

A QUALITATIVE ASSESSMENT OF ORTHODONTIC
RESIDENTS' SELF PERCEPTIONS OF FACIAL FEATURES

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ABSTRACT

Mankind has always sought ways to improve appearance. These esthetic goals have been ever-present throughout our history and have evolved dramatically over time. The teeth and smile have always been a central focus in the way we view ourselves and others. Thus, we have appropriately sought ways to improve upon this appearance and alter the look of our teeth. Although orthodontics has evolved greatly over time, the goals of this specialty continue to change as paradigms shift. The subjective nature of treatment success and the judgment of an individual patient's outcome illustrate the importance of a qualitative approach. The purpose of this study was to elucidate the factors that influence facial preferences and self-perceptions, in order to maximize patient-doctor communication and treatment goals. Eleven orthodontic residents participated in a sculpture course and subsequent interviews to determine how they qualitatively analyze faces. The residents enlarged the most liked, important, and defining internal features (nose, eyes, and mouth) in their respective clay busts. A self enhancement bias was observed in the form of thinned faces and improvements in the shape and size of certain sculpted features. The importance of symmetry, averageness, and sexually dimorphic (primarily feminine) alterations were witnessed. The reliance on expression to convey personality was seen in all of the women that participated in this study. Facial distinctiveness was increased by accentuating liked or defining facial features and over-exaggerating disliked features, as in a caricature. The accuracy of a residents' perception was greatest in a frontal two dimensional view but decreased markedly in three dimensions. Residents prioritized physical characteristics over personality traits. Residents were able to correctly identify which features were the least

accurately recreated in the bust and closely estimated the measurement differences. The results of this study illustrate the importance of employing carefully structured interviews and evaluations to psychologically analyze patients considering treatment.

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CHAPTER 1

INTRODUCTION

The most important motivation for patients to seek orthodontic treatment is an improvement in their dental and facial appearance (Burden, 1995). Standards of facial esthetics and patient expectations are equally difficult to elucidate. It is important for the orthodontist to determine a patient's desired outcome so that an acceptable treatment result can be delivered.

Proper communication is vital to understanding the desires of patients so that we can efficiently meet their expectations. Successful treatment is defined by the perception of the patient and not by treatment mechanics, cephalometric measurements, final casts, or ABO scores (Lempert, et al., 2002). The esthetic outcome of orthodontic treatment is ultimately assessed qualitatively. Most orthodontic research and clinical findings, however, are conducted quantitatively. The vast majority of orthodontic residencies and resources have been dedicated to a system of standards and measurements that are vastly different from the patient's perception of treatment outcome. Although qualitative research data can be gathered through a vast number of methods, interviews and surveys have been the basic tool for collecting this information (Atkinson, Coffey, and Delamont 2001).

The purpose of this study is to explore how orthodontic residents assess the soft tissues and how they define themselves. The self perceptions and preferences of orthodontic residents in regard to their facial characteristics will be investigated. This study will attempt to evaluate the accuracy and ability of residents to recognize their own

facial characteristics in three dimensions, as well as determine the effects of gender on self perception. These complicated questions could best be studied by interviews and three dimensional analyses.

Each of the eleven orthodontic residents enrolled in the spring semester of 2010 created a life-size bust of themselves during a sculpture course. The busts represented a self study of each resident that was both three dimensional in sight and in tactile sense. These sculptures and a structured interview with each resident were used to discuss their self perception. This information could provide a valuable tool for orthodontists to communicate with their patients and arrive at a mutually acceptable treatment outcome. A better understanding of these concepts will help orthodontists to better educate their patients about what results are realistic, and what may be unattainable through orthodontics alone. This research will help to explain an important aspect of treatment where there is no literature currently available.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Historical Perspective on the Analysis of Facial Esthetics

2.1.1 Ancient Artwork: Body Measurements and Canons

The concept and interpretation of beauty and symmetry of the human face was studied as far back as we can find in human history (Caltagirone and Kostecki, 1955). A complex system known as the canon was used in ancient Egyptian artwork to depict proportions of the human body (Moorrees, 2006). Measurements and grid systems were established to standardize the human figure and face.



Figure 1. Egyptian Canon

This system allowed for easy transfer of images and could be scaled to any size (Moorrees, 2006). Statues of kings from Egypt's Old Kingdom (2600-2000 B.C.) were portrayed using "ideal" proportions and later sculptures of Queen Nefertiti (1370-1330

B.C.) exhibited facial features that would become modern standards of beauty (Peck & Peck, 1970). In fact, Nefertiti's name literally translates to the "Perfect One". Many aspects of ancient measurements can also be found in modern clinical anthropometric proportions (Vegter and Hage, 2000).



Figure 2 Queen Nefertiti

The Egyptian principles for the canons, that defined artistic human form, greatly influenced the Greeks and Romans (Vegter and Hage, 2000). This influence can be seen in the works of early Greek sculptors like Polykleitos (450-420 B.C.), who also tried to achieve ideal physical proportions through mathematical divisions. In his writings he reported the importance of symmetry in the human form (Naini, Moss, & Gill, 2006). His famous sculpture of Doryphorus (The Spear Bearer) exhibited his ideal body proportions and was copied many times because of its beauty (Edler 2001). The height of the face is one-tenth of the length of the body. The height of the head is one-eighth of the body and the head and neck together are one-sixth of the length of the entire body (Vegter and Hage, 2000). These ratios are still considered ideal.

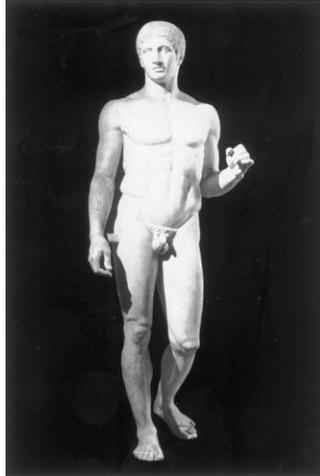


Figure 3 Doryphorus “The Spear Bearer”

The Greek sculptures of the fourth and fifth centuries B.C conformed to these strict standards for ideal bodily proportions and their facial features were later recognized by early orthodontists, such as Edward Angle (Peck & Peck, 1995; Peck & Peck, 1970). It was also the Classical Greek philosophers Aristotle and Plato that first defined the study of beauty and the philosophy of art, as “esthetics” (Peck & Peck, 1970).

2.1.2 The “Gold-en Proportion”

The concept of a “divine proportion,” or “golden proportion,” was first recorded in the third century BC by the Pythagoreans and later by the Greek geometrician Euclid (325-265 B.C). In fact, the presence of the golden proportion in Egyptian architecture suggests an even earlier awareness of this ratio (Vegter and Hage, 2000). The calculation was used to describe their ideal of perfect harmony and considered the most attractive ratio between parts of a whole to the human eye and mind (Wahl 2006). The ratio of 1:1.61803, designated the Greek letter phi (Φ) after the sculptor Phidias, is defined as the

proportion between the length or dimension of two unequal parts, such that the lesser part divided by the greater part was equal to the greater part divided by the total sum of both parts. Mathematically, this equation can be described as a line ABC that is cut such that $AB/AC=BC/AB$ (Bashour 2006). The Parthenon in Athens, Greece is perhaps one of the most famous examples of a building architecturally designed according to the golden proportion (Vegter and Hage, 2000). Its application to the study of human facial form can be attributed to the work of Luca Pacioli (1446-1517) (C. F. Moorrees 2006, Naini, Moss and Gill 2006, Wahl 2006). His early 16th century composition, *De Divina Proportione*, featured figures of proportionate faces and bodies. These images were drawn by Leonardo Da Vinci, who also believed in using the divine proportion when depicting human form (Naini, Moss and Gill 2006).

2.1.3 Renaissance Artwork: Ideal Facial Proportions

The next major artistic development of the canons occurred during the Renaissance period that spanned the 14th to 17th centuries. A number of artists from this period, including Alberti, Cousin, Audran, della Francesca, Pacioli, Cennini, Savonarola employed these neoclassical canons (Bashour 2006). Specifically, the 15th century contributions of Leonardo Da Vinci (1452-1529) and Albrecht Dürer (1471-1528) had the greatest impact on the analysis of facial esthetics (Peck and Peck 1995, Wahl 2006). Da Vinci extensively studied the shapes and proportions of the human body and head. His famous “human figure in a circle” illustrated the proportions in human form and symmetry recorded by the Roman architect Vitruvius during the 1st century B.C. (Howe 1999). In this figure, the vertical face height was equal to the length of the hand and, as Polykleitos prescribed, was one-tenth of the total body height (Naini, Moss and Gill

2006). Leonardo Da Vinci's facial and bodily proportions were based on actual measurements taken from human bodies and related to one another.

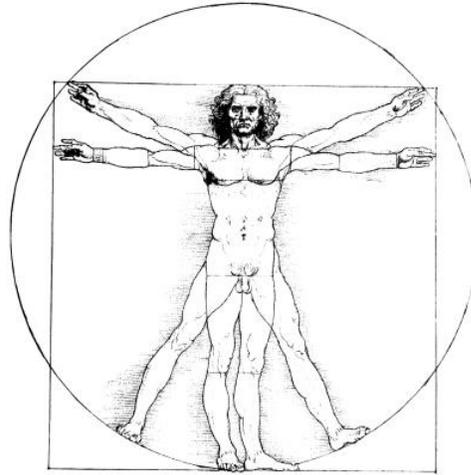


Figure 4 Vitruvian Man

Other Da Vinci works, *The Proportions of the Head* and *Study of Horse and Horseman*, also used a coordinate grid system to obtain correct facial proportions (C. F. Moorrees 2006, Naini, Moss and Gill 2006, Wahl 2006). The face was divided using horizontal and vertical lines. The width of the mouth equals the distance from the edge of the chin to where the lips meet, and the height of the ear equals the length of the nose in a properly proportioned face. Additionally, the face can be sectioned into thirds from the hairline to eyebrows, eyebrows to nasal base, and nasal base to inferior chin (Vegter and Hage, 2000; C. F. Moorrees 2006; Naini, Moss and Gill 2006). Although these facial thirds are identical to those that are used in modern day orthodontic and surgical profile analyses, Da Vinci himself could not deny the natural variations of nature (Proffit, Fields and Sarver 2007).

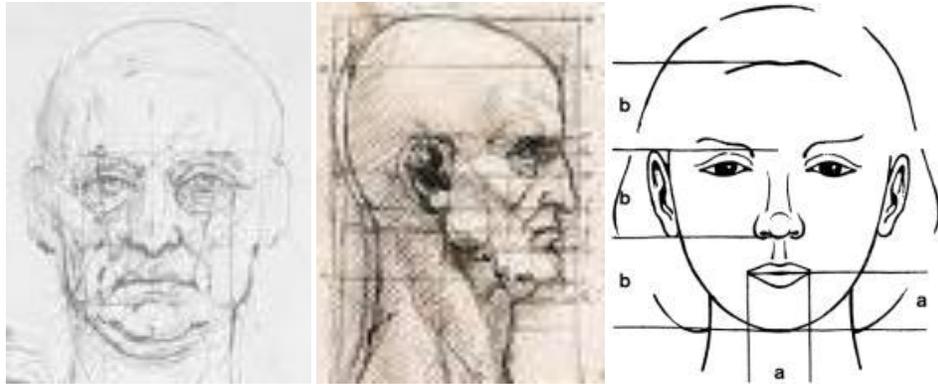


Figure 5 Proportions of the Head

Albrecht Dürer also contributed greatly to the analysis of facial esthetics and proportions with his own coordinate system. Like Da Vinci, Dürer recognized that the face could be divided vertically into equal thirds. He further divided the lower third into four equal parts. The length from the base of the nose to the edge of the chin could be divided in half at the mental sulcus and the superior portion could be further halved where the lips parted. He also found that the length of one eye equaled the width between the eyes (Vegter and Hage, 2000).

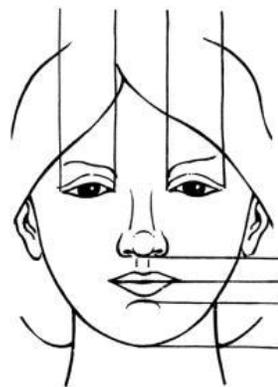


Figure 6 Proportions of the Face

He used his coordinate system to illustrate the difference between a retroclined and a proclined face in profile. Dürer was the first to propose that a single angle could characterize a person's facial morphology. His facial angle was composed of a tangent line from the forehead to the nose that intersected a line from the chin to the upper lip. His drawings provided a revolutionary perspective on the analysis of facial form that would later serve as a basis for cephalometric analysis (C. F. Moorrees 2006, Wahl 2006).

Dürer understood the subjectivity involved in the assessment of facial beauty, but still believed that facial proportions could be analyzed objectively (Naini, Moss and Gill 2006). He was the first to depict the proportional differences between a leptoprosopic (long and narrow) and a euryprosopic (short and broad) face (C. F. Moorrees 2006, Wahl 2006). He believed that properly proportioned faces were more esthetic than disproportionate faces and his ideas of proportionality in facial esthetics still shape our present goals in the field of orthodontics.

2.1.4 Eighteenth and Nineteenth Centuries: Physical Anthropology

Physical anthropology emerged in the 18th and 19th centuries as the scientific study of race. The studies of facial form at this time were taken predominately from direct measurements of skulls. Very few soft-tissue measurements were performed during this era (Vegter and Hage, 2000). One of the greatest contributors to this area of study was an anatomist, physician and painter named Petrus Camper (1722-1789). His standardized studies of human crania were oriented by a line that connected the lower boundary of the nose with the external auditory meatus (i.e. Camper's horizontal). He

also introduced the facial line, or *linea facialis*, which extended from the frontal bone to the edge of the maxillary incisors. Camper measured the facial angle formed between these two lines in a large number of skulls and used it to describe facial profiles. These measurements were used by Retzius when he defined the terms “prognathic” and “orthognathic” and provide a universal standard for studying facial form (C. F. Moorrees 2006, Wahl 2006). It was Paul Topinard (1830-1911) that finally included soft-tissue measurements in his *Elements d'anthropologie generale* (Bashour 2006).

