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THE EFFECTS OF ANTERO-POSTERIOR INCISOR POSITION ON
ATTRACTIVENESS RATINGS BY ETHNICITY

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A manuscript submitted to the faculty of the
Comprehensive Dentistry Graduate Program

Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
in partial fulfilment of the requirements for the degree of
Master of Science
in Oral Biology

June 2020

Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
Bethesda, Maryland

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's Manuscript of

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ACKNOWLEDGEMENTS

Special Thanks To:

- CAPT Michael Rudmann
- CAPT Stephen Yune
- CAPT (sel) William Anderson
- CDR Ling Ye
- CDR Robert Stoner
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June 2020

NAVAL POSTGRADUATE DENTAL SCHOOL

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2020

ABSTRACT

EFFECTS OF ANTERO-POSTERIOR INCISOR POSITION ON ATTRACTIVENESS RATINGS BY ETHNICITY

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Introduction: Establishing a harmonious facial profile is a major objective in orthodontic treatment. As L.F. Andrews proposed, excessive protrusion of the maxillary incisors can impede an esthetic result. However, this finding was based on studies utilizing a population of Caucasians, and it is unclear if this true in other populations.

Purpose: To determine if the ethnicity of either the model or evaluator influence subjective ratings of facial attractiveness when evaluating various antero-posterior positions of maxillary incisors.

Methods: Smile profile photographs of three female models, each of different ethnicity - Caucasian, African American, and Asian - were obtained and digitally manipulated to move maxillary incisors anteriorly by 2mm, 4mm, and 6mm, and posteriorly by 2mm. One hundred fifty layperson evaluators (50 Caucasian, 50 African American, 50 Asian) rated attractiveness of the images using a 0-100mm visual analog scale.

Results: Generally, attractiveness decreased as incisor protrusion increased for all models by all evaluators, regardless of ethnicity. Analysis confirmed a highly significant overall effect of incisor position ($p < 0.0001$). When considering ethnicity, there was no incisor position preference determined by evaluator ethnicity ($p = 0.25$) or effect of same, compared to different ethnicity ($p = 0.80$). There was a preference by all evaluators for -2mm compared to baseline (0mm) for the Asian model, and baseline compared to +2mm for the African American model

($p < 0.0001$). Evaluators preferred all three models at baseline when compared to +4mm and +6mm images (all p values < 0.01).

Conclusions: Evaluator ethnicity had no effect, and model ethnicity had a minimal effect on perceived attractiveness at various incisor positions. All evaluators - Asian, African American and Caucasian - considered incisor protrusion beyond 2mm detrimental to facial attractiveness. A slightly retrusive incisor position was preferred for the Asian model by all evaluators.

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CHAPTER I: LITERATURE REVIEW AND PURPOSE OF RESEARCH

Orthodontic Philosophy

Orthodontic treatment can effectively address malocclusion, improve function, and enhance smile esthetics (Proffit, et al. 2007). Edward Angle, widely accepted as the father of modern orthodontics, postulated that in order to achieve an optimal esthetics, one must correct the underlying malocclusion. He claimed doing so in a patient with a full complement of teeth would naturally lead to an esthetic result (Proffit, et al. 2007).

In more recent times, patient motivation in seeking orthodontic treatment has stemmed from a focus on esthetic outcomes (Nguyen, et al. 1998, Peck and Peck, 1970, Samsonyanova, et al.

2014, Sharma, et al. 2011). With the understanding that “ideal occlusion” as proposed by Angle rarely occurs, the focus has shifted to achieving esthetic results with a potential deviation from what Angle considered to be perfect tooth alignment. (Ackermann, et al. 1999).

Incisor Positioning

Positioning of the maxillary incisors can affect profile esthetics (Cao, et al. 2011, Schlosser, et al. 2005, Ghaleb, et al. 2011). It has been demonstrated that a more protrusive incisor position (Peck and Peck, 1970, Schlosser, et al. 2005, Cao, et al. 2011) and soft tissue profile (Turley, 2015) is considered more attractive than a retrusive incisor position and profile (Peck and Peck, 1970, Schlosser, et al. 2005, Cao, et al. 2011). However, some have found a more retrusive profile to have a neutral (Rathod, et al. 2015) or even a positive effect on perceived attractiveness (Leonardi, et al. 2010, Janson, et al. 2016, Lim, et al. 2008). Considering this variability, a reliable method to predict treatment outcomes is of utmost importance.

Treatment Planning and L.F. Andrews’ Element II

Although ubiquitous in modern orthodontic practice (Keim, 2003) and considered by some to be the ‘gold’ standard for diagnosis (Nijkamp, et al. 2008), identification error and lack of reproducibility has been demonstrated in cephalometric analysis (Trpkova, et al. 1997). It has been argued that cephalometrics has little influence on treatment planning (Nijkamp, et al. 2008, Keim, et al. 2003) and lacks the ability to effectively assess and predict esthetic outcomes (Akan, et al. 2017, Proffit, et al. 2007). Furthermore, variability exists in cephalometric analyses between individuals of different ethnicities. (Alcalde, et al. 2000, Sharma, et al. 2011, Shimizu, et al 2018) Sharma established that cephalometric values differed between Caucasians, Japanese, Nepalese, and even between Nepalese of different ethnic groups. Considering these limitations,

alternative methods of measurement should be considered, preferably utilizing soft tissue points that are fixed and reproducible.

Andrews introduced the concept of the Goal of Anterior Limit Line (GALL) and Forehead Facial Axial point (FFA) as an alternative to traditional cephalometrics and a way to objectively measure soft tissue points in a sagittal view. This analysis utilizes the forehead as a landmark for AP incisor position, which has the benefit of being both readily visible and fixed (Andrews). GALL was introduced as Element II of Andrews' Six Elements of Orofacial Harmony. To determine GALL, a line is drawn parallel to the head's frontal plane, connecting points glabella and the anterior prominence of the maxillary central incisors, or "Facial Axis Point" (FA) in the ideal profile. Starting at FFA (the midpoint of the forehead between superior and glabella), a line is drawn parallel to GALL to determine the ideal posterior limit. According to Andrews, if the maxillary anterior incisors are Element I (all roots are centered over basal bone, and crowns are inclined so the teeth can interface and function optimally) and fall between these two lines, one is considered to have a "good" profile. This would likely indicate that the lips have an ideal amount of support, so good lip posture and an esthetic profile can be anticipated (Andrews, 2001).

