4397473	0	8
			LOG VALUE	276	0.9217405	0.530499	0	2.1972246
	Male	492	# FIX	492	1.695122	1.3540828	0	7
			LOG VALUE	492	0.8641906	0.5171722	0	2.0794415

Table 9. Density- Area by Rater Gender- Raw and Log Summary Data

Figure 8. Duration: Area by Attractiveness

Duration-											
Attractiveness by Area	Attractiveness Area	Attractiveness 2 Area 2	Estimate	Standard Error	DF	t Value	Pr > t	Adjustment	Adj P		
ATRC*AREA	Unattractive	EY Unattractive	MO	3.7511	1.1121	248	3.37	0.0009	Tukey-Kramer	0.0239	
ATRC*AREA	Unattractive	EY Unattractive	NO	5.1713	1.1121	248	4.65	<.0001	Tukey-Kramer	0.0002	
ATRC*AREA	Unattractive	EY Average	EY	1.7274	1.1121	248	1.55	0.1216	Tukey-Kramer	0.8288	
ATRC*AREA	Unattractive	EY Average	MO	-0.7304	1.1121	248	-0.66	0.5119	Tukey-Kramer	0.9992	
ATRC*AREA	Unattractive	EY Average	NO	6.7019	1.1121	248	6.03	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	EY Attractive	EY	-1.0097	1.1121	248	-0.91	0.3648	Tukey-Kramer	0.9924	
ATRC*AREA	Unattractive	EY Attractive	MO	4.836	1.1121	248	4.35	<.0001	Tukey-Kramer	0.0007	
ATRC*AREA	Unattractive	EY Attractive	NO	6.6817	1.1121	248	6.01	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	MO Unattractive	NO	1.4202	1.1121	248	1.28	0.2028	Tukey-Kramer	0.9371	
ATRC*AREA	Unattractive	MO Average	EY	-2.0237	1.1121	248	-1.82	0.07	Tukey-Kramer	0.6691	
ATRC*AREA	Unattractive	MO Average	MO	-4.4815	1.1121	248	-4.03	<.0001	Tukey-Kramer	0.0024	
ATRC*AREA	Unattractive	MO Average	NO	2.9508	1.1121	248	2.65	0.0085	Tukey-Kramer	0.1704	
ATRC*AREA	Unattractive	MO Attractive	EY	-4.7608	1.1121	248	-4.28	<.0001	Tukey-Kramer	0.0009	
ATRC*AREA	Unattractive	MO Attractive	MO	1.0849	1.1121	248	0.98	0.3302	Tukey-Kramer	0.9878	
ATRC*AREA	Unattractive	MO Attractive	NO	2.9306	1.1121	248	2.64	0.0089	Tukey-Kramer	0.1775	
ATRC*AREA	Unattractive	NO Average	EY	-3.4439	1.1121	248	-3.1	0.0022	Tukey-Kramer	0.0549	
ATRC*AREA	Unattractive	NO Average	MO	-5.9017	1.1121	248	-5.31	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	NO Average	NO	1.5306	1.1121	248	1.38	0.1699	Tukey-Kramer	0.9058	
ATRC*AREA	Unattractive	NO Attractive	EY	-6.181	1.1121	248	-5.56	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Unattractive	NO Attractive	MO	-0.3353	1.1121	248	-0.3	0.7633	Tukey-Kramer	1	
ATRC*AREA	Unattractive	NO Attractive	NO	1.5104	1.1121	248	1.36	0.1756	Tukey-Kramer	0.9121	
ATRC*AREA	Average	EY Average	MO	-2.4578	1.1121	248	-2.21	0.028	Tukey-Kramer	0.4024	
ATRC*AREA	Average	EY Average	NO	4.9745	1.1121	248	4.47	<.0001	Tukey-Kramer	0.0004	
ATRC*AREA	Average	EY Attractive	EY	-2.7371	1.1121	248	-2.46	0.0145	Tukey-Kramer	0.2563	
ATRC*AREA	Average	EY Attractive	MO	3.1086	1.1121	248	2.8	0.0056	Tukey-Kramer	0.122	
ATRC*AREA	Average	EY Attractive	NO	4.9543	1.1121	248	4.46	<.0001	Tukey-Kramer	0.0004	
ATRC*AREA	Average	MO Average	NO	7.4323	1.1121	248	6.68	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	MO Attractive	EY	-0.2793	1.1121	248	-0.25	0.8019	Tukey-Kramer	1	
ATRC*AREA	Average	MO Attractive	MO	5.5664	1.1121	248	5.01	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	MO Attractive	NO	7.4121	1.1121	248	6.67	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	NO Attractive	EY	-7.7116	1.1121	248	-6.93	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Average	NO Attractive	MO	-1.8659	1.1121	248	-1.68	0.0946	Tukey-Kramer	0.7595	
ATRC*AREA	Average	NO Attractive	NO	-0.02022	1.1121	248	-0.02	0.9855	Tukey-Kramer	1	
ATRC*AREA	Attractive	EY Attractive	MO	5.8457	1.1121	248	5.26	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Attractive	EY Attractive	NO	7.6914	1.1121	248	6.92	<.0001	Tukey-Kramer	<.0001	
ATRC*AREA	Attractive	MO Attractive	NO	1.8457	1.1121	248	1.66	0.0982	Tukey-Kramer	0.7703	