2.1.5 Twentieth Century: Objective Measurements and Proportions in Facial Plastic Surgery

The father of modern rhinoplasty (“nose job”), Jacques Joseph (1865-1934), placed strong emphasis on the importance of the nasal profile in facial esthetics. Joseph, like his predecessors discussed above, also considered the length of the nose to be equal to the length from the base of the nose to the edge of the chin. Additionally, he subdivided the nose into three main components: the bony part, the septal cartilaginous part, and the cartilaginous and soft-tissue tip. Joseph described the consequences of deformities of any of these three parts to facial cosmesis, and presented his own depictions of what he considered to be the ideal nasal shape. His studies related the esthetics of various inclinations of the nasal bridge to the general profile line (Vegter and Hage, 2000).

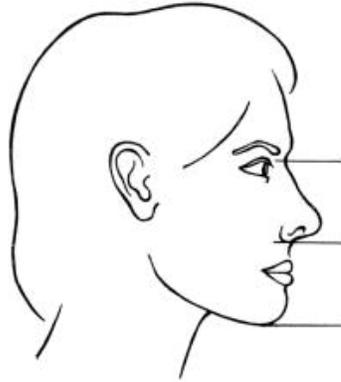


Figure 7 Proportions of the Nose

The concept of profileplasty was introduced by Mario González Ulloa (1913–1995), who stressed the importance of entire facial profile surgical correction. He felt that glabella, subnasal point, and pogonion should ideally be placed on a line perpendicular to Frankfurt horizontal. He applied this principle for facial corrections in his Mexican patients with satisfactory results. It is important to note however, that although the results were considered successful in this population, application of these same principles to other ethnic groups would not have yielded an esthetically acceptable outcome (Vegter and Hage, 2000).

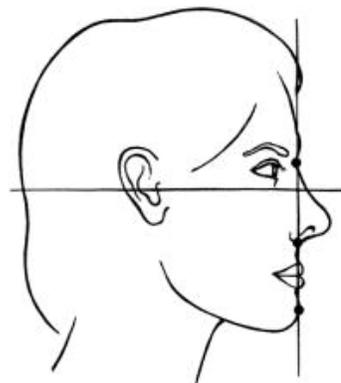


Figure 8 Profile Relationships

Modern craniofacial and soft-tissue anthropometry was most influenced by Leslie G. Farkas (1915-2008). His contributions established our current understanding of the craniofacial complex (Naini 2010). He defined standards for nearly every imaginable soft-tissue measurement and index ratio in the head and face (Bashour 2006). Farkas measured and compared more than 100 dimensions and proportions in hundreds of people and authored more than 120 publications. His studies offered information about the esthetics of women's faces and compared normal and attractive characteristics. He revised the neoclassical canons for facial proportions in art in order to correlate them to current norms in various ethnic populations. Additionally, his extensive work included the role of anthropometry in the evaluation of lateral facial dysplasia and cleft lip and palate disorders (Vegter and Hage, 2000; Farkas 2000). The craniofacial normative data that he collected on children and adults, different ethnic groups, and various craniofacial deformities continue to be used as guidelines in reconstructive and esthetic surgery (Naini 2010).

2.2 History of Facial Esthetics in Orthodontics

2.2.1 Cephalometric Standards

Orthodontists began to take quantitative measurements of structural changes in the facial skeleton on radiograms in the first decades of the 20th century. The study of dried skulls by craniometry and facial anthropometry were adapted to indirect head measurements taken from live subjects oriented in lateral radiographs. These cephalometric techniques, introduced by Birdsall Holly Broadbent, Sr. (1894-1977) in 1931, recorded the shadow images of both hard and soft tissues of the head and face

(Bashour 2006, Vegter and Hage 2000). The films provided a tool for the standardized evaluation of dentofacial proportions and malocclusions and some of the first analyses of these relationships were devised by Lucien de Coster and William B. Downs (Moorrees, 2006).

Cephalometry became the focus of countless studies and systems to quantify and evaluate growth and harmony of dentoskeletal and facial tissues (Bashour 2006, Vegter and Hage 2000). In 1949, Downs published *Variations in Facial Relationships: Their Significance in Treatment and Prognosis*, which attempted to determine the relationship of the dentures to the facial skeletal pattern (Downs 1949). Downs stressed that proper occlusion must not be achieved at the expense of the facial profile. Downs emphasized that “the ten figures used in the appraisal to describe skeletal and dental relationships as single readings are not so important: what counts is the manner in which they all fit together and their correlation with type, function and esthetics” (Downs, 1956). In 1955, another analysis was developed by Viken Sassouni that examined both vertical and horizontal relationships in a well proportioned face (Proffit, Fields and Sarver 2007).

A plethora of cephalometric analyses have been developed to evaluate facial harmony and dento-skeletal relationships, and enhance diagnosis and treatment planning. It was believed that these numerical measurements would provide orthodontists with standards for tooth placement and that optimal soft tissue harmony would be the end result (Steiner, 1953; Tweed, 1954; Downs, 1956). Contrary to these beliefs, a large body of recent literature has arrived at a quite different conclusion. It is the soft tissue, which can vary considerably in thickness that dictates the majority of esthetic outcomes that result at the end of treatment (Burstone, 1978; Ricketts, 1968; Holdaway, 1984).

Treatment of 30 adolescent patients that established lower incisors at 1.5mm anterior to the point A-pogonion line, resulted in a large variability, 10mm, in the final lip position. Although all of the individuals were treated to the same hard tissue standards the resultant esthetics produced were neither desirable nor reproducible (Park and Burstone, 1986). Therefore, it is important to separate dental, from skeletal, from soft tissue problems, and recognize the difference between analogous and homologous malocclusions, which can require special considerations and unique treatment strategies (Ackerman, 1969).

Although cephalometric films are useful, they represent an oversimplified and limited two dimensional (2-D) view. Additionally, many of the analyses were based upon a relatively small collection of “norms” for a given population. An orthodontist must account for the individual norms that come from specific characteristics of the actual patient (Moorrees, 2006).

2.2.2 Hard Tissue Standards

The father of modern orthodontics, Edward H. Angle (1855-1930), stressed the importance of ideal dental occlusion and considered it ‘nature’s intended ideal form’ (Ackerman, Proffit and Sarver 1999). Angle adamantly asserted the importance of a full complement of 32 teeth, a viewpoint he shared with Moses, who originally discussed this concept back in 1640 B.C. (Weinberger, 1926). He felt that a full complement of teeth was necessary to achieve proper occlusion and that esthetic facial harmony and balanced proportions would follow naturally. Angle used the neoclassical Greek statue of the bust of Apollo Belvedere and the skull ‘Old Glory’ to illustrate these views (Angle, 1907).

Angle also enlisted the help of his artist friend, Edmund H. Wuerpel (1866-1958), to formulate a concept of facial beauty and harmony. Wuerpel advised Angle of the individuality of faces and that a universal analysis and classification of esthetic faces was impossible (Wuerpel 1981, Wahl 2006).

Perhaps Angle's greatest contribution to modern orthodontics was his classification of three basic occlusal deviations in the anteroposterior dimension, which he termed malocclusion (Ackerman, 1969). This system was used to describe the sagittal relationship of the underlying dental and skeletal components as either, Class I (orthognathic), Class II (retrognathic), and Class III (prognathic), and is still in use today (Bashour 2006). Angle and his followers believed that the attainment of a Class I, functional occlusion was the main goal of orthodontic treatment, and that the rest of the face would develop and adapt in harmony with the established occlusion (Brodie 1956, Peck and Peck 1995). It has been recently shown however, that occlusal relationships do not correlate with facial attractiveness or esthetics (Tolleth 1998).

In 1972 Lawrence Andrews devised "The six keys to normal occlusion", in which he outlined the goals of successful orthodontic treatment. These guidelines were based upon the classifications set out by Edward Angle, who established a proper occlusion (Class I) as the mesiobuccal cusp of the upper first permanent molar in line with the groove between the mesial and middle cusps of the lower first permanent molar. Andrews built upon this concept and added the importance of mesiodistal tip or angulation of the long axis of the crowns, labio/buccolingual inclination of the long axis of the crowns, the absence of spaces or rotations, and a flat to light curve of Spee to the occlusal plane. Although Andrews acknowledges the vast differences among people, "as one of a kind as

snowflakes”, he believes we should strive to accomplish as many of these goals as possible (Andrews, 1972). Although Andrew’s six keys built upon Angle’s concepts to provide a more detailed view of normal occlusion in three dimensions of space, it still disregards the relationship of the teeth to the face.

In a 1912 report to the British Society for the Study of Orthodontics, Norman Bennett suggested that malocclusions be classified with regard to deviations in all three dimensions (transverse, sagittal, and vertical). Simon added, in his system of gnathostatics, that the teeth be related to the rest of the face and cranium. Later, in 1969, Ackerman and Proffit described another system of diagnosis in which nine different classification groups related the alignment and profile to deviations in all three planes of space (Ackerman, 1969).

2.2.3 Soft Tissue Standards

As early as the 19th century, the correction of aberrant facial proportions was a goal of orthodontists (Proffit, Fields and Sarver 2007). According to Norman Kingsley (1825-1896), esthetics and facial appearance were the primary goal of orthodontic treatment and articulation of the teeth was secondary (Kingsley 1880). This view was shared by Calvin Case (1847-1923), who published *The Esthetic Correction of Facial Contour*, in which he discussed the improvement of soft tissue profiles by moving teeth (Peck and Peck 1995; Moorrees, 2006; Wahl, 2006). Case described the use of prosthetics to treat cleft palates, an application he termed “dentofacial orthopedics” (Goldsmann, 1959). In opposition to the Angle paradigm, Case emphasized the importance of facial contours in orthodontic treatment objectives. Case also criticized Angle for not paying proper

attention to facial esthetics and his objection to treatment by extraction when indicated. Case proclaimed that the only true basis of diagnosis was the real position of the dentures in relation to facial outlines, lending little weight to Angle's classification of malocclusion (Bernstein, 1992).

Another opponent of Angle was Charles H. Tweed (1895-1970), who also understood that facial esthetics was the primary goal of orthodontic treatment. Tweed adopted the flat Apollo-like face as a representative of ideal facial esthetics and appreciated that extractions were often necessary to achieve proper facial contours and occlusion (Peck and Peck 1995). The Tweed philosophy attempted to improve stability of the dentition by uprighting the mandibular incisors to achieve the maximum in balance and harmony of facial lines (Gebeck, 1995). The limitations of treatment are determined by the dimensions of the denture bases within bone, muscle and most importantly soft tissue (Merrifield, 1994).

Charles Tweed, P.R. Begg, Robbert Strang, Hays Nance, Calvin Case, Matthew Cryer, T.E. Constant and others have all been proponents of extraction treatment, discarding methods of arch development or expansion because of instability, poor facial esthetics and iatrogenic or undesirable periodontal effects (Bowman, 1999; Bernstein, 1992). Others, such as Edward Angle and A.E. Ketcham have vehemently opposed the removal of sound teeth in orthodontic treatment (Bernstein, 1992). The pendulum has swung back and forth over the years. Extraction rates have at times reached highs of 60% to 80%, and more recently declined to below 30% (Peck, 1979; O'Connor, 1993).

The literature shows that extraction treatment is not found to “dish-in” profiles or have any detrimental effects on facial esthetics. Most studies show that the judicious use of extractions improved patient profiles and led to more stable results. In cases of crowding and excessive lip protrusion only extraction treatments had the capacity to reduce the profile (Bowman, 1999). The width of the arch, the relationship of the dentition and the mouth during smile, and the buccal corridor are unaffected by extraction (Johnson, 1995).

The fundamental difference between these conflicting theories is the quintessential argument of what comes first- the chicken or the egg. Case and others believed that facial form and esthetics should dictate the treatment of the dentition, while Angle and his followers believed that once the dentition was corrected into an ideal occlusion that facial balance and esthetic harmony would follow.

As the focus of orthodontic goals continue to shift toward soft tissues, new quantitative and qualitative techniques are needed to analyze these structures. A few soft tissue assessments, such as Rickett’s “E” line, Holdaways “H” line, Tweed’s Z-angle, and Merrifield’s “profile line” were developed using cephalometry and photography. These were used to evaluate soft tissue profiles with particular emphasis on lip posture. These measurements are all based upon a two dimensional profile view and possess obvious limitations. The disadvantages inherent in these types of analyses can be attributed to their lack of three-dimensional information as well as their vantage point. The profile view is an uncommonly observed angle in real life interactions with others and is rarely used to view oneself. Additionally, the impact of profile on overall facial attractiveness is highly debated (Bashour 2006, Bowman 1999). The emergence in orthodontics of the

so-called “soft tissue paradigm” illustrates the demand for novel diagnostic tools (Proffit, White and Sarver 2003).

2.2.4 The “Golden Proportion”: Revisited in Orthodontics

Although the ancient concept of a “golden proportion” was first introduced in facial plastic surgery by Seghers et al. (1964), it was R. M. Ricketts, a dentist, who popularized the concept and extended it to the analysis of facial form in orthodontic diagnosis and treatment planning (Vegter and Hage, 2000, Ricketts 1982, Bashour 2006). Ricketts used a sliding caliper, termed the golden divider, to analyze if the harmonious faces of beautiful magazine advertisement models exhibited the golden proportions. He found a large number of horizontal and vertical measurements could be related in accordance with the ratio, which suggested that facial esthetics could be analyzed scientifically and objectively (Vegter and Hage, 2000; Wahl 2006). His findings were further supported by Moorrees mesh diagrams, as well as Brons, and other’s studies (C. F. Moorrees 2006; Amoric 1995; Jefferson 1996; Jefferson 2004). Most recently, oromaxillofacial surgeon Stephen Marquardt patented facial overlay systems to objectively evaluate the attractiveness of the human face with archetypes based on the golden proportion (Marquardt 1997, Marquardt 1999).

Despite evidence of the divine proportion in the analysis of facial form and beauty, its clinical significance in orthodontic treatment remains controversial. The divine proportions have been shown to have little influence on overall esthetic outcomes in treatment that ranged from functional appliances to orthognathic surgery (Baker and Woods 2001, Shell and Woods 2004). Subsequent studies that utilized three-dimensional

(3-D) optical surface scans to analyze faces have refuted Rickett's observations and reported that the faces of professional models possessed a variety of proportions, malocclusions, and cephalometric values (Moss, Linney and Lowey 1995). In 1959 Samuel Goldsman discovered a wide variability in the dentures of above average Caucasian faces, therefore disproving any universal standard for beauty (Goldsman, 1959). In *A Concept of Facial Esthetics*, Peck and Peck state that "there is no such thing as an equation to facial beauty. No numbers or devices can totally express the complexity of facial esthetics" (Peck and Peck 1970). The application of the divine proportion as a universal standard for the analysis of facial proportion and beauty has questionable validity.