Schlosser showed the validity of this concept by digitally manipulating maxillary incisors in a smiling photograph of a model who fit Andrews' criteria. Evaluators preferred the original image and those that manipulated the incisors to a protrusive position. The images that were manipulated to a retrusive position (-4mm) were rated least attractive (Schlosser, et al. 2005). W.A. Andrews (2008) and Adams (2013) also found Andrews' theory to be a good evaluator of attractiveness. Resnick (2018) showed Andrews' concept was consistent with desirable outcomes of orthognathic surgery.

In a different approach to test Andrews' theory, Ellis examined attractiveness ratings by altering the position of glabella while keeping the maxillary incisors fixed in female models of Asian, African American, and Caucasian ethnicities. Statistical significance was seen for a preference in the +6mm image for the Caucasian model, but no difference was seen in the other models. The ethnicity of the evaluators was not considered (Ellis, et al. 2017).

Profile Esthetics by Ethnicity

It is well established that variability exists in facial proportions amongst individuals of different ethnicities (Olusanya, et al. 2018, Moate, et al. 2002, Liew, et al. 2016, Porter, et al. 2001, Rhee 2018). Ethnicity also has the potential to affect an individual's perception of attractiveness (Hall, et al. 2000). Chong et al, showed that ethnicity played a critical role in how attractiveness was perceived between white and Chinese judges when evaluating lip position (Chong, et al. 2014). Nomura et al supported this concept in a study evaluating soft tissue profiles, using both subjects and evaluators of African, Hispanic, and Japanese descent (Nomura, et al. 2009).

However, Sena et al found that ethnicity was not a factor in determining attractiveness when evaluating various photos in which the position of the mandible had been altered (Sena, et al. 2017). Morar utilized computer-generated images of subjects in repose to determine that there is agreement amongst evaluators, regardless of ethnicity, when determining the ideal limit of protrusiveness (Morar, et al. 2011).

The effect of manipulating incisor position on attractiveness ratings, while keeping glabella fixed, has not been thoroughly tested across multiple ethnicities. Andrews' concept has not been proven to be effective in ethnicities other than Caucasian.

Purpose of Research

Effects of manipulating incisor position in relation to glabella is of great significance in planning orthodontic treatment. The usefulness of Andrews' concept in determining a harmonious facial profile, with respect to variations in ethnicity, has not been extensively tested.

The purpose of this study is to determine if changes in the antero-posterior position of the maxillary incisors, from a smiling profile view, impact subjective ratings of facial attractiveness, and if ethnicity has any influence on the determination of perceived attractiveness. The null hypothesis is that there is no difference in attractiveness ratings after changing the antero-posterior position of the maxillary incisors in models of different ethnicities, by evaluators of different ethnicities. This study will aid in determining the importance of ethnicity in the esthetic perception of the horizontal positioning of the maxillary incisors.

CHAPTER II: MATERIALS AND METHOD

The protocol for this research project, which included the selection of models, acquisition of model photographs, and ranking of the photographs by evaluators, was conducted by Ellis and colleagues (Ellis et al., 2017), and Ku and colleagues (Master's thesis 2017) and reprinted with minor changes.

Models

Three volunteer adult female models were selected from orthodontic patient evaluations at the Naval Postgraduate Dental School (NPDS), Bethesda, MD. The models represented different races: Caucasian, Asian, and African American (*Figure 1*). Exclusion criteria included major skeletal deformities and active orthodontic treatment. Each model signed the NPDS release form giving permission to use their photos.



Figure 1

Photographs

Right lateral profile photographs were taken with a Nikon D3300 digital camera (Minato City, Tokyo, Japan) under standard conditions (Schlosser, et al., 2005). The first image was taken in repose and was used to ensure that the patient fell within the inclusion criteria for the study. The second image was a smiling profile photograph, with the patient in full animation. The third image utilized a cheek retractor, affixed with a 100-mm ruler to calibrate for magnification and to assist with incisor position and manipulation. This was utilized to retract the soft tissue in order to reveal dentition posterior to what was revealed in natural, full animation in the second image. (Figure 2)

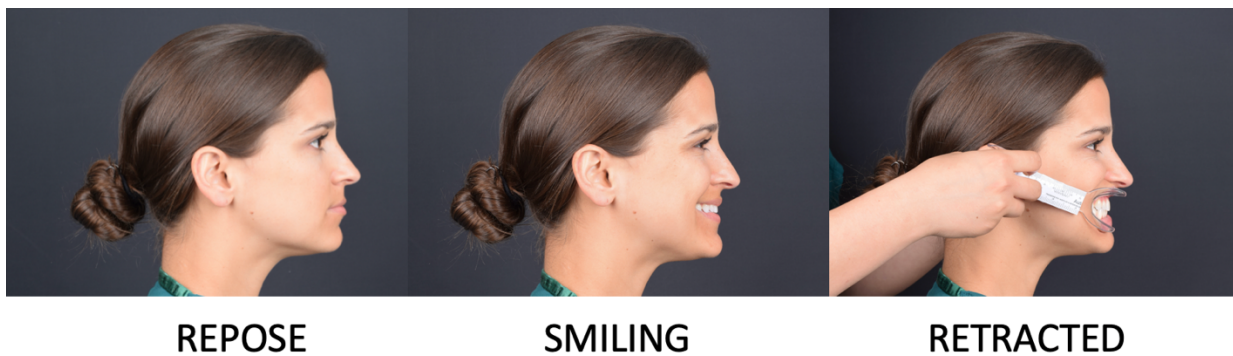


Figure 2

Image Alteration and Presentation

Image alterations and presentation of photographs was conducted by protocol established by Ellis and colleagues (Ellis, et al., 2017) with slight alterations:

The models' smiling profile photographs were altered with a computer graphics program (Adobe Photoshop Version 20.0). Four altered images were created by moving the most anterior plane of the maxillary incisors and the remaining visible teeth in a segment from the retracted image, (-2 mm), (+2 mm), (+4 mm), (+6 mm), and overlaid on the animation-smiling image (*Figure 3*).