Table 10. Duration- Attractiveness by Area- Differences of Least Squares Means

Duration- Attractiveness by Area	Area	# of Observations	Variable	N	Mean	Standard Deviation	Minimum	Maximum
Attractiveness level								
Unattractive	Eye	256	DUR FIXATION	256	704.53125	566.3379015	0	2501
			SQRT VALUE	256	23.4973741	12.3694109	0	50.009999
	Mouth	256	DUR FIXATION	256	592.2539063	551.5899176	0	2347
			SQRT VALUE	256	20.1046522	13.7402454	0	48.445846
	Nose	256	DUR FIXATION	256	487.9921875	524.453927	0	2748
			SQRT VALUE	256	18.7201262	11.7511051	0	52.42137
Average	Eye	256	DUR FIXATION	256	675.3242188	606.5019991	0	2615
			SQRT VALUE	256	21.8692704	14.0652769	0	51.137071
	Mouth	256	DUR FIXATION	256	770.0976563	637.6141883	0	3493
			SQRT VALUE	256	24.6061774	12.8561002	0	59.101607
	Nose	256	DUR FIXATION	256	406.9375	420.9797862	0	2645
			SQRT VALUE	256	16.9848843	10.9048485	0	51.429564
Attractive	Eye	256	DUR FIXATION	256	760.515625	613.4222227	0	2728
			SQRT VALUE	256	24.1713405	13.3023738	0	52.230259
	Mouth	256	DUR FIXATION	256	534.8125	494.1346288	0	2144
			SQRT VALUE	256	19.0519558	13.1342813	0	46.303348
	Nose	256	DUR FIXATION	256	420.265625	480.2446106	0	2919
			SQRT VALUE	256	17.1402106	11.2683096	0	54.027771