2.3 Orthodontic Treatment Need

The most important motivation for patients to seek orthodontic treatment is an improvement in their dental and facial appearance (Burden 1995). Despite the general perception that orthodontic treatment confers benefits in terms of reducing susceptibility to dental disease, no conclusive evidence has been found to support this view.

Orthodontic treatment has not been shown to prevent caries or reduce the incidence of traumatic dental injury. Additionally, there is no reliable evidence to suggest a link between improved or worsened gingival or periodontal health or temporomandibular disorder as a result of orthodontic intervention (Burden, 2007; Bollen, 2008).

Malocclusion and its treatment by orthodontics have little effect on general quality of life or children's oral health related quality of life (Taylor et al., 2009).

Since it is well established that patients seek orthodontic treatment for esthetic reasons and not for improved health, it is important to focus on how to best define and achieve their esthetic goals. These esthetic goals and addressing the patient's chief complaint are the primary goal of orthodontic treatment.

2.4 Orthodontic Treatment Goals

More recently, the orthodontist's, general dentist's, patient's and parent's goals of orthodontic treatment have emphasized esthetics (Bowman, 1999). Several studies have focused on the differences between orthodontists and laypersons when judging facial profiles and found no significant differences in their perspectives (Shelly 2000).

The aging process changes the smile and smile line throughout the course of an individual's life (Miller, 1989). Therefore, the orthodontist must consider the age of the patient when treatment planning and the objectives of treatment must be in harmony with growth, maturation, and the natural aging process (Jacobson, 2006).

Differing treatment goals also exist between races. Preferences for more convex profiles in African-Americans than whites were unanimous across all racial backgrounds. African Americans prefer a "straighter" profile than the norms for Blacks but "fuller" than the norms for Whites (Scott and Johnston 1999; Bowman 1999). More convex African-American profiles were seen as more attractive (Farrow, Zarrinnia and Azizi 1993). Therefore, different standards and analyses need to be developed for African-Americans. Each patient should serve as his or her own control to create a template from which to assess skeletal, dental, and craniofacial disharmonies (Faustini, Hale and Cisneros 1997).

Orthodontic treatment goals should attempt to achieve a harmonious face with a well-balanced functional occlusion. There is no “ideal” or perfect smile that applies to all patients. Age, gender and race must be considered when treating patients (Chalifoux, 1996).

Dental esthetics is influenced by tooth form and proportion, color, size, and position (Qualtrough and Burke 1994). Dental and facial problems have been linked with negative characteristics and stereotypes throughout human history. Unattractive teeth are equated with poverty and a lack of success (Miller, 1989). Conversely, attractive smiles are associated with positive characteristics such as warmth, calmness, extroversion, and low anxiety (Phillips 1999; Dong, et al. 1999).

The orthodontist’s goal is to achieve a balance of occlusal (functional) and facial (esthetic) outcomes that would most benefit the individual patient and address their chief complaint. This goal must be accomplished within the bounds of the individual’s ability to adapt physiologically to the morphological changes that have been rendered during treatment. Soft tissue relationships and functions represent the greatest determinants of therapeutic modifiability. These constraints include forces created by the lips, cheeks, and tongue; periodontal apparatus; neuromuscular positioning of the mandible; soft tissue facial mask contours; lip-tooth relationships; and anterior tooth display during facial animation (Ackerman, 1999). In Moss’ functional matrix model, these soft tissue envelopes greatly influence the growth of the bones of the craniofacial complex (Ackerman, 1980).

2.5 Psychology of Facial Esthetics

2.5.1 Social and Developmental Psychology

Since the last few decades of the 20th century, social and developmental psychologists have been primarily concerned with the effects of facial attractiveness on human interaction (Bashour 2006). Both males and females (across 37 cultures) prioritized physical attractiveness over personality characteristics like dependability, emotional stability and maturity in their selection of mates (Buss, et al., 1990). It has been stated that “Beauty is a universal part of human experience, it provokes pleasure, rivets attention, and impels actions that help ensure survival of our genes” (Etcoff 1999). Attractive individuals are attributed with a variety of positive qualities and characteristics that include being nicer, better, healthier, more interesting, more extraverted, more socially skilled, more effective teachers, and more intelligent (Baldwin 1980, Cunningham, Barbee, and Pike 1990, Hönn and Göz 2007). This phenomenon has been dubbed the “beauty premium” (Hamermesh & Biddle 1994). Attractive applicants are also perceived to be more qualified and thus more likely to be recommended, hired, and promoted in the workplace. Additionally, they are predicted to be more successful and ultimately are better compensated. Aside from occupational success, attractive people are more popular, have more self-esteem and self-confidence, are more assertive, have greater experience in dating and sex, and experience better mental and physical health (Bashour 2006). Throughout life, from infancy to adulthood, the benefits of beauty have been shown. Attractive babies receive more attention, attractive children are punished less severely by adults, and adults are treated preferentially in the medical, mental health and legal systems. A preference toward attractive individuals begins early in development. Infants and newborns prefer to look at attractive faces, regardless of

gender, race, or age. (Langlois, et al., 1987; Slater, et al., 1998). These findings strongly implicate an innate and culturally universal origin for the perception of beauty (Olson and Marshuetz 2005).

2.5.2 Cognitive Psychology

Recent discoveries by cognitive psychologists and neuroscientists have greatly elucidated the mechanisms and pathways beneath our judgments of facial attractiveness. It has long been experienced that attractive faces possess esthetic properties and recent research now confirms the mechanisms and neurobiological substrates that activate reward centers in the brain (Aharon et al., 2001, O'Doherty et al., 2003). The positive signals elicited by an attractive face take only 150 msec and no eye movement to trigger neuronal pathways and circuits that can be studied through the use of electroencephalographic activity, positron emission tomographic scans, and functional magnetic resonance imaging (Bashour 2006).

2.5.3 Evolutionary Psychology

Evolutionary biologists and psychologists build upon Darwin's theories of natural and sexual selection to associate phenotypic expression of morphologic characteristics such as attractiveness to genetic components of fitness, health, quality, and reproductive value. In this context, any characteristic or trait that enhances biological survival or benefits the species will increase in frequency over time. Consequently, the average attributes found in a given population will evolve to reflect the most adaptive configuration for survival. As dictated by sexual selection pressures, attractive features

are manifested at the onset of the reproductive age (puberty), are sex-specific (under the control of sex hormones), and are indicative of reproductive success (e.g., immunocompetence or fertility). Certain characteristics of the face may advertise health and viability. Facial attractiveness has always been the most valued aspect of beauty and is a major target of selective mate choice in humans and therefore has been shaped by millions of years of evolution (Buss 1994, Bashour 2006).

2.6 Aspects and Examination of Facial Attractiveness

Although an attractive face can be recognized in an instant (150 msec), the qualities that comprise beauty are extremely difficult to articulate (Eisenthal, Dror, and Ruppin 2006). Writer Margaret Wolfe Hungerford famously stated in 1878, “Beauty is in the eye of the beholder” (Hungerford 1890). This often quoted statement implies a subjective quality of beauty that is individual to each person and unique to their personal perspective and historical era. It was thought that the perception of facial beauty was multifactorial, with genetic, environmental, and cultural foundations. Recent research has indicated that the perception of facial beauty is surprisingly common to subjects of Asian (Chinese, Japanese and Indian), Caucasian (English and Greek), Hispanic, and African American extraction (Bernstein, Lin, and McClellan 1982, Nanda and Ghosh 1995). The qualities of beauty remain universally pleasing and are neither arbitrary nor culturally bound (Naini and Moss 2004). There is a high level of agreement (when rated on a visual analog scale) for attractive faces irrespective of ethnicity, education, social class, age, and gender, which suggest an objective and similar criteria in their judgments (Knight and Keith 2005, Eisenthal, Dror, and Ruppin 2006). Studies have shown that

although the perception of beauty is assessed rapidly and requires very limited visual information, the subsequent cognitive processes that follow can be dramatically biased (Olson and Marshuetz 2005).

Early literature on the subject of facial attractiveness focused on line drawings and shadowgraphs to elicit an observer response. It was thought that tracings and silhouettes eliminated extrinsic variables that may distract the eye, such as hairstyle, make-up, and skin complexion (Shelly et al., 2000, Smedley 2003). Although the highly specialized skill of human face recognition is dependent on the processing of a combination of edge-based and surface-based information, modern research indicates that the greater verisimilitude involved in facial representations the more realistic the results (Hönn, et al., 2005, Michiels, Sather 1994, Peerlings, Kuijpers-Jagtman, and Hoeksma 1995, Leder 1996). Facial attractiveness and esthetics are not related to or influenced by profile outline shape (Spyropoulos and Halazonetis 2001). Despite the popularity of the profile view, the best view to observe human faces is the one used most in everyday life, a slightly lateral angle (Kerr and O'Donnell 1990, Phillips, Tulloch, and Dann 1992). Internal features such as eyes, nose, and mouth are more important for the recognition of the face than external features like face shape and hair (Ellis, Shepherd, and Davies 1979).

Universal standards of beauty result from fixed neuroanatomical arrangements that have biological relevance in the identification of healthy mates (Rhodes, et al., 2007). The predominant psychophysical factors that have been shown to influence facial attractiveness are spatial or configurational (averageness, symmetry, and youthfulness)

and component or featural (gender distinctiveness) (Chen, German, and Zaidel 1997, Sarwer, Grossbart, and Didie 2003).

2.6.1 Averageness of the Face

The term koinophilia has been used to describe the human attraction to others of average appearance (Adamson and Zavod 2006). This phenomenon was first described in terms of human faces in the work of Sir Francis Galton (1833-1888). Composite photographs were found to be more attractive than any individual photograph used to make the composite (Rhodes 2006). These findings were later corroborated by modern studies that utilized computer superimposition (Langlois and Roggman 1990). Face recognition is processed in humans through information developed by multiple exposures to stimuli that are captured, encoded, and retrieved in reference to an archetype or prototype, termed a facial schema or norm. A face that exhibits a high mathematically averaged trait value for a given population, also called prototypicality, is low in distinctiveness and high in perceived attractiveness. This inverse relationship is best illustrated by caricature studies in which facial features are greatly exaggerated. As the caricature increases in distinctiveness and deviates further from the average face or norm, the perceived attractiveness declines significantly (Rhodes, Brennan, and Carey 1987, Bashour 2006). Another interesting attribute of caricatures is that they are recognized more easily than the actual face, due to the accentuation of the recognizable characteristics that differentiate the face from the norm. In other words, caricatures represent a better likeness of familiar faces than the faces themselves. This finding is

also true of more distinctive faces that are able to be recognized more accurately and rapidly than typical faces (Baudouin and Gally 2006).

As previously discussed, evolutionary pressures operate against the extremes of the population according to Darwinian theory. A facial pattern close to the average for the population signals genetic diversity and confers greater immunocompetence. Parasite resistance and host immune defense are enhanced by genetic heterozygosity, especially in the major histocompatibility complex, and displayed phenotypically as averageness or the “average expression of continuously distributed, heritable traits” (Mitton and Grant 1984, Elder 2001).

In the modern world, connected through electronic media and the Internet, we are constantly exposed to visual reminders of the multiracial aspects of faces. Differences as small as one millimeter are recognized and new composites and standards of attractiveness are continuously adapted and formulated (Adamson and Zavod 2006).

2.6.2 Symmetry of the Face

Bilaterally symmetrical facial features have been correlated with the perceived attractiveness and health of an individual in numerous publications (Baudouin and Tiberghien 2004, Grammer and Thornhill 1994, Mealey, Bridgstock, and Townsend 1999, Rhodes, Sumich, and Byatt 1999, Zaidel, Aarde, and Baig 2005). Paired body features (ie, eyes and ears) develop in synchronicity under ideal conditions. Therefore, the presence of an asymmetry can indicate the incidence of an external stress from environmental and epigenetic factors like temperature extremes, pollutants, toxins,

physical trauma, protein deprivation, noise, parasitic infection, or other pathogens that adversely affected development (Parsons 1990, Møller 1992, Sarwer, Grossbart, and Didie 2003). Conversely, symmetrical features may denote that an individual is more durable and hardy and has overcome or avoided such developmental stressors. Genetic stresses (associated with in-breeding) can lead to genomic homozygosity that is also manifested as an asymmetry (Clarke, Brand, and Whitten 1986). Symmetric men have more sexual partners, fitter sperm, more offspring and fewer diseases (Bashour 2006).

2.6.3 Neoteny/Youthfulness of the Face

Youthfulness may advertise an extended period of reproductive potential and is particularly important in the attraction of a male to a female mate. Female faces that exhibit smaller preadolescent features, with a tiny jawline, small nose, delicate lower face and pronounced eyes and cheekbones are consistently characterized as more beautiful (Johnston and Franklin 1993). Physical signs of youth and health such as full lips, smooth clear skin, clear eyes, lustrous hair, good muscle tone, animated facial expression, high energy level are reliable markers of fertility, and are therefore evolutionarily appreciated cross-culturally (Buss 2000). More neotenous or babylike features in children are likely to result in more parental attention, better care and less abuse. Cuter infants and adolescents are therefore more likely to survive to sexual maturity and pass on their genes (Bashour 2006).

2.6.4 Sexual Dimorphism/Maturity of the Face

Male and female faces differ only slightly from birth until the onset of puberty, when the effects of sex hormones (i.e., testosterone and estrogen) begin to induce changes in facial shape and features (Bashour 2006). Additionally, sex hormones have a suppressive or handicapping influence on the immune system. Thus, an individual that expresses a relatively high sex hormone ratio and therefore prominent sex specific traits must possess a particularly robust immune system to overcome its deleterious effects (Folstad and Karter 1992).

Attractiveness may signal health and reproductive capabilities of potential sexual partners. Feminine characteristics, directly related to perceived attractiveness, are thought to indicate youth, fertility and good health (Sarwer, Grossbart, and Didie 2003). These estrogen-dependent features in females include full lips, narrow nose, small face, high forehead and cheekbones and a small chin (Casey, Mernagh, and Newell 2009). Attractive female faces exhibit youthful traits in the central region (eyes, nose, and lips) and sexual maturity in the periphery (cheekbones). A wide smile and high, sweeping eyebrows contribute to the expressiveness of the face (Hönn and Göz 2007).