The original and four altered images of each model were printed on 8.5" x 11" photo paper. The photos were then randomly organized, keeping all images of each model grouped together, and labeled 1 through 15.

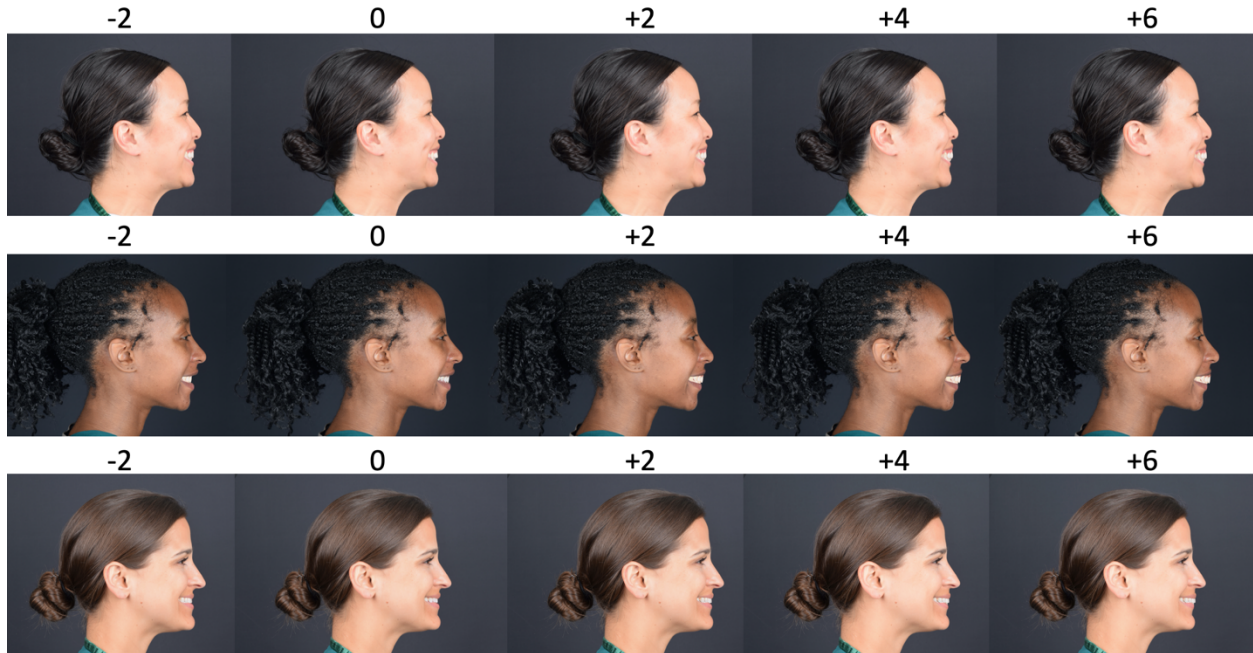


Figure 3

Evaluators

One hundred fifty evaluators - 50 Caucasian, 50 African-American, and 50 Asian - without any professional background in dentistry, were recruited from the Walter Reed National Military Medical Center (WRNMMC).

Rating of Photographs and Data Collection

Each evaluator was provided with the binder of 15 photographs and score sheets. Each score sheet contained written instructions and an area for the evaluator participant to select their self-identified ethnicity (*Figure 4*) and one 100 mm visual analog scale (VAS) per photograph (*Figure 5*). The principal investigator delivered instructions and answered any questions. After the evaluator acknowledged that he or she understood the instructions, no further guidance was offered.

Please circle one. I consider myself to be:			
Caucasian	African American	Asian	None of these

- Please mark the assessment of the subject’s facial attractiveness on the 100 mm visual analog scale. Please mark the closest millimeter marking.
- The attractiveness of the photograph is based purely on the criteria which you deem important.
- You may not return to any previous photographs as you proceed through the binder.

Figure 4

Each evaluator rated the attractiveness of the 15 photographs by placing a vertical mark along the VAS scale, with the 100mm mark representing the highest level of attractiveness and 0mm representing the lowest level. All of the subjects viewed the images in the sequence provided, could take as long as they desired looking at each image, and were not allowed to return to any previously viewed photos, per the protocol developed by Schlosser and colleagues (Schlosser et al., 2005).

Each VAS rating was measured from the 0 line using a 100 mm ruler to the closest millimeter increment. Measurements were entered into a Microsoft Excel spreadsheet for data analysis.

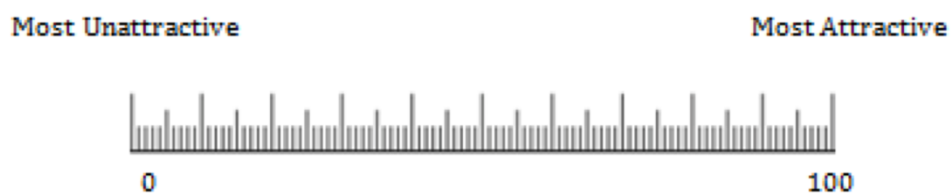


Figure 5

Statistical Analysis

Statistical analysis was done utilizing a mixed effects model to evaluate the variables of ethnicity and incisor position. Paired t-tests were used to evaluate planned comparisons. The R project for statistical computing software, version 3.6.1, was used to calculate the results.