Table 11. Duration- Attractiveness by Area- Raw and Square Root Summary Data

Figure 9. Duration: Dental Esthetics by Area

Duration:	Dental Esthetics (IOTN)	Area	Dental Esthetics 2 (IOTN)	Area 2	Estimate	Standard Error	DF	t Value	Pr > t	Adjustment	Adj P
OCCL*AREA	1	EY	1	MO	6.3871	1.2841	372	4.97	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	EY	1	NO	5.4196	1.2841	372	4.22	<.0001	Tukey-Kramer	0.0018
OCCL*AREA	1	EY	7	EY	-1.3478	1.2841	372	-1.05	0.2946	Tukey-Kramer	0.9964
OCCL*AREA	1	EY	7	MO	1.5933	1.2841	372	1.24	0.2155	Tukey-Kramer	0.9853
OCCL*AREA	1	EY	7	NO	7.4914	1.2841	372	5.83	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	EY	10	EY	1.2501	1.2841	372	0.97	0.3309	Tukey-Kramer	0.9981
OCCL*AREA	1	EY	10	MO	-4.7874	1.2841	372	-3.73	0.0002	Tukey-Kramer	0.0118
OCCL*AREA	1	EY	10	NO	7.3208	1.2841	372	5.7	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	MO	1	NO	-0.9675	1.2841	372	-0.75	0.4516	Tukey-Kramer	0.9998
OCCL*AREA	1	MO	7	EY	-7.735	1.2841	372	-6.02	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	MO	7	MO	-4.7938	1.2841	372	-3.73	0.0002	Tukey-Kramer	0.0116
OCCL*AREA	1	MO	7	NO	1.1043	1.2841	372	0.86	0.3904	Tukey-Kramer	0.9994
OCCL*AREA	1	MO	10	EY	-5.137	1.2841	372	-4	<.0001	Tukey-Kramer	0.0043
OCCL*AREA	1	MO	10	MO	-11.1746	1.2841	372	-8.7	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	MO	10	NO	0.9337	1.2841	372	0.73	0.4676	Tukey-Kramer	0.9999
OCCL*AREA	1	NO	7	EY	-6.7675	1.2841	372	-5.27	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	NO	7	MO	-3.8263	1.2841	372	-2.98	0.0031	Tukey-Kramer	0.1187
OCCL*AREA	1	NO	7	NO	2.0718	1.2841	372	1.61	0.1075	Tukey-Kramer	0.9034
OCCL*AREA	1	NO	10	EY	-4.1695	1.2841	372	-3.25	0.0013	Tukey-Kramer	0.0567
OCCL*AREA	1	NO	10	MO	-10.2071	1.2841	372	-7.95	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	1	NO	10	NO	1.9012	1.2841	372	1.48	0.1396	Tukey-Kramer	0.9451
OCCL*AREA	7	EY	7	MO	2.9412	1.2841	372	2.29	0.0226	Tukey-Kramer	0.4853
OCCL*AREA	7	EY	7	NO	8.8393	1.2841	372	6.88	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	EY	10	EY	2.598	1.2841	372	2.02	0.0438	Tukey-Kramer	0.6773
OCCL*AREA	7	EY	10	MO	-3.4396	1.2841	372	-2.68	0.0077	Tukey-Kramer	0.2412
OCCL*AREA	7	EY	10	NO	8.6687	1.2841	372	6.75	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	MO	7	NO	5.8981	1.2841	372	4.59	<.0001	Tukey-Kramer	0.0004
OCCL*AREA	7	MO	10	EY	-0.3432	1.2841	372	-0.27	0.7894	Tukey-Kramer	1
OCCL*AREA	7	MO	10	MO	-6.3808	1.2841	372	-4.97	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	MO	10	NO	5.7275	1.2841	372	4.46	<.0001	Tukey-Kramer	0.0007
OCCL*AREA	7	NO	10	EY	-6.2413	1.2841	372	-4.86	<.0001	Tukey-Kramer	0.0001
OCCL*AREA	7	NO	10	MO	-12.2789	1.2841	372	-9.56	<.0001	Tukey-Kramer	<.0001
OCCL*AREA	7	NO	10	NO	-0.1706	1.2841	372	-0.13	0.8944	Tukey-Kramer	1
OCCL*AREA	10	EY	10	MO	-6.0376	1.2841	372	-4.7	<.0001	Tukey-Kramer	0.0002
OCCL*AREA	10	EY	10	NO	6.0707	1.2841	372	4.73	<.0001	Tukey-Kramer	0.0002
OCCL*AREA	10	MO	10	NO	12.1083	1.2841	372	9.43	<.0001	Tukey-Kramer	<.0001

Table 12. Duration- Dental Esthetics by Area- Differences of Least Squares Means

Duration- Dental Esthetics by Area									
Area	Area	# of Observations	Variable	N	Mean	Standard Deviation	Minimum	Maximum	
Dental Esthetics									
Normal (IOTN1)	Eye	192	DUR FIXATION	192	747.3802083	600.9923698	0	2635	
			SQRT VALUE	192	23.9882729	13.1469844	0	51.332251	
	Mouth	192	DUR FIXATION	192	475.125	442.3917799	0	2347	
			SQRT VALUE	192	17.974112	12.3633492	0	48.445846	
Borderline (IOTN7)	Nose	192	DUR FIXATION	192	499.3177083	506.0004533	0	2645	
			SQRT VALUE	192	19.2466983	11.3823148	0	51.429564	
	Eye	192	DUR FIXATION	192	819.5833333	632.7838546	0	2728	
			SQRT VALUE	192	25.3010632	13.4305252	0	52.230259	
Unesthetic (IOTN10)	Mouth	192	DUR FIXATION	192	675.828125	561.5661688	0	2567	
			SQRT VALUE	192	22.5561603	12.9584857	0	50.66557	
	Nose	192	DUR FIXATION	192	414.4635417	505.0558921	0	2919	
			SQRT VALUE	192	16.7102707	11.6592627	0	54.027771	
	Eye	192	DUR FIXATION	192	669.9427083	568.2254105	0	2518	
			SQRT VALUE	192	22.3956716	13.0099253	0	50.179677	
	Mouth	192	DUR FIXATION	192	984.5885417	591.1442383	0	2658	
			SQRT VALUE	192	29.405673	10.9782813	0	51.555795	
	Nose	192	DUR FIXATION	192	404.5364583	419.9953362	0	2610	
			SQRT VALUE	192	17.1956775	10.4601627	0	51.088159	