Women value physical attributes as well as a man's ability as a provider in their considerations of attractiveness. A women's menstrual cycle has been shown to influence their preferences in male faces (Hönn and Göz 2007). Women's preferences shift toward more masculine facial traits during the fertile phase of the menstrual cycle when conception is likely (Rhodes 2006). During ovulation, women prefer male faces that exhibit testosterone-dependant secondary sex characteristics such as abundant facial hair, large jaw size (wide mandible), strong chin, small deep-set eyes, thin lips, and brow

ridge prominence (Grammer and Thornhill 1994). These features have also been linked to a more cold, dominant, and insincere appearance. Women who seek long term partnerships prefer a less masculine face that is perceived as less dominant, warmer, more honest and cooperative, and therefore more likely to be a better parent (Perrett 1998).

Facial contrast also influences perception of facial gender and can help determine the sex of the face. A greater facial luminance contrast between the eyes, lips and the surrounding skin can make a face appear more feminine and hence more attractive. Conversely, male faces exhibit decreased facial contrast (Russell 2009). Attractive faces are also discriminated by sex with greater speed and accuracy. The contribution of the entire package or configuration of the face lends to the identification of gender rather than any individual feature alone (Hoss, et al., 2005).

2.6.5 Computational Analysis

With the introduction of revolutionary new ideas in facial esthetic preferences, the objective nature of these findings provides an ideal opportunity for the computational analysis of beauty (Eisenthal, Dror, and Ruppin 2006). If the parameters of facial attraction are amenable to measurement, the computer would seem an obvious tool to perform these valid, three-dimensional (3-D), non-invasive calculations. A number of new computer programs (e.g., FacePrints) have been developed to evolve faces by means of a genetic algorithm. These programs and other computer generated simulations may have useful applications in the future for treatment planning, patient education, and patient communication in orthodontics and facial surgery (Bashour 2006).

2.7 Self-Image: Influences and Modifiers

An individual's interpretation or assessment of their own outer appearance (i.e., self-image) often dominates the way in which a person feels about themselves (i.e., self-esteem). Self-image is a multidimensional construct influenced by perceptual, developmental, and sociocultural elements. Perceptual influences account for an individual's ability to accurately judge the size and shape of a given feature or body part. Developmental influences consider the contribution of childhood and adolescent experiences, most importantly appearance-related teasing, on the adult self-image. Sociocultural influences deal with the influence of mass media and cultural ideals of appearance (Sarwer, Grossbart, and Didie 2003).

It has been suggested that self-image consists of valence (orientation), defined as the degree of importance of self-image to one's self-esteem, and value (evaluation), defined as the degree of satisfaction with the self-image. According to large-scale surveys, Americans are dissatisfied with their self-image and overall appearance and these trends have increased dramatically over time. This dissatisfaction is thought to motivate many behaviors that include dieting, exercise, cosmetics use, and cosmetic surgery. Patients with various psychological, interpersonal and social agendas, share a primary motivation for improvement of self-image that is almost exclusively appearance-related as opposed to health-related (Sarwer, Grossbart, and Didie 2003, Grossbart and Sarwer 2003). In fact, some are even willing to compromise their health for beauty. These psychopathological behaviors are witnessed frequently in late adolescence and young adulthood. The potentially harmful health consequences associated with

attractiveness-enhancement practices such as going tanning and taking diet pills are disregarded in the pursuit of attractiveness (Hill and Durante 2011).

An enormous amount of money and effort are spent on the improvement of outward appearances and alteration of the facial form as evidenced by the multi-billion dollar diet, cosmetics, and medical (e.g., cosmetic surgery, esthetic dentistry, orthodontics, and dermatology) industries. The face is the most important predictor of overall attractiveness, with the oral region, eyes, nose, and the complexion as the most significant contributors (Tatarunaite et al., 2005). Cosmetics application offers a noninvasive and affordable means to enhance desirable facial features and create the appearance of youth or sexuality. Cosmetic are used to darken the eyes and lips to increase facial contrast and manipulate and accentuate sexual dimorphism and other attributes of facial beauty. Similarly, women pluck their eyebrows to increase the brow-to-eye distance and create more feminine, thinner brows (Russell 2009). Cosmetic surgery has dramatically increased in popularity for both men and women. The vast majority of cosmetic surgery patients display a high self-image valence (i.e., they derive much of their self-esteem from their self-image) and a low self-image value (i.e., they are dissatisfied with their self-image)(Sarwer, Grossbart, and Didie 2003). The most important parameters to measure successful outcome of surgical and nonsurgical esthetic interventions are improved quality of life and patient satisfaction. Some of the most common facial cosmetic procedures include rhinoplasty, blepharoplasty (eyelid surgery), skin resurfacing procedures (laser, chemical peels, and dermabrasion), rhytidectomy (facelift), facial rejuvenation and volume restoration (injectable fillers, volumizers, and

biostimulators for soft tissue augmentation (Most, Alsarraf, and Larrabee 2002; Kosowski, et al., 2009; Alsarraf 2000; Lupo 2008).

Facial preferences are not influenced by a personal history of orthodontic therapy (Cala et al., 2010). Psychological analysis, through carefully structured interviews and psychosomatic evaluations, is as clinically important as soft and hard tissue parameters for patients undergoing enhancement procedures (Baing 2004). The objectives of any facial enhancements should be the delivery and stability of a symmetric face, with appropriate augmentation of secondary sex characteristics and, most importantly, with dimensions that closely approximate the mean of the population (Edler 2001).

2.8 Self Perception of the Face

Self recognition is distinct from familiar and unfamiliar face-recognition (Keenan et al., 2000). The act of facial perception can have different goals. For instance, the goal of perceiving another individual's face is most often identification, whereas self-perception is most likely focused on the inspection of facial features as in that involved with the act of grooming (Tarr and Pinker 1989). Facial self-image has been studied with questionnaires and electrically powered flexible distorting mirrors that can be manipulated by subjects in an attempt to obtain a true reflection of their faces. These studies have concluded that on average, subjects were unable to accurately define the dimensions of their own faces to within five centimeters. Furthermore, the less well subjects performed on the flexibility mirror test, the higher the subject scored on the facial image section of the questionnaire. In other words, the subjects with better body and facial self-image scores had higher self-esteem but less of an idea of the true

dimensions of their own faces. These more self-confident subjects may lack the familiarity with their facial dimensions because they have less of a need to reassure themselves about their appearance in the mirror (Pogrel and Scott 1989). People also tend to form a more desirable or enhanced image of their own traits and abilities than might actually exist. Interestingly, differences arise among the sexes in self-estimates of intelligence, with men demonstrating a consistent self-enhancing bias and women a self-effacing bias (Furnham 2001). In all humans, a self-enhancement bias occurs rapidly and intuitively with little or no apparent conscious deliberation when subjects are asked to identify their own face from a lineup of distracter faces. Subjects automatically recognize attractively enhanced versions of their face as their own. The perceptual process of self-face recognition is positively distorted and may be the reason that people rarely seem to like photographs of themselves. As the investigators point out, “The image captured by the camera lens just does not match up to the image captured in the mind’s eye” (Epley and Whitchurch 2008).

2.9 Three Dimensional Facial Analysis

Although photography and radiography have long been used as standard records for analysis and are required for ABO certification, they are only two dimensional representations of three dimensional, dynamic structures. Therefore, these records are severely limited by their static nature and lack of depth of field.

Justus Antoni Wilhelm van Loon suggested in 1915 that, in order to properly diagnose and treatment plan, a three dimensional system was needed to relate the dentition to the face (Moorrees 2006). In order to achieve this, Van Loon would orient

the casts of the dentition into a plaster cast of the patient's face using natural head position and Frankfort horizontal (Peck and Peck 1995). Van Loon's method, although time consuming and complex, was an evolutionary step towards relating the dentition to the face in three planes of space (Moorrees 2006).

3-D technology can be used to create a morphometric analysis to measure subtle size and shape differences to improve diagnosis and planning and to monitor changes during and after treatment. A number of different three-dimensional technologies have been employed including laser scanning, structured light, stereophotogrammetry, surface image analysis, magnetic resonance imaging and surface scanning, computerized tomography, and cone-beam computerized tomography. The future of diagnostic imaging could realize a fourth (time) and fifth (dynamic function) dimension (Harrell 2006). The Dynamic Smile Visualization was used by Sarver and Ackerman to develop an ideal smile arc from a recording of a patient's anterior tooth display during speech and smiling (Sarver and Ackerman 2003). Both form and function of a patient's speech and smile can be examined with digital imaging. Computer imaging is the future for orthodontics, not only as a diagnostic and treatment planning tool, but also in the education of the patient and obtaining informed consent.

2.9.1 3dMD

The 3dMD imaging system, in particular 3dMDface, uses a combination of stereophotogrammetry, structured light technique, and multiple high-resolution digital cameras (color and infrared) to capture an image of the face. A continuous point cloud is projected from the infrared cameras onto the patient's face, and the image is captured

from two precisely synchronized stereo cameras positioned at various angles in an optimum configuration on either side of the subject (3dMD 2011, Kau, et al. 2007). The system has the ability to capture data rapidly at speeds of 1.5 milliseconds and precisely in less than or equal to 0.2 millimeters. Data collection at such high speeds helps to eliminate errors due to patient movement and is highly repeatable. The acquisition of both facial surface geometry and texture occur simultaneously. The process is non-invasive and computer algorithms can be used to integrate the images with cone beam computed tomography images that can be viewed and analyzed on a PC (3dMD 2011). Various studies have validated the precision (repeatability and reproducibility less than 0.6 mm), reliability, and accuracy of the anthropometric data from 3dMD images. All the errors associated with the placement of landmarks, the digitization, and the imaging systems were sub-millimetric and negligible. The data acquisition, processing, and analytic capabilities of the 3dMD system far exceed those of other clinical methods, such as direct anthropometry and two-dimensional photography and radiography (Wong, et al., 2008; Aldridge, et al., 2005; Weinberg, et al. 2006; Lübbers, et al., 2010; Maal, et al., 2010).

Recent studies conducted at Temple University Kornberg School of Dentistry, Department of Orthodontics, have shown that 3dMD images are suitable for qualitative studies (Croft 2008, Rich 2009). With this emerging three-dimensional imaging technology comes a growing need for standardization, measurement and manipulation as well as qualitative research (Meadows, Verdi and Crabtree 2003; Tuncay, 2001).

2.10 Qualitative Research

The esthetic outcome of orthodontic treatment is ultimately assessed qualitatively. Most orthodontic research and clinical findings, however, are conducted quantitatively. The vast majority of orthodontic residencies and resources have been dedicated to a system of standards and measurements that are vastly different from the patient's perception of treatment outcome.

Qualitative research begins with a clearly defined problem. Once this problem is identified the appropriate strategies to gather and investigate the data are employed. Finally, these findings are interpreted through different analytic methods to elucidate the solution to the initial problem (Meadows, Verdi and Crabtree 2003). Although qualitative research data can be gathered through a vast number of methods (including field notes, conversations, photographs, recordings, memos, etc.), interviews and surveys have provided the basic tools for collecting this information (Atkinson, Coffey, and Delamont 2001, Denzin and Lincoln 2000, Holstein and Gubrium 1995).

Qualitative data analysis (QDA) is extremely valuable, in spite of the fact that information may not be compiled through the traditional scientific method. Although this non-linear process is remarkably complex, the methods involved can be distilled into three fundamental and interwoven parts: Noticing, Collecting, and Thinking about interesting things (Seidel 1998).

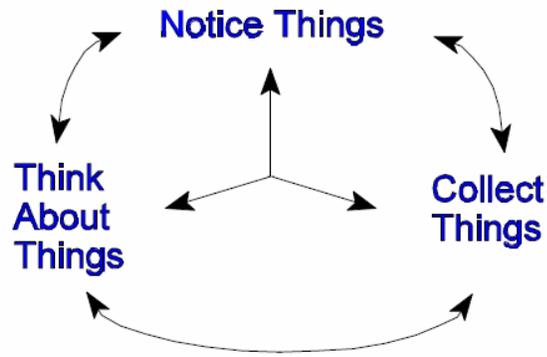


Figure 9 Qualitative Data Analysis

The process is an infinite cycle that has been described as iterative, progressive, recursive and holographic. The noticing stage involves the documentation of observations. These records are then read and once the important components are identified, they are named or coded (Seidel 1998).

Codes serve to summarize, synthesize, and sort many observations made of the data....coding becomes the fundamental means of developing the analysis....Researchers use codes to pull together and categorize a series of otherwise discrete events, statements, and observations which they identify in the data (Charmaz, 1983: 112).

At first the data may appear to be a mass of confusing, unrelated, accounts. But by studying and coding (often I code the same materials several times just after collecting them), the researcher begins to create order (Charmaz, 1983: 114).

This coded information is sorted in the collecting stage. The QDA process can be likened to a jigsaw puzzle (Seidel 1998).

Analysis is a breaking up, separating, or disassembling of research materials into pieces, parts, elements, or units. With facts broken down into manageable pieces, the researcher sorts and sifts them, searching for types, classes, sequences, processes, patterns or wholes. The aim of this process is to assemble or reconstruct the data in a meaningful or comprehensible fashion (Jorgensen, 1989: 107).

In the thinking stage, the collected information is examined to: 1) make sense out of each collection, 2) detect patterns and relationships both within a collection, and also across collections, and 3) make general discoveries about the phenomena observed or researched (Seidel 1998).

2.11 Conclusion

Throughout human history, the appearances of the face and teeth have been altered for esthetic purposes. The ideas of beauty and the goals of these alterations have changed dramatically over time and over many different cultures despite some universal elements. These ideals are very much individual and can have many influences. The orthodontist must be sensitive to the different objectives and expectations of the patient.