CHAPTER III: RESULTS

Figure 6 shows the results for each group of evaluators based on scaled scores. The y-axis represents scaled attractiveness scores, which were scaled from ratings for the baseline images. Positive values represent ratings that were higher than those of the baseline images, while negative values represent ratings that were lower than those of the baseline images. The x-axis represents incisor position, from -2mm to 6mm. Each group of evaluators is represented in a separate graph, and each model is represented by a different color, Asian in red, African American in green, Caucasian in blue. A general trend is clear, the more the incisors were protruded the less attractive the image was perceived. The line slopes downward moving to the right, towards +6mm. It is apparent that evaluators of all ethnicities had similar preferences, as the lines have similar slopes, other than the Caucasian evaluators' relative preference for the Caucasian model's +6mm image. Overall, there was high significance for incisor position ($p < 0.0001$)

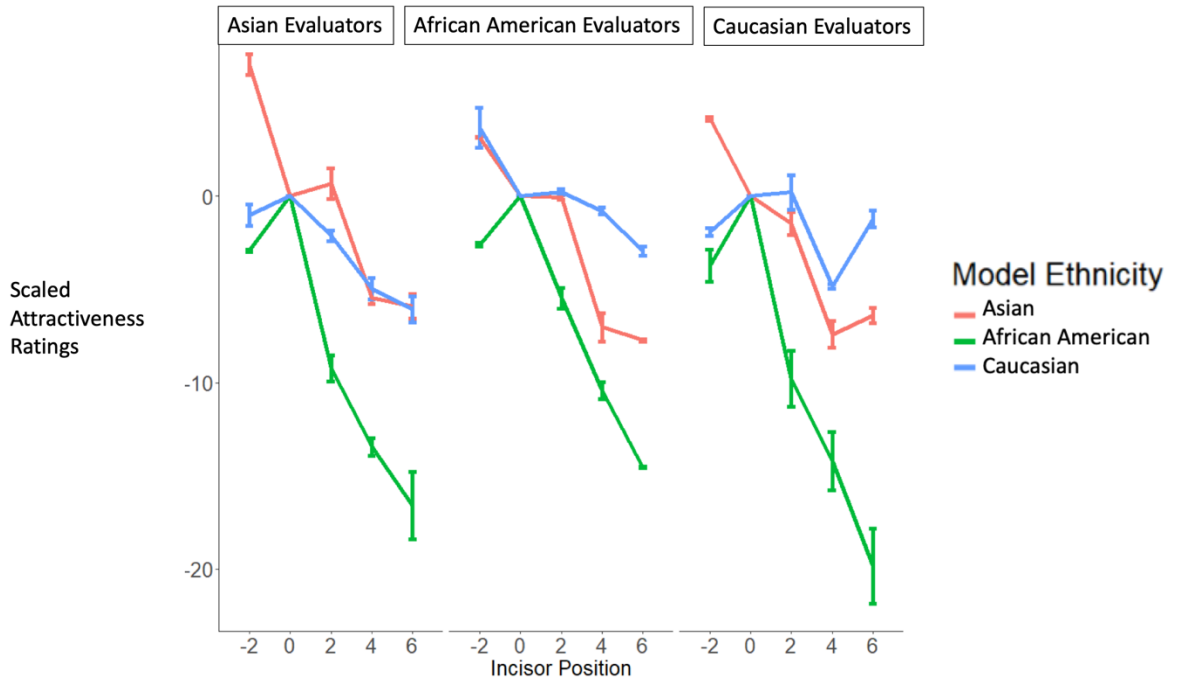


Figure 6

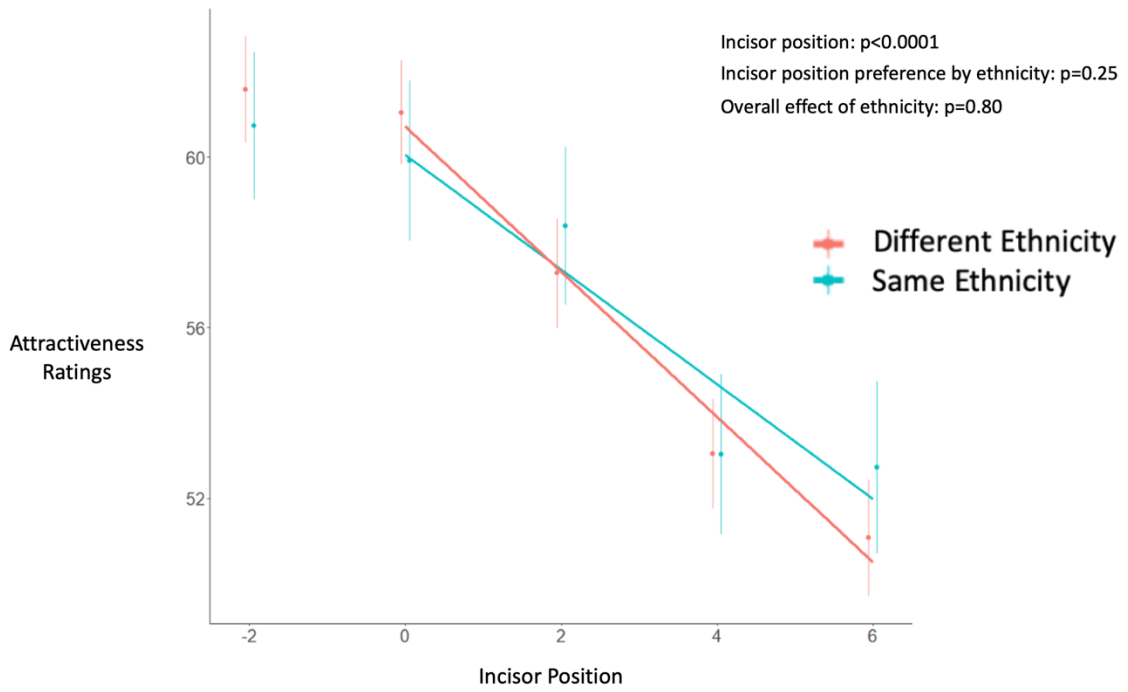


Figure 7

A mixed effects model is shown in *Figure 7*. This graph represents a comparison of the effects of same vs different ethnicity while taking incisor position into account. The y axis represents raw attractiveness ratings from 0 to 100. The x axis is incisor position, from -2mm to 6mm. Each point represents the mean scores for the model being evaluated, as perceived in red by evaluators of a different ethnicity as the model, and green by evaluators of the same ethnicity as the model. The vertical lines represent standard error. For both groups, there is a clear decline in scores as the incisor position is changed from 0 to +6mm, especially beyond 2mm. The slopes of both lines are similar, indicating no effect of same ethnicity vs different ethnicity. Overall, incisor position was highly significant, with a p value of less than 0.0001. Incisor position preference was not significantly affected by evaluator ethnicity, with a p value of 0.25, and the overall effect of ethnicity was not significant with a p value of 0.80. Since the linearity did not include the -2mm images, paired analyses were performed to elucidate their effect.