Table 13. Duration- Dental Esthetics by Area- Raw and Square Root Summary Data

Figure 10. Duration: Area by Rater Gender

Duration:													
Area by Rater Gender	Area	Rater Gender		Area 2	Rater Gender 2		Estimate	Standard Error	DF	t Value	Pr > t	Adjustment	Adj P
AREA*RGEND	EY	FEMALE	EY	MALE			2.9476	1.0544	124	2.8	0.006	Tukey-Kramer	0.0649
AREA*RGEND	EY	FEMALE	MO	FEMALE			3.996	1.0278	124	3.89	0.0002	Tukey-Kramer	0.0022
AREA*RGEND	EY	FEMALE	MO	MALE			3.7109	1.0544	124	3.52	0.0006	Tukey-Kramer	0.0078
AREA*RGEND	EY	FEMALE	NO	FEMALE			7.3021	1.0278	124	7.1	<.0001	Tukey-Kramer	<.0001
AREA*RGEND	EY	FEMALE	NO	MALE			7.537	1.0544	124	7.15	<.0001	Tukey-Kramer	<.0001
AREA*RGEND	EY	MALE	MO	FEMALE			1.0484	1.0544	124	0.99	0.322	Tukey-Kramer	0.919
AREA*RGEND	EY	MALE	MO	MALE			0.7633	0.7698	124	0.99	0.3233	Tukey-Kramer	0.9199
AREA*RGEND	EY	MALE	NO	FEMALE			4.3544	1.0544	124	4.13	<.0001	Tukey-Kramer	0.0009
AREA*RGEND	EY	MALE	NO	MALE			4.5894	0.7698	124	5.96	<.0001	Tukey-Kramer	<.0001
AREA*RGEND	MO	FEMALE	MO	MALE			-0.2851	1.0544	124	-0.27	0.7873	Tukey-Kramer	0.9998
AREA*RGEND	MO	FEMALE	NO	FEMALE			3.306	1.0278	124	3.22	0.0017	Tukey-Kramer	0.0201
AREA*RGEND	MO	FEMALE	NO	MALE			3.541	1.0544	124	3.36	0.001	Tukey-Kramer	0.013
AREA*RGEND	MO	MALE	NO	FEMALE			3.5911	1.0544	124	3.41	0.0009	Tukey-Kramer	0.0112
AREA*RGEND	MO	MALE	NO	MALE			3.8261	0.7698	124	4.97	<.0001	Tukey-Kramer	<.0001
AREA*RGEND	NO	FEMALE	NO	MALE			0.235	1.0544	124	0.22	0.824	Tukey-Kramer	0.9999

Table 14. Duration-Area by Rater Gender- Differences of Least Squares Means

Duration: Area by Rater Gender		# of						
Rater Gender	Observations	Variable	N	Mean	Standard Deviation	Minimum	Maximum	
Area								
Eye	Female	276	DUR FIXAITON	276	761.2608696	529.4172275	0	2463
			SQRT VALUE	276	25.0676535	11.5480212	0	49.628621
	Male	492	DUR FIXAITON	492	686.6402439	629.2904764	0	2728
			SQRT VALUE	492	22.1200239	14.0622441	0	52.230259
Mouth	Female	276	DUR FIXAITON	276	609.9456522	525.4240614	0	2421
			SQRT VALUE	276	21.071607	12.9048992	0	49.203658
	Male	492	DUR FIXAITON	492	644.9776423	597.1522214	0	3493
			SQRT VALUE	492	21.3567267	13.7569084	0	59.101607
Nose	Female	276	DUR FIXAITON	276	432.1086957	420.6996542	0	2524
			SQRT VALUE	276	17.7655932	10.8127704	0	50.239427
	Male	492	DUR FIXAITON	492	441.9268293	507.4208041	0	2919
			SQRT VALUE	492	17.5306359	11.6136891	0	54.027771

Table 15. Duration- Area by Rater Gender- Raw and Square Root Summary Data

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