The fundamental goals of orthodontic treatment have been described as an objective “to establish optimal proximal and occlusal contact of the teeth within the framework of acceptable facial esthetics, normal function, and reasonable stability” (Ackerman and Proffit 1970). The goal of orthodontic treatment is to establish harmony and balance between the hard tissues (skeleton and dentition) and the surrounding soft tissue. As the contemporary orthodontic paradigm shifts toward an emphasis on the soft tissue, technology must evolve to allow for proper three-dimensional assessment of these structures. Additionally, the subjective nature of these goals lends credence to qualitative methods of data collection, analysis and research. The future of orthodontics will allow both clinician and patient to better understand, communicate, and achieve their treatment goals (Romani, et al., 1993).

CHAPTER 3

AIM OF THE INVESTIGATION

The aim of the investigation was to develop a qualitative understanding of the facial preferences and perceptions of orthodontic residents. In this study, orthodontic residents were interviewed and asked a specific series of questions about how they evaluate and perceive faces. This study employed the use of three-dimensional images, acquired using the Temple University Department of Orthodontics 3dMD imaging system. The images used in each interview were those of the resident's face and their sculptured bust. The superimposed images and residents' responses were analyzed and compared to determine trends in qualitative facial assessment and preferences. This information can help practitioners to better understand the factors that influence one's self-perception and increase communication with patients considering facial enhancement procedures, including orthodontic treatment.

CHAPTER 4

MATERIALS AND METHODS

4.1 Study Sample Selection

The study sample consisted of eleven orthodontic residents concurrently enrolled in the Temple University Kornberg School of Dentistry, Department of Orthodontics, Philadelphia, Pennsylvania, 2010. All residents participated in the spring semester sculpture course. The sample demographic was comprised of Caucasian individuals of both sexes that ranged from twenty six to thirty three years of age.

RESIDENT	SEX	AGE	PROGRAM YEAR
1	Male	28	2 nd
2	Male	29	2 nd
3	Male	31	2 nd
4	Male	33	2 nd
5	Female	28	2 nd
6	Female	27	2 nd
7	Male	27	1 st
8	Male	31	1 st
9	Male	33	1 st
10	Female	26	1 st
11	Female	26	1 st

Table 1 Resident Demographics

The data collected are responses by orthodontic residents to interview questions, as well as, two dimensional and three dimensional photographic images. The residents gave verbal consent to participate in this study. They agreed to provide their responses and images in compliance with approved university IRB protocols.

4.2 Sculpture Course

The course objective was for each of the residents to create a life size bust of themselves in repose. Each resident acted as both sculptor and model. Calipers, mirrors, and posed photographs at various angles were utilized to observe and measure all three dimensions of the face. Forty hours of structured hands on class time and instruction were dedicated from May to July 2010. Additional time was granted and utilized by the residents if needed. The course was guided by professional sculptor and artist Marilyn Simon with the resources and support of the Temple University Orthodontic Department and Tyler School of Art.

4.3 Sculpture Course Evaluation

Upon completion of the course, which included sculpting, firing and painting of the bust, the final product was graded on the quality and likeness of the sculpture to the resident. The grade represented the averaged numeric score (on a one hundred point scale) given by five evaluators. The evaluators were orthodontists and attending faculty members of the Temple University Kornberg School of Dentistry, Department of Orthodontics who were personally familiar with each of the subjects and their facial features.

4.4 Two Dimensional Composite Images

A digital camera was used to capture two dimensional photographic images of each resident and their final sculptured bust side by side in profile, three quarter, and frontal view. The photographs attempted to recreate the posture and expression of the resident and corresponding bust at an equal height, depth and size for easy comparison. The viewing angles selected represent standard views familiar to orthodontists in their evaluation of the face. These composite photographs were utilized for the resident's reference during the interview process.

4.5 Interviews

A structured interview was conducted with each resident to discuss their personal background, self perception, individual characteristics and facial features, facial preferences, and their self evaluation of artistic skill level, the sculpture process and final sculpture outcome. The interview process followed a specific set of questions given to each resident in advance for their perusal and preparation. After the residents had an opportunity to familiarize themselves with the questions, they were brought into a private consultation room where their composite photographs were displayed on the desk for reference. Prior to conducting the interviews, the residents were asked for verbal consent to record the session using a digital audio recorder. Each resident was then interviewed and asked the questions listed on the questionnaire.

4.6 Questionnaire

The interview questionnaire consisted of both "open-ended" and "yes" or "no" questions. Certain questions also employed the use of a psychometric response scale

known as a visual analogue scale or (VAS) to measure a subjective characteristic or attitude. This instrument is designed to indicate the respondent's level of agreement to a statement by marking a position along a line between two end-points corresponding to a score from zero to ten. In order to ascertain the process by which resident's qualitatively assess, evaluate, and analyze faces the following questions were asked.

4.7 Interview Data Compilation and Analysis

After each interview, the audio information was transcribed into a word document that represented a complete written account of the dialogue. These records were then coded or summarized and distilled into categorized statements in the noticing stage. The component responses to each of the thirty three questions were compiled for all eleven residents and put into a Microsoft Excel spreadsheet. In order to observe common elements or related accounts the responses were designated different colors and grouped based upon similar information during the collecting stage. This color coding provided discrete patterns and a visual means of analysis. Response frequencies were determined for both quantitative and qualitative data sets. In the thinking stage, the collected information was examined for each resident separately as well as cumulatively.

4.8 Three Dimensional Image Acquisition

The department's 3dMD imaging system located in the Orhan C. Tuncay, DMD imaging suite 1, room 2L12 was used to capture a three dimensional surface image of each resident and their final unpainted sculptured bust. The decision was made to acquire the images at this time to avoid any interference or artifact that the painted surface might introduce and eliminate extraneous variables of color or

reflectiveness. The 3dMD system was calibrated and all images were acquired on a single day by the same resident operator. Once reconstructed by the 3dMD PC-based software, all images were manipulated and viewed for acceptability.

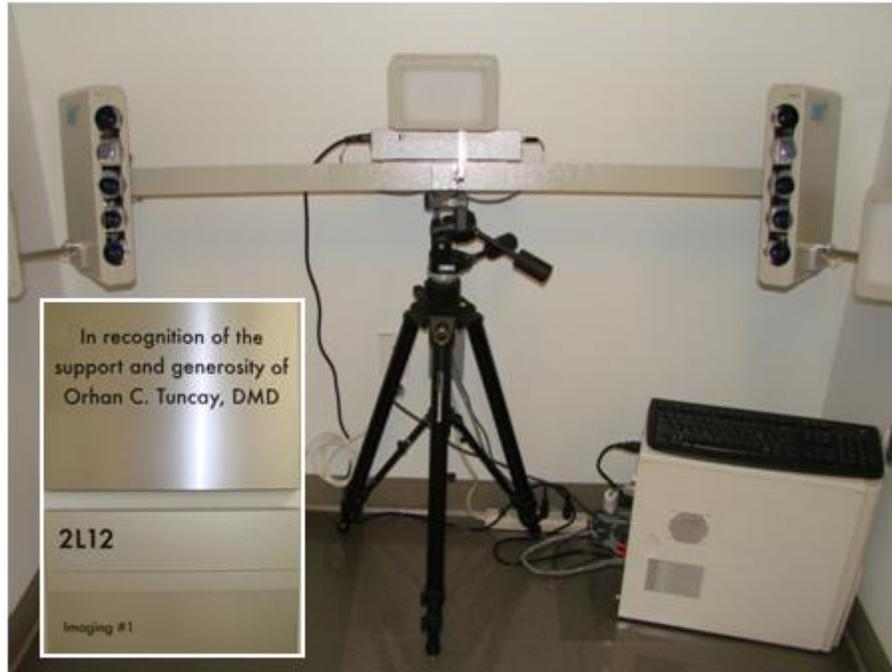


Figure 10 Temple University 3dMD Imaging System

4.9 Image Manipulation

The 3dMD image files (.tsb format) were transferred from the unit's computer to a personal Hewlett-Packard m8020n desktop computer, and 3dMDpatient software, Version 4.0 (3dMD, Atlanta, GA), was used to view, manipulate, register, measure and analyze the images. The image of the resident was loaded and oriented in a level frontal direction. Subsequently, the image of the bust was loaded and oriented in a similar fashion. The images were then overlaid by selecting each surface separately with the "Move data/plane" button and manipulating the data files to approximate one another as

closely as possible. Using the mouse to change the viewpoint, the 3D surface image can be rotated about an axis by holding the left mouse button and dragging the mouse. The image can be re-positioned by holding the right mouse button and dragging the mouse to move the image to another position in the viewing window. The right and left mouse buttons can be depressed together and by dragging the mouse up or down the 3D surface can be zoomed in and out of the screen (Users Guide for 3dMD patient software v4.0 2009).

4.10 Selection of Image Region and Surface Based Registration

A region was selected to include the facial features and exclude the extraneous field (hair, clothes, etc.). This application is useful for performing accurate registration of the two surfaces, specifically in the areas of interest. The two surfaces were loaded and only the second surface (the sculptured bust) was selected. This surface will be registered to the referenced surface (the resident's face). A relatively large region of polygons that included the entire facial complex on the sculptured bust was selected using "*Selection>Polygons>Area Via>Radius*". A window will then open with a millimetric scale depicting the length of the radius. A radius of 100mm was selected to include all facial features and the mouse was moved over the tip of the bust's nose (a reproducible central point). The area was then selected by hitting the space bar and the subsequent color change indicated the selected region (Users Guide for 3dMD patient software v4.0 2009).

The registration overlay process allows the alignment of the two surfaces for direct comparison in three dimensions. This was done by selecting "*Registration>Surface Based>Selected Region*". The "*Select a REFERENCE surface*"

window then opens showing the color-coded surfaces. The first surface (the resident's face) was selected by highlighting it with the mouse and clicking "OK". This is the surface that will remain fixed while the other second surface (the sculptured bust) moves towards it. The "*Select one or more surfaces*" window will then open showing the same color-coded list of options. The second surface was then selected in the same fashion and registered with the reference surface (Users Guide for 3dMD patient software v4.0 2009).

4.11 Measurements and Statistics

Comparison measurements can be made once the two surfaces have been registered. By selecting "*Measurement>Distance Between Two Surfaces>Color Histogram*" you can look at regions of difference between two surfaces both by quantitative measurements and by qualitative visualization. The first surface image of the resident's face was selected in the "*Select a REFERENCE Surface*" window by highlighting it and clicking "OK". In the "*Select a DIFFERENCE Surface*" window the sculptured bust was selected and the reference surface is measured to this surface. The comparison calculation then takes place as indicated by the cursor changing to an hour glass. At the completion of this process, a "*Distance between two surfaces*" window appears showing a color histogram of the distance measurements between the two surfaces, measured for each vertex on the "*Reference*" surface. On the left of this window, the associated statistical measurements calculated from the histogram data are located. Millimeters are used for all distances. The "*Difference*" surface is automatically deselected and hidden. The image shown displays the "*Reference*" surface overlaid with a color representation of the distance from the "*Reference*" surface to the "*Difference*" surface at each vertex. These overlaid colors correspond directly to those

displayed in the histogram. The “*Reference*” surface is colored gray where there is no overlap between this surface and the “*Difference*” surface, and therefore, no valid distance measurements. The colors of the histogram and image can be interpreted as the most positive distances shown on the red end of the scale (i.e., where the “*Difference*” surface is in front of the “*Reference*” surface); and the most negative in green (i.e., where the “*Difference*” surface is behind the “*Reference*” surface). Therefore, the areas seen in red were excessively built up in the clay bust and the areas of green were deficient. Areas in blue represent the best fit between the two surfaces, and thus, these were the most accurately recreated areas of the bust. The limits of the histogram were changed to include only those areas of interest in the histogram and statistical calculations. This was done by dragging the edges of the histogram with the right mouse button to adjust the range to the point where the color variation was maximized in the facial region and just before the presence of black holes begin to appear on the face itself. The blue numbers displayed at the borders of the histogram color gradient represent the positive (red side) and negative (green side) limits or maximum distance between the surfaces in millimeters. This process allows the ability to measure in millimeters the range in accuracy or deviation between the resident’s face and their sculptured bust. The RMS value was also of particular interest in this study. The quality of the registration and therefore the quality of the sculptured bust can be quantified mathematically by analyzing the Root Mean Square or RMS error of the distance measurements over the selected and registered surface area. The smaller the value obtained directly equates to a more accurate registration and bust. (Users Guide for 3dMD patient software v4.0 2009).

CHAPTER 5

RESULTS

5.1 Findings by Resident

5.1.1 Resident 1



Figure 11 Resident 1 Composite 2-D Images

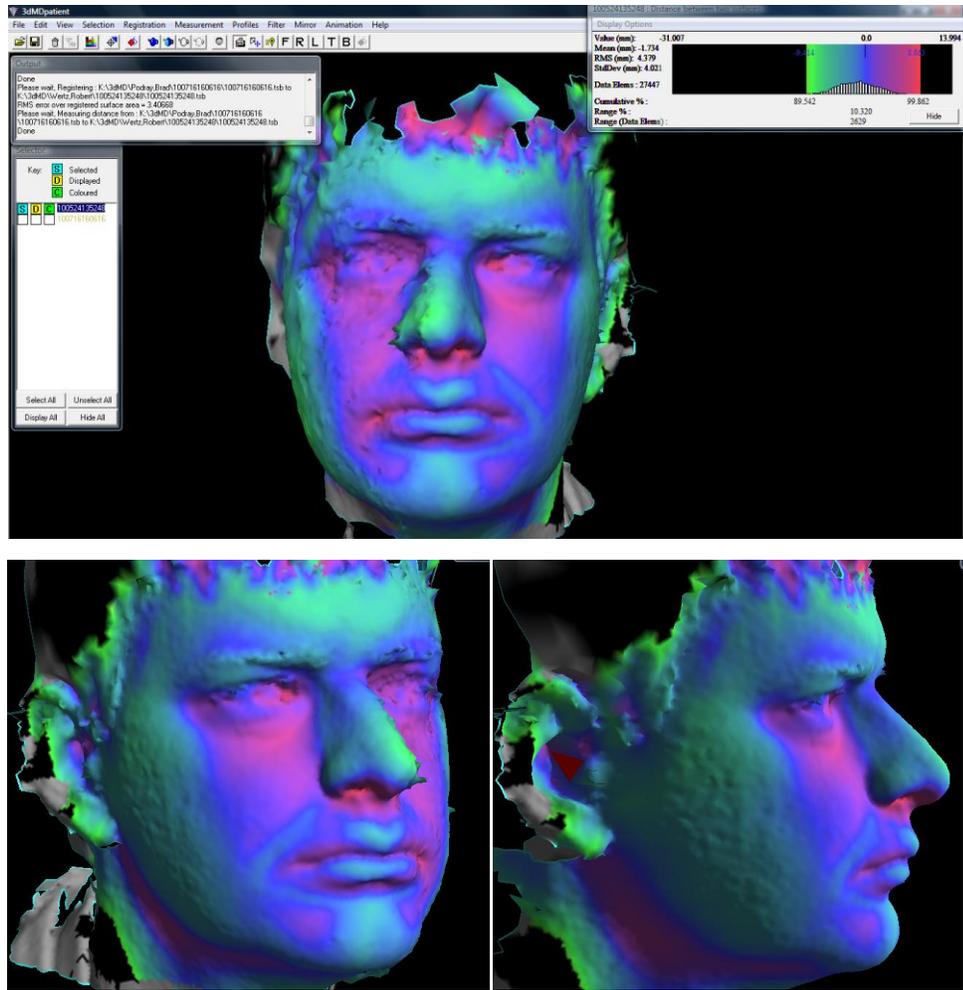


Figure 12 Resident 1 Composite 3-D Image Color Histograms and Statistics

I focus on eyes.