Comparing the ratings of the same ethnicity vs. different ethnicity for incisor position, there is no statistical significance in preference ($p=0.25$). The raw attractiveness scores were also not influenced by ethnicity ($p=0.80$). (*Figure 7*).

Evaluating specific paired analyses, the scatter plots seen in *Figures 8-12* were calculated from the paired t-test and determines the mean difference between two observations. This allow us to more clearly see evaluator preferences between two images for particular models. The first scatterplot looks at images for the Asian model. The y-axis represents attractiveness ratings for the -2mm image, while the x-axis represents the attractiveness ratings for the baseline image. Each dot represents an evaluator. Whichever side of the diagonal line has a higher concentration of dots tells us which image was preferred. For the first comparison, there are more dots on the

blue side of the diagonal line, so we know evaluators preferred the -2mm image for the Asian model. This produced a statistically significant p-value ($p < 0.0001$).

For the African American model, comparing -2mm on the y-axis vs baseline on the x-axis, baseline was preferred and produced a statistically significant p-value ($p < 0.0001$). (Figure 9).

For the Caucasian model at -2mm on the y axis vs baseline on the x-axis, there is no clear difference in preference, as supported by the p-value ($p < 0.0001$). (Figure 10).

Plots for all models at +4mm on the y axis vs baseline on the x-axis are combined in (Figure 11) and plots for all models at +6mm on the y-axis vs baseline on the x-axis are combined (Figure 12). It is clear that for all models, baseline was preferred and produced a statistically significant p value ($p < 0.0001$).

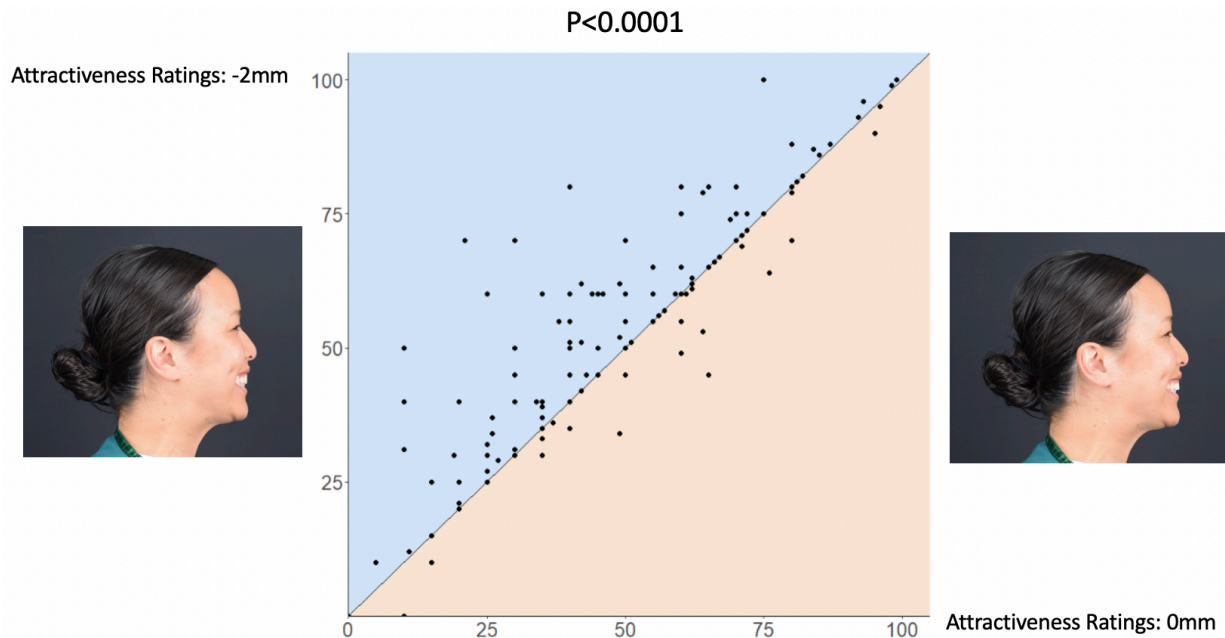


Figure 8

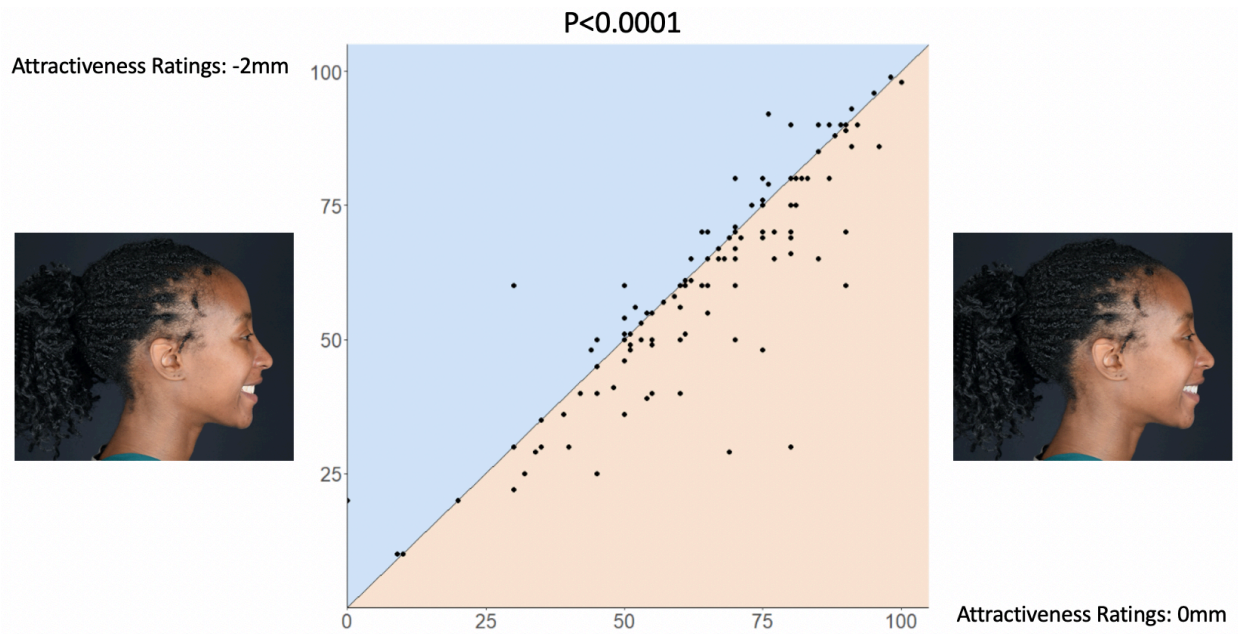


Figure 9

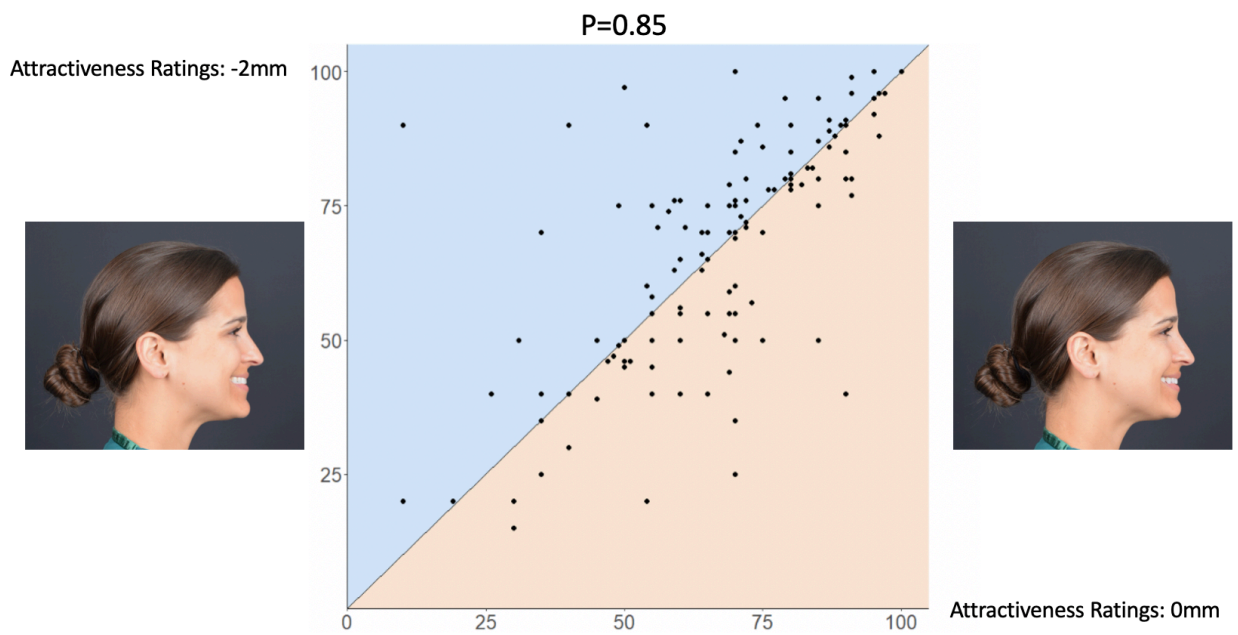


Figure 10

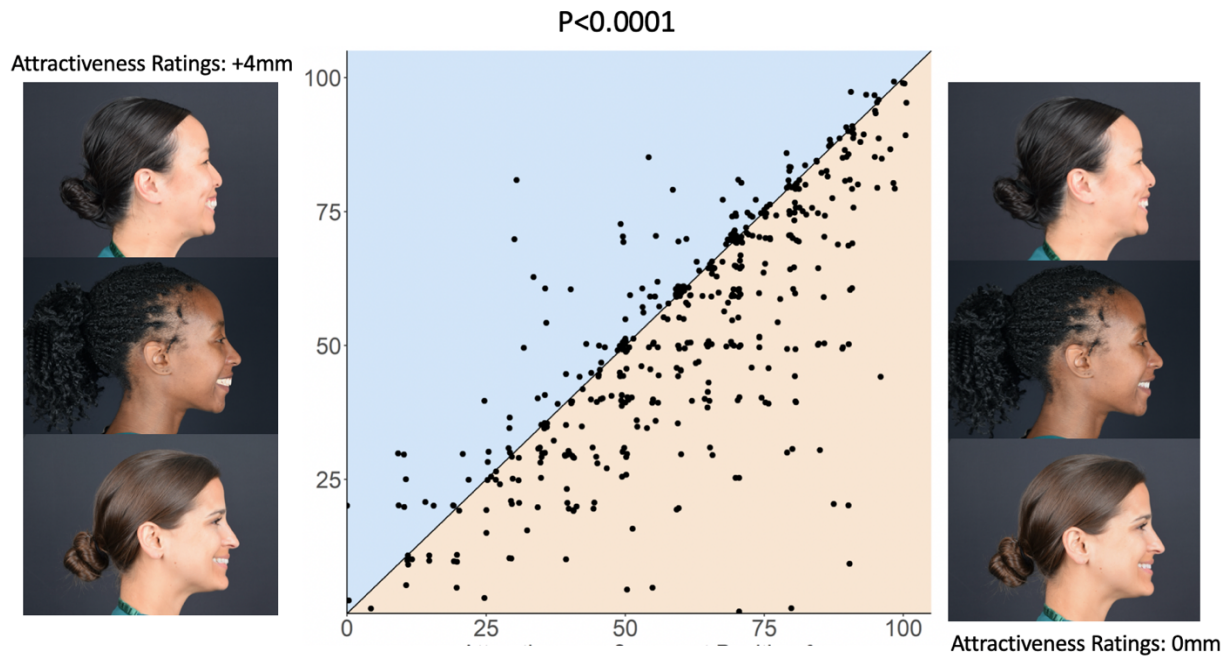


Figure 11

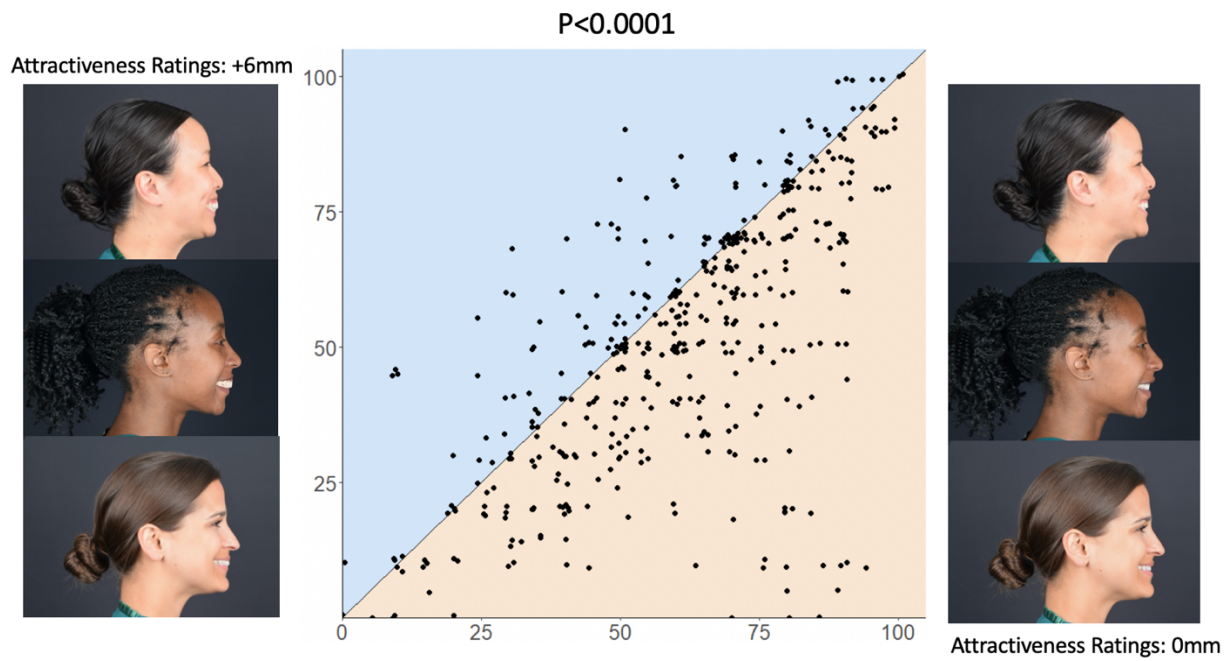


Figure 12

To summarize the results, there was some variability in preferences for the images between -2mm, baseline and +2mm. For the Asian model, -2mm was preferred. For the African American model, baseline was preferred. For the Caucasian model, there was no clear preference between -2mm, baseline and +2mm.

CHAPTER IV: DISCUSSION

The objective of determining if a statistically significant difference in the perceived attractiveness levels between various incisor positions was met. Generally, a more natural appearance (0, -2mm, +2mm) was favored by all evaluators for all models. Independent of model or evaluator, there was a statistically significant decrease in the ratings of perceived attractiveness as the amount of protrusion exceeded 2mm ($p < 0.0001$). This finding supports the concept that excessive maxillary incisor protrusion disrupts facial harmony.

Considering the concept of Andrew's goal of anterior limit line (Figure 13) we can see that at baseline, the incisors of the Asian model are well anterior to the ideal anterior limit. The incisors of the African American model are closer to this line, and the incisors of the Caucasian model are at the ideal anterior limit.