I don't like my chin- It's too retrognathic.

I spent the most time on the nose because it differentiates me from others.

I was most pleased with the results of the nose.

I felt the nose and chin were most accurate.

I found the lips and eyes the most difficult to recreate.

The lips and eyes were the least accurate. I accidentally exaggerated the fullness of the lips. The lips were puffed out 4-5mm and the eyes were 2mm too large.



Figure 13 Resident 1 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 58	Resident Self Evaluation (Q10x10): 60
RMS: 3.40668	Degree Accentuated (histogram mm range): -9.414 → +8.863

Table 2 Resident 1 Correlation of Accuracy

5.1.2 Resident 2



Figure 14 Resident 2 Composite 2-D Images

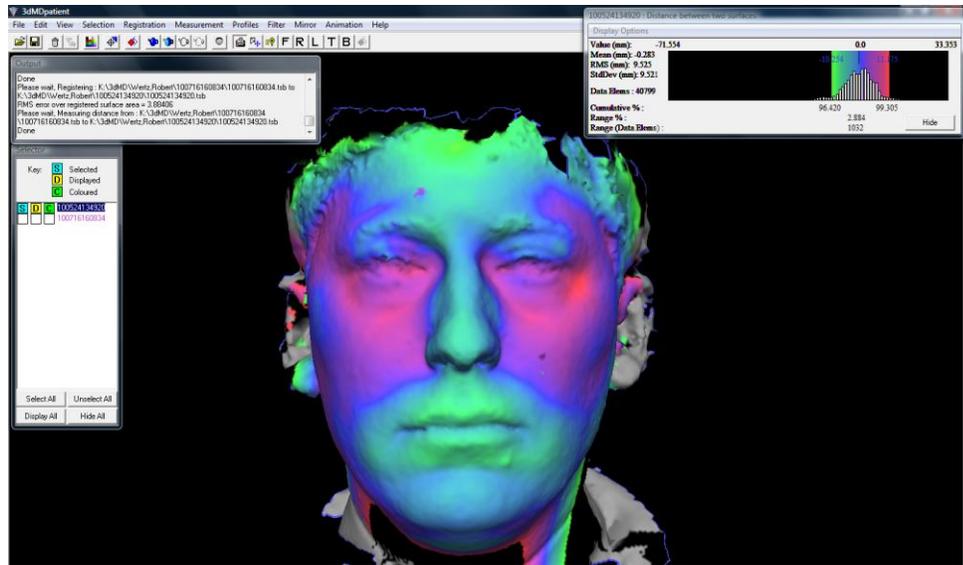


Figure 15 Resident 2 Composite 3-D Image Color Histograms and Statistics



I had difficulty capturing the proportions of the face.

I am more aware of my profile.

I have a slender face with a gaunt look. My eyes are set back with puffiness below my eyes. My ears stick out and I have a small hump on my nose.

I spent most time on the eyes because I had difficulty with the symmetry and making them look like mine.

I was most pleased with the nose and believe it was the most accurate.

The lips, ears, eyes, and forehead were the least accurate and the proportions were way off. The distance in the midface, between the lips and eyes, was excessive by 10mm.



Figure 16 Resident 2 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 32	Resident Self Evaluation (Q10x10): 0
RMS: 3.88406	Degree Accentuated (histogram mm range): -10.254 → +11.175

Table 3 Resident 2 Correlation of Accuracy

5.1.3 Resident 3



Figure 17 Resident 3 Composite 2-D Images

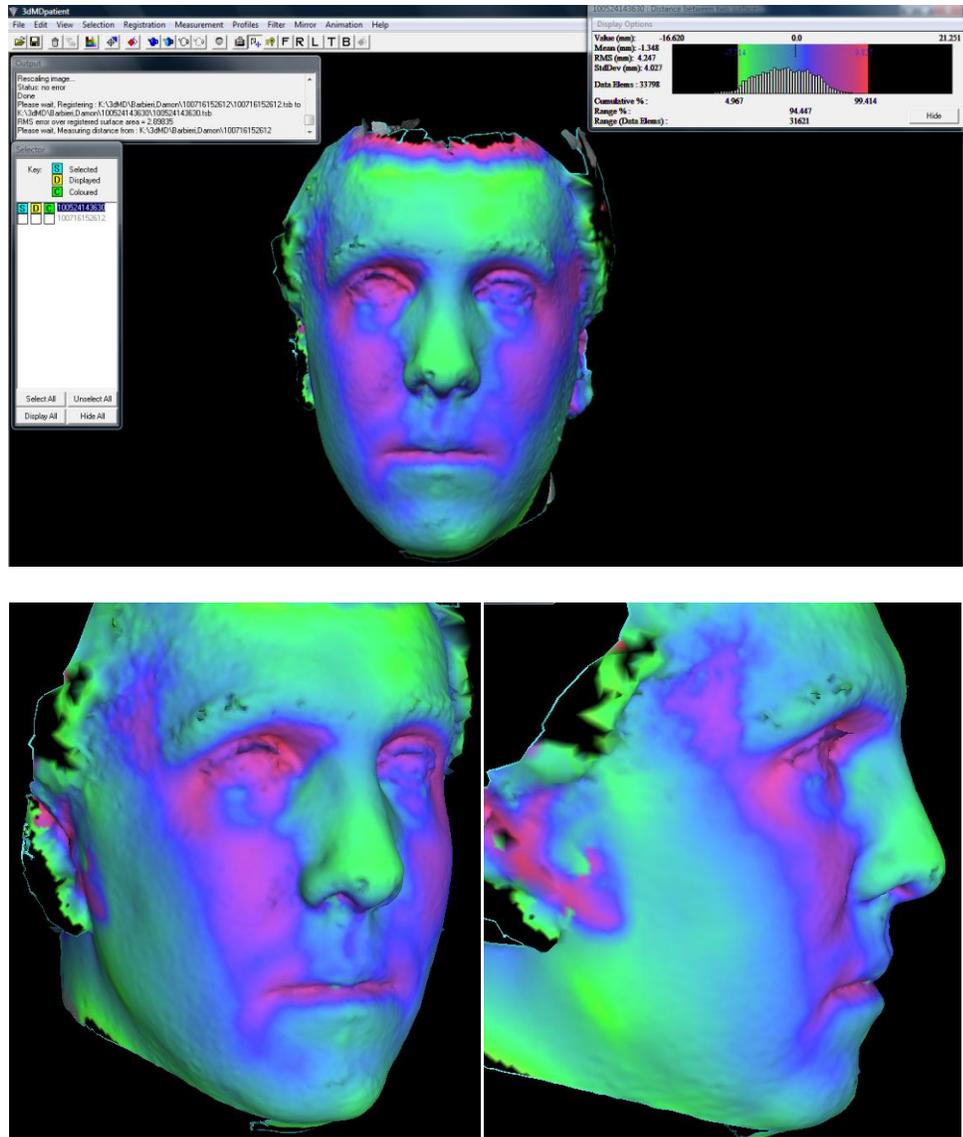


Figure 18 Resident 3 Composite 3-D Image Color Histograms and Statistics



I gained the ability to appreciate proportions.

The bust reflects my personality more than my features.

I have a long face, large nose, and cupid lips.

I focus on lips and eyes because I like them. They are the most prominent features that stand out first when I look at others.

I dislike the lack of definition in my neck and jawline.

I spent the most time on the eyes because they were the most difficult to recreate.

I am most pleased with the nose and it is the most accurate.

The lips were the least accurate. They are too pursed by 2mm.



Figure 19 Resident 3 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 78	Resident Self Evaluation (Q10x10): 80
RMS: 2.89835	Degree Accentuated (histogram mm range): -7.714 → +9.827

Table 4 Resident 3 Correlation of Accuracy

5.1.4 Resident 4



Figure 20 Resident 4 Composite 2-D Images

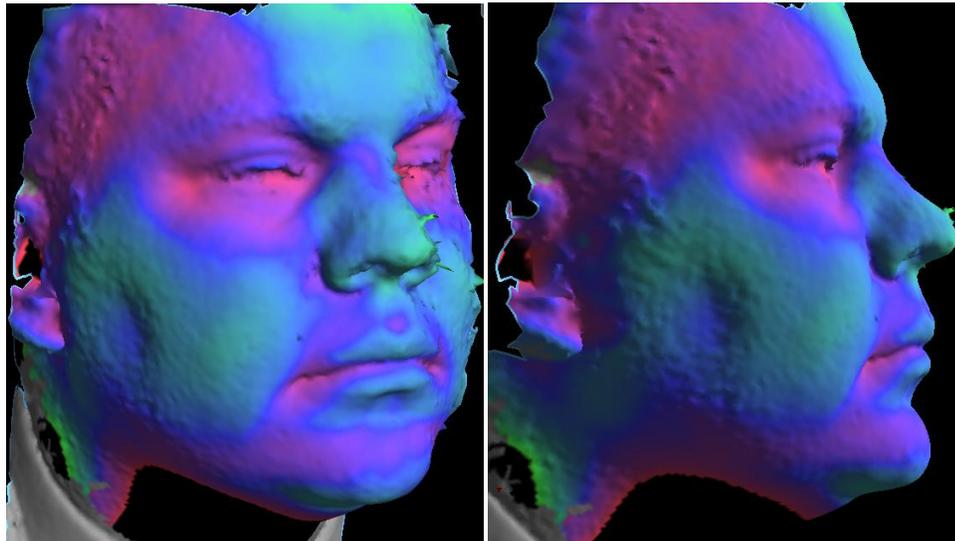
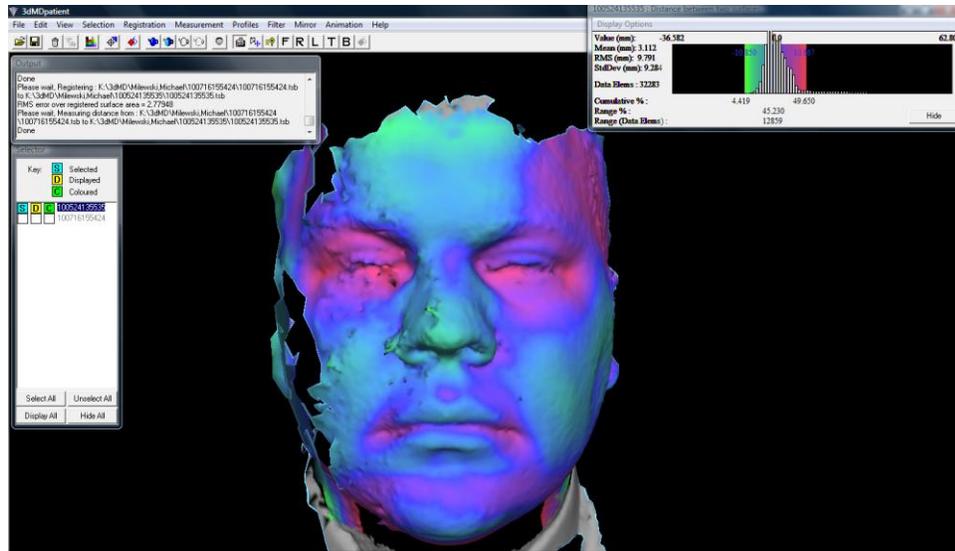


Figure 21 Resident 4 Composite 3-D Image Color Histograms and Statistics



I am extremely critical of myself.

I think I captured my personality more than my features.

I have a stern, intimidating, military look.

I like my smile and my eyes.

I don't like that I don't have much of a bridge on my nose because I've broken it so many times.

I spent the most time on the eyes and nose. I feel these areas dictate the face so I wanted to accurately capture them.

I am most pleased with the eyes, nose and lips/mouth and feel these are the most accurate.

I over exaggerated the lower third and made the cheeks too flat near the malar processes by 1-2 mm.