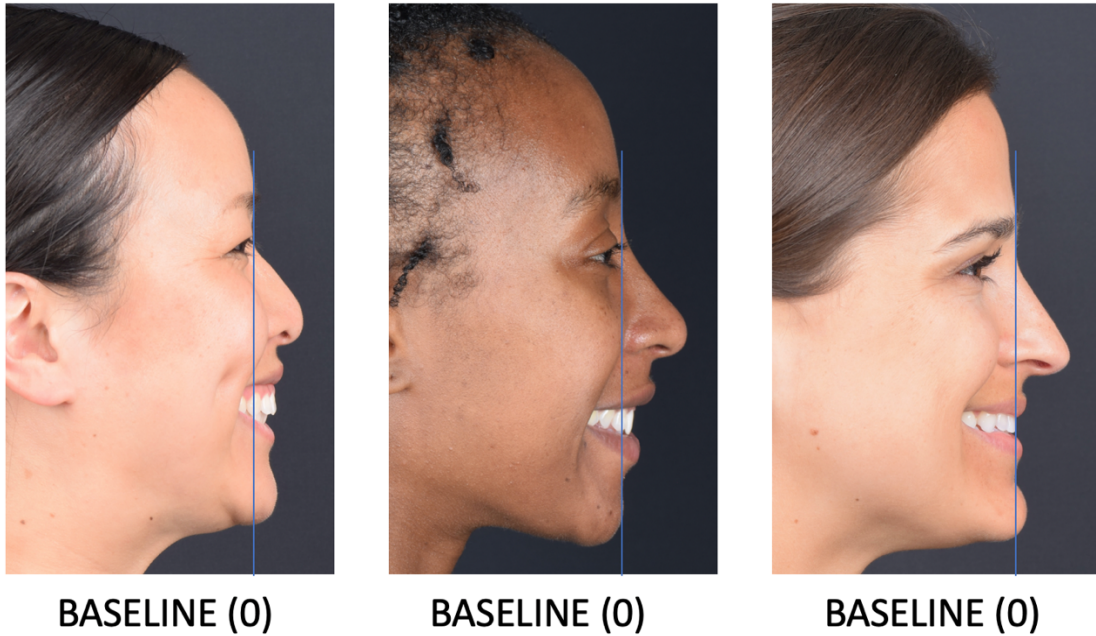


Figure 13

Comparing the images of the Caucasian model at baseline, +4mm, and +6mm (*Figure 14*), it is clear that the +4mm and +6 mm images fall anterior to the goal of anterior limit line. This is consistent with Andrews' philosophy of what determines a 'good' profile, as the evaluators showed significant preference for the baseline image over the +4mm and +6mm images.

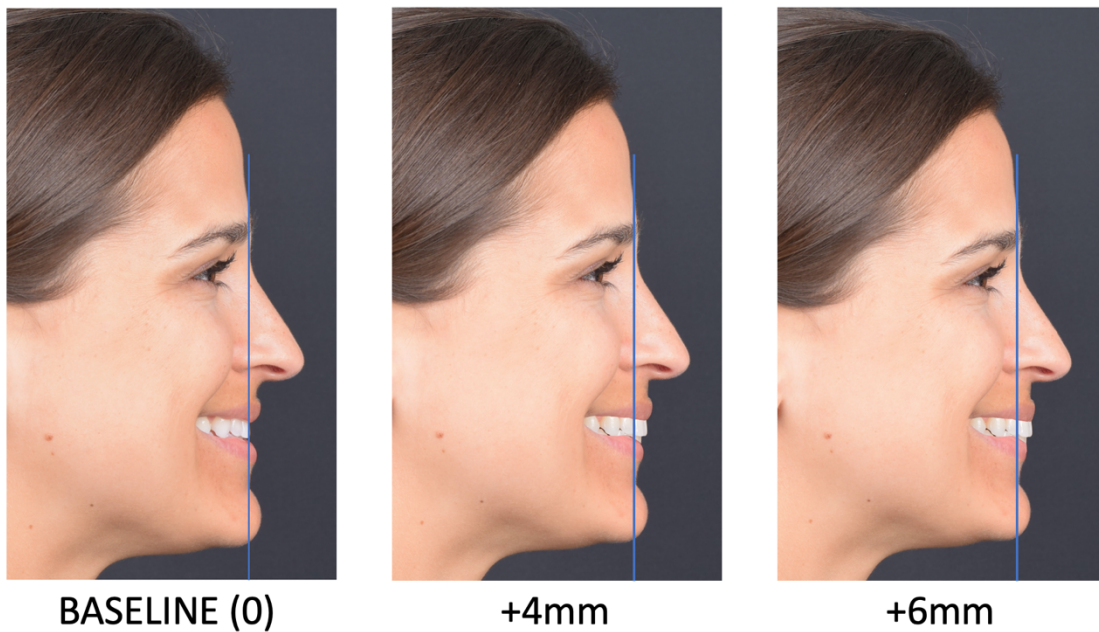


Figure 14

The retrusive position of the Asian model was preferred, which is consistent with previous research, specifically the findings of Chong (2014) and Lim (2008). It also supports the concept of Andrews' goal of anterior limit line. Compared to baseline, the retrusive (-2mm) image was closer to the parameters that determine an esthetic profile, according to Andrews.

However, for the African American model, the baseline image was preferred over the retrusive (-2mm) image, despite the fact that the -2mm image was closer to Andrews' GALL. This can possibly be explained by the fact that the African American model is the only model of the three that had a convex facial profile at baseline, which might have made the retrusive manipulation more obvious to the evaluators and was exacerbated by the fact that the soft tissue was not manipulated. The result may have been a less natural appearance that was noticed by

evaluators. Although lip support is difficult to predict, as discussed by Schlosser (2005), manipulating the lip along with the incisors in this model might have produced a more esthetic result that reflects Andrews' concept. The applicability of Andrews' GALL for ethnicities other than Caucasian is still unclear.

This study failed to show statistical significance that the ethnicity of the model or evaluator plays a role in determining a preference for attractiveness levels when incisor position is manipulated. This is consistent with the findings of Morar (2011), who concluded that, although a protrusive limit exists when determining attractiveness, it is not dependent upon the ethnicity of the subject and/or evaluator. Morar's study illustrated this with computer generated images in repose, while the current study did so with computer modified images of smiling photos. Combining the findings of Morar (2011) with the present study supports the observations of Ackermann, et al. (1999) that the soft tissue profile is influenced by incisor position.

Some limitations existed in this study. Since only one model per ethnicity was used, we cannot definitively claim that the trends we noticed between the models are of great significance. Since only the horizontal dimension of incisors was changed, we are still uncertain about the effects of manipulation of the vertical component of incisors. Since lip position was not altered, the images were likely not realistic representations of how incisor position influences lip support, a potential confounding factor in the preference for the baseline over -2mm image of the African American model.

CHAPTER V: CONCLUSION

The null hypothesis for this study cannot be rejected. There was a general trend showing that the less the incisors were protruded, the higher they were ranked and the more they were protruded, the lower they were ranked. The notion that perceived attractiveness decreases beyond a considerable magnitude of protrusion can be supported. Although some variation in preferred incisor position between models was seen, there is insufficient evidence to conclude that ethnicity has a clear effect on perceived attractiveness. Further studies should be performed to include more models of each ethnicity, modify lip position in conjunction with incisor position, and evaluate the effect of manipulating the vertical component of incisors.

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