Figure 22 Resident 4 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 78	Resident Self Evaluation (Q10x10): 50
RMS: 2.77948	Degree Accentuated (histogram mm range): -10.850 → +10.867

Table 5 Resident 4 Correlation of Accuracy

5.1.5 Resident 5



Figure 23 Resident 5 Composite 2-D Images

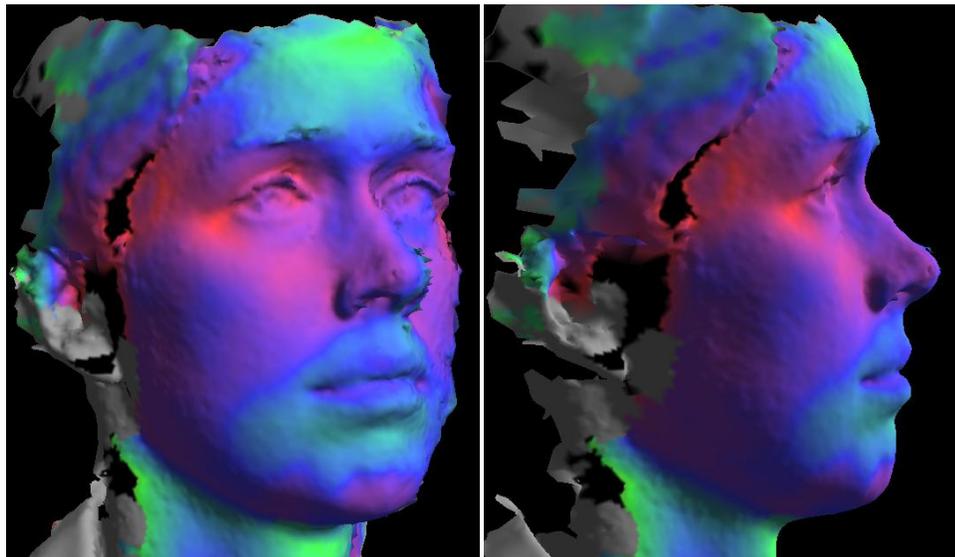
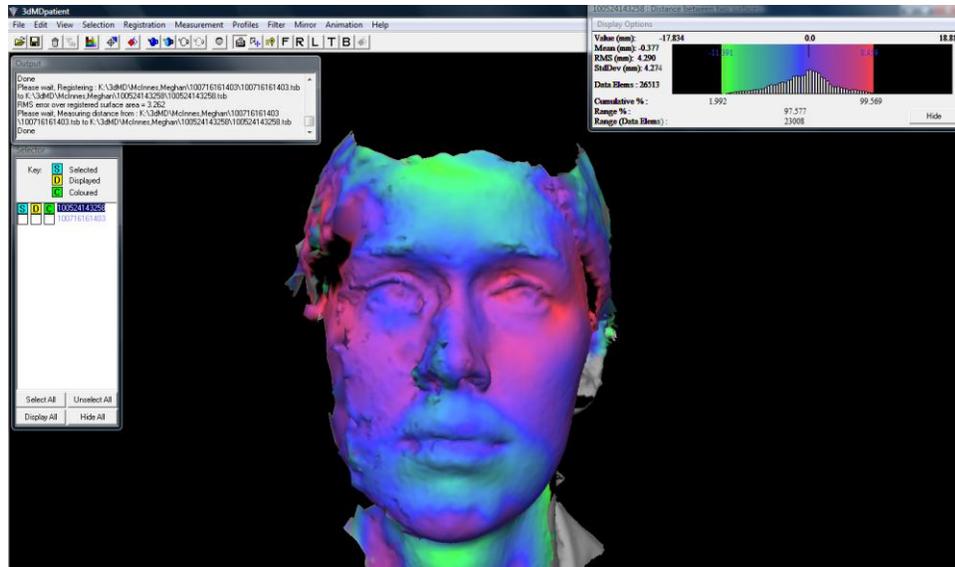


Figure 24 Resident 5 Composite 3-D Image Color Histograms and Statistics



I was unable to capture my features or my personality in clay. I wanted the bust to reflect kindness but was unsuccessful. It looks scary and too artificial with no expression.

I have a long, symmetrical face with high cheekbones.

I like and focus on eyes and smile because they are the most expressive.

I spent the most time on the eyes because it was difficult to capture expression in them.

I am most pleased with the nose and cheekbones. The cheekbones are the most accurate.

I made the eyes too close together by 3mm, the lips are too pursed and 2mm too narrow, and the chin is 4mm too strong.

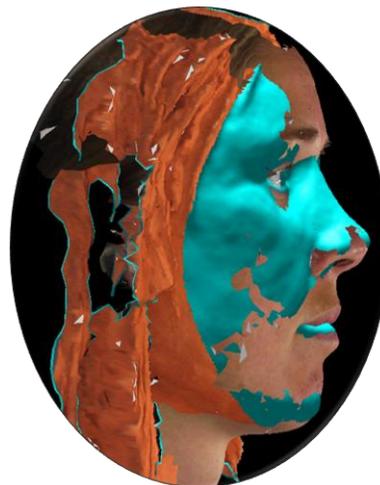


Figure 25 Resident 5 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 67	Resident Self Evaluation (Q10x10): 20
RMS: 3.262	Degree Accentuated (histogram mm range): -11.391 → +8.459

Table 6 Resident 5 Correlation of Accuracy

5.1.6 Resident 6



Figure 26 Resident 6 Composite 2-D Images

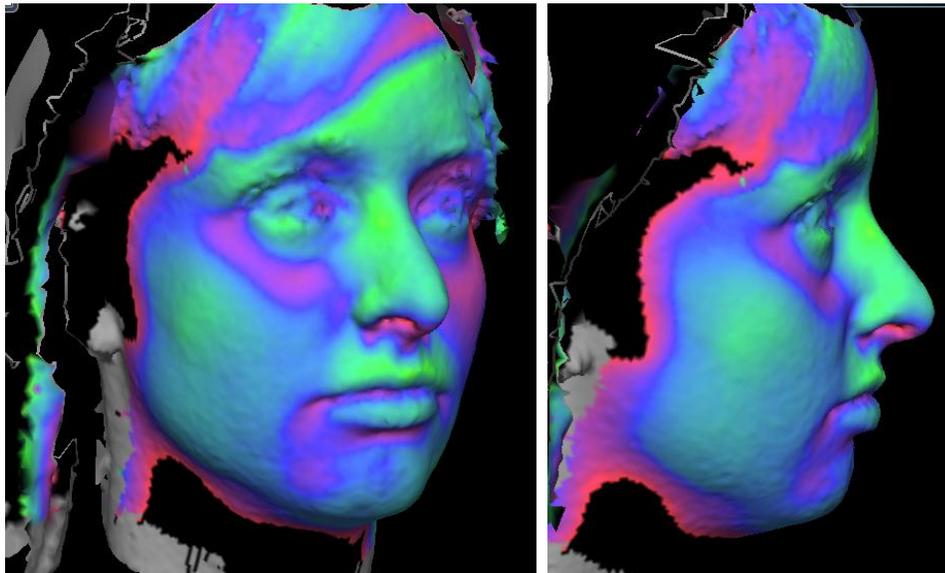
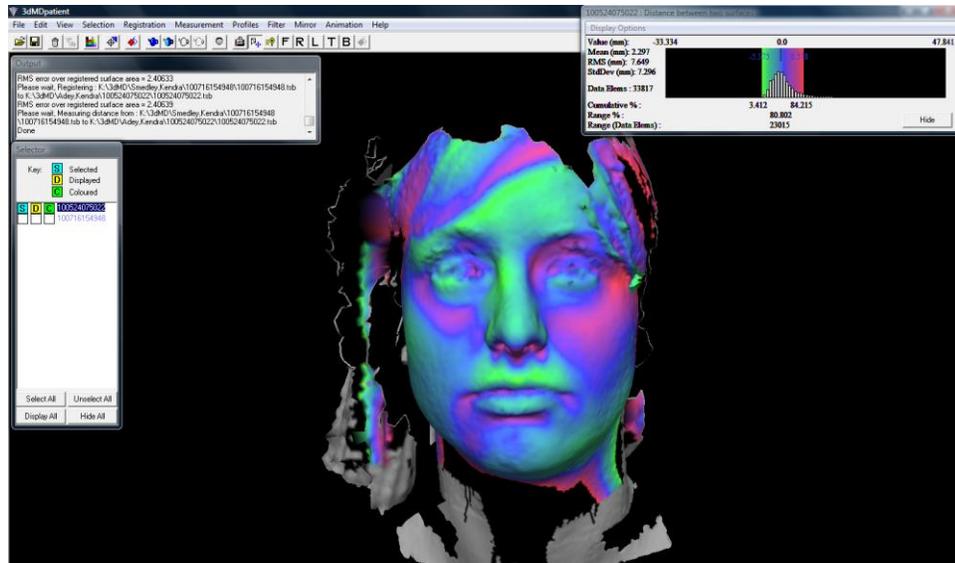


Figure 27 Resident 6 Composite 3-D Image Color Histograms and Statistics



I was able to generally capture some of the facial features but the expression turned out angry looking. I am used to seeing myself posed and smiling in photographs. I am most aware of my face from a frontal view because you don't see yourself in profile in the mirror or in many photographs.

The eyes and smile are the most animated features in a person and can tell you the most about someone.

I have a long face, slightly larger than average nose, a high forehead, a slightly retrognathic chin, and a little chin strain. I describe myself very orthodontically.

I don't like that my eyes are not symmetrical and my one eye squints more than the other. The tip of my nose and columella are too long.

I like the face shape and cheekbones and feel that they are the most accurate.

I made the forehead too short by 10 mm and the width of the eyes 8 mm too close together and too deeply set.



Figure 28 Resident 6 Composite 3-D Image Superimpositions with Resident's Comments in text

Grade (Q4): 70	Resident Self Evaluation (Q10x10): 70
RMS: 2.40639	Degree Accentuated (histogram mm range): -5.375 → +6.578

Table 7 Resident 6 Correlation of Accuracy

5.1.7 Resident 7

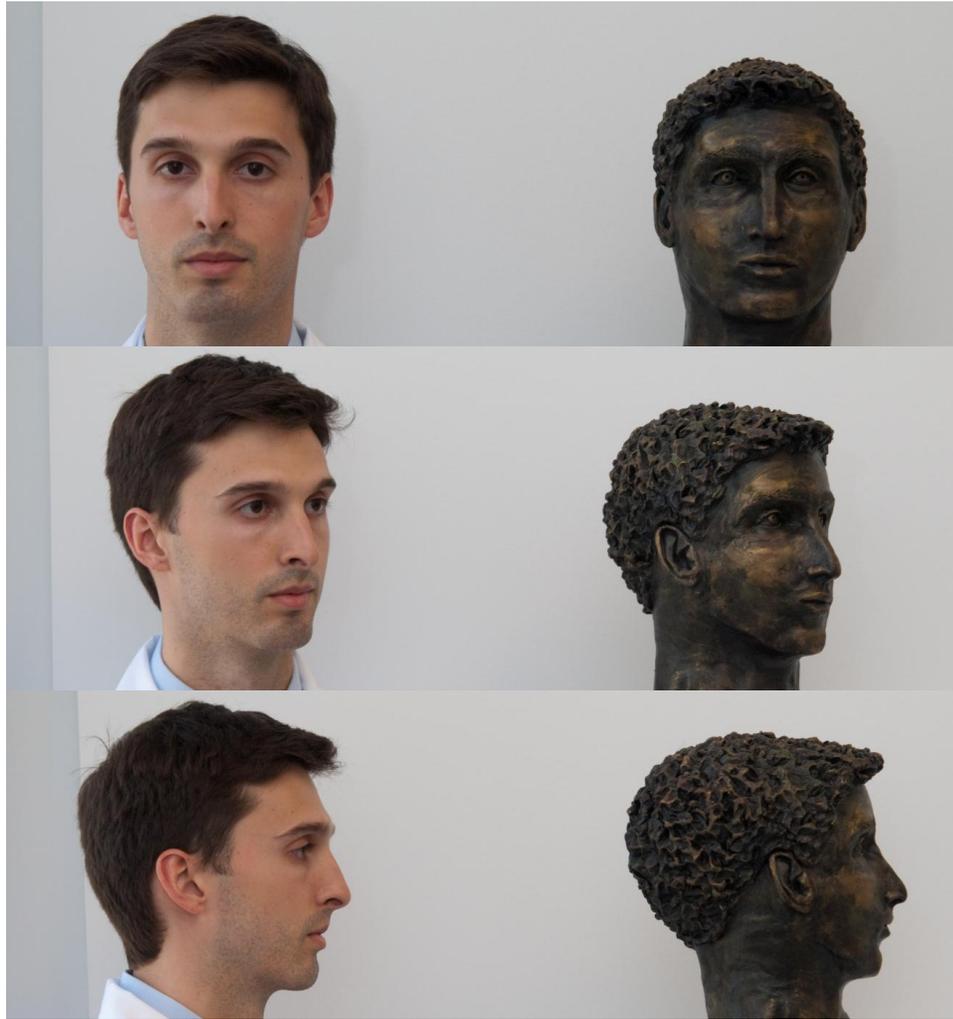


Figure 29 Resident 7 Composite 2-D Images

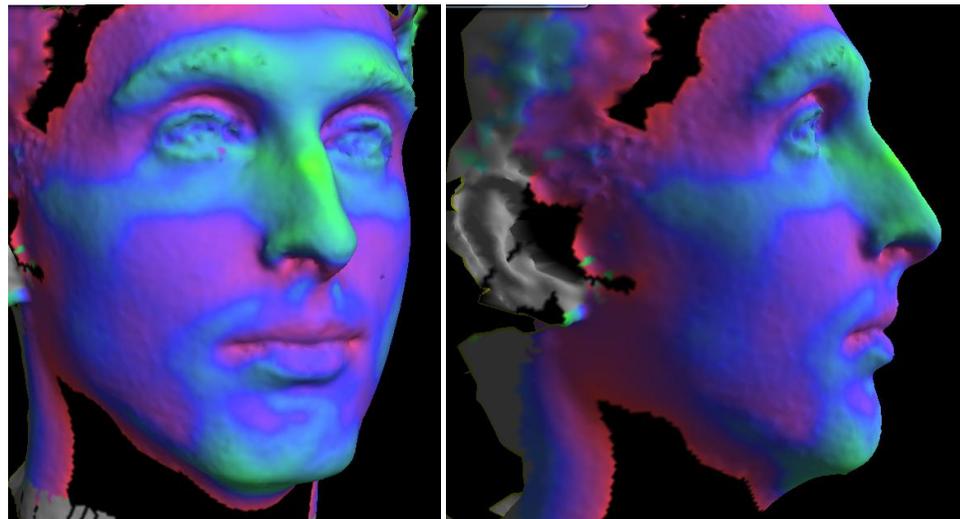
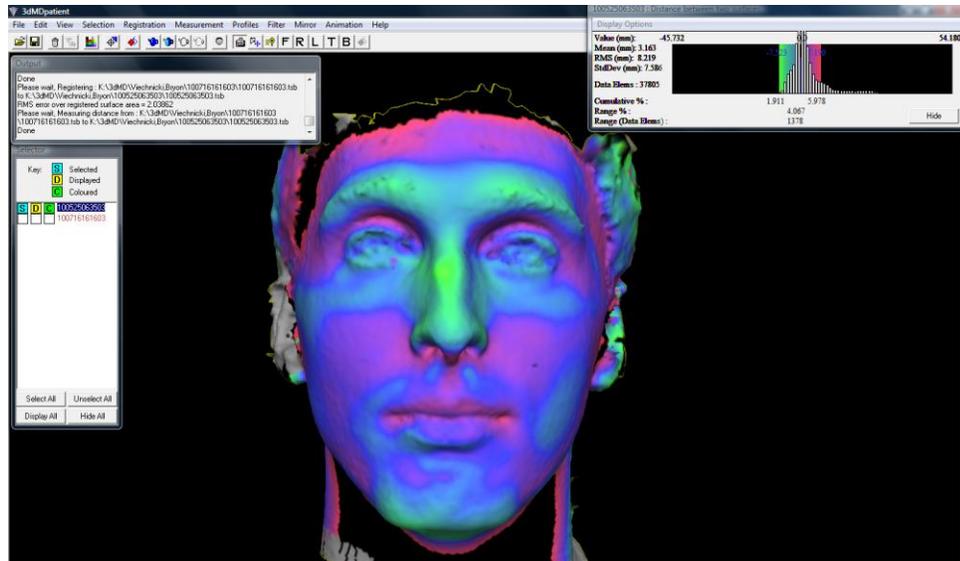


Figure 30 Resident 7 Composite 3-D Image Color Histograms and Statistics



The bust reflects my features and personality. I wanted it to depict a charismatic personality and was successful.

I am tall, humorous, charismatic, vivacious, smart, intellectual, and pedantic.

I found the lips to be the most difficult to recreate because it was hard to gauge the depth transversely.

I am most pleased with the profile.

The forehead is the least accurate in all dimensions by 10 mm.



Figure 31 Resident 7 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 92	Resident Self Evaluation (Q10x10): 100
RMS: 2.03862	Degree Accentuated (histogram mm range): -7.523 → +7.190

Table 8 Resident 7 Correlation of Accuracy

5.1.8 Resident 8



Figure 32 Resident 8 Composite 2-D Images

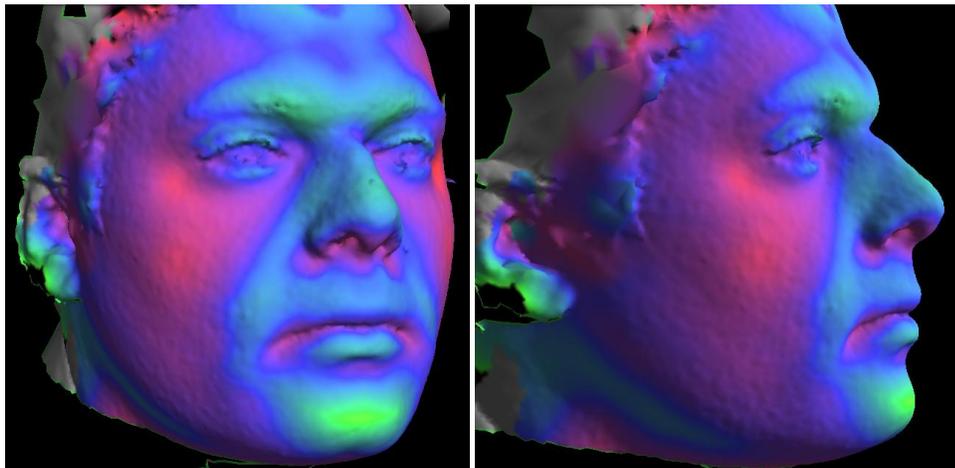
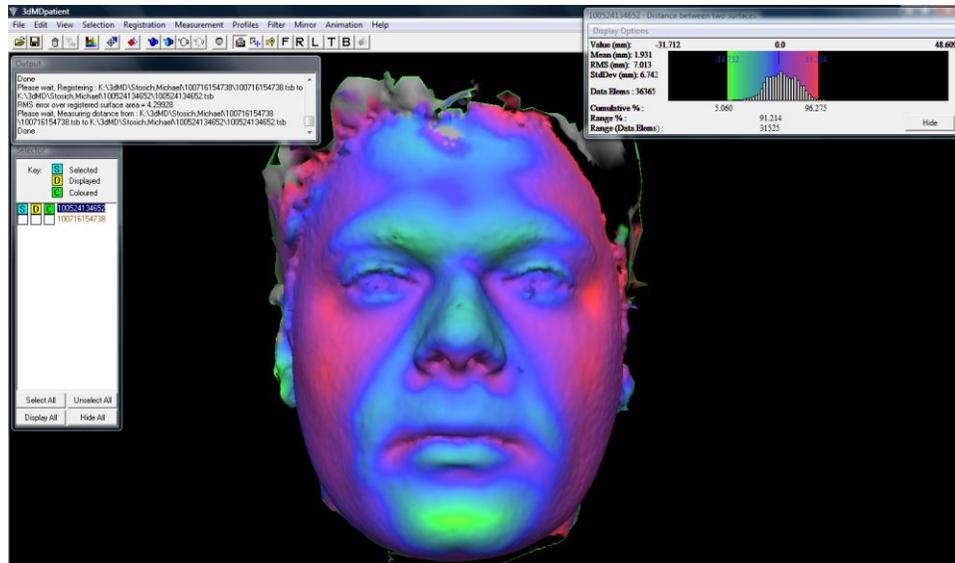


Figure 33 Resident 8 Composite 3-D Image Color Histograms and Statistics



The bust does not depict an accurate representation of me or my features. It captured my dominant personality and assuredness.

I would describe myself as having above average looks.

I don't like exceedingly large lips.

I found the eyes and nose to be very difficult to recreate.

The lips and cheeks are too robust and are the least accurate. The cheekbone prominence and width are off by 3 mm.



Figure 34 Resident 8 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 58	Resident Self Evaluation (Q10x10): 50
RMS: 4.29928	Degree Accentuated (histogram mm range): -14.732 → +11.214

Table 9 Resident 8 Correlation of Accuracy

5.1.9 Resident 9



Figure 35 Resident 9 Composite 2-D Images

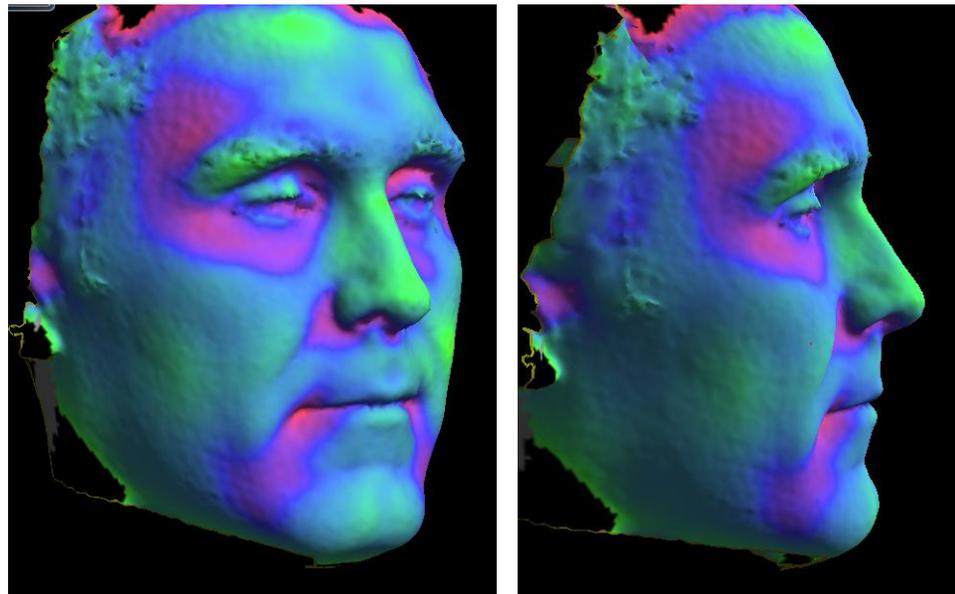
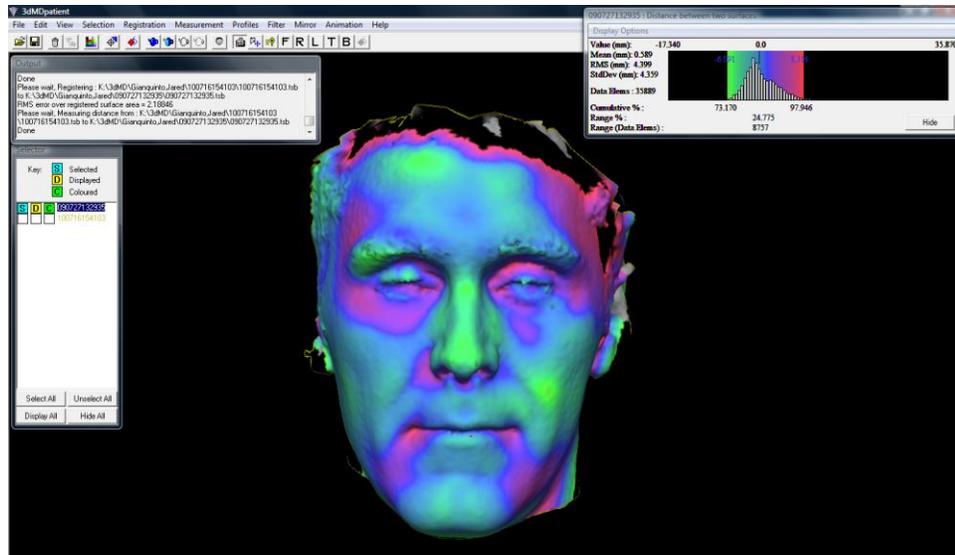


Figure 36 Resident 9 Composite 3-D Image Color Histograms and Statistics



I was able to capture a few specific features that made my bust somewhat recognizable.

I am a handsome man with angular features.

I focus on my nose because it is a very common feature in my family.

My receding hairline bothers me.

I spent the most time on the nose and eyes because they are the most defining characteristics of someone's image and personality. People gravitate toward the eyes when identifying others.

I found the eyes and lips/mouth the most difficult to recreate because I couldn't get the proportions right.

I am most pleased with the nose because it is most accurate.

The chin is inaccurate by 5 mm in width and the forehead is too short by 4-5 mm.



Figure 37 Resident 9 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 92	Resident Self Evaluation (Q10x10): 50
RMS: 2.18846	Degree Accentuated (histogram mm range): -6.091 → +8.316

Table 10 Resident 9 Correlation of Accuracy

5.1.10 Resident 10



Figure 38 Resident 10 Composite 2-D Images

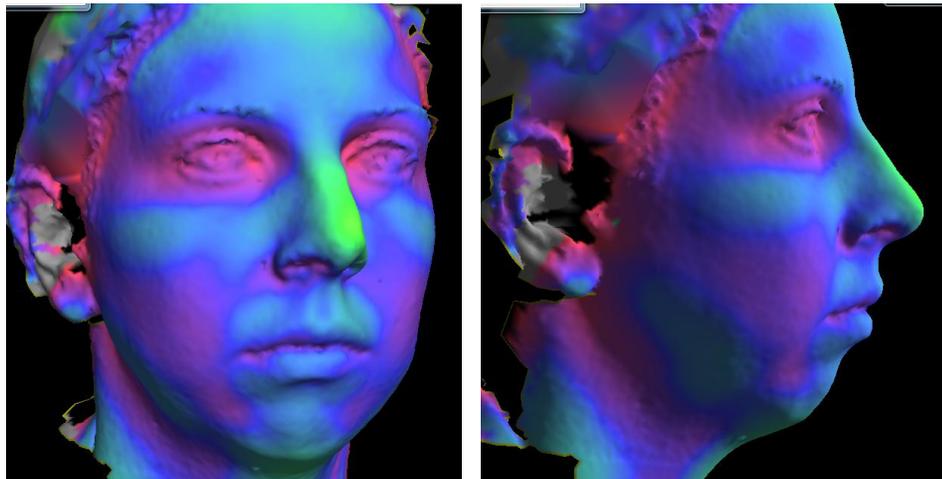
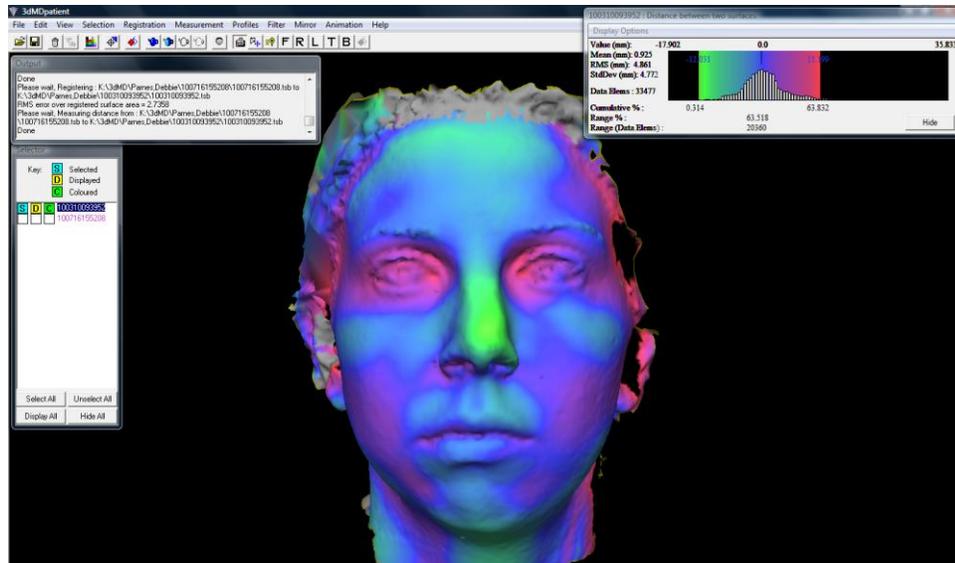


Figure 39 Resident 10 Composite 3-D Image Color Histograms and Statistics



I am considering surgery and this process confirmed that for me and how I see myself. I am more aware of myself as a result.

I think I was able to capture my features in clay but not my personality.

I have a small chin, chubby cheeks and large eyes.

I like and focus on smiles because they can change the whole way a person's face looks. It's the first thing that I look at in others. I like my lips.

People's noses can vary drastically and a badly shaped nose is not attractive. I don't like my nose because it has a bump.

I spent the most time on the shape of the face because that is my most distinct facial characteristic.

The eyes were the most difficult to recreate.

I was most pleased with the nose and the shape of the face.

I think the cheeks were the most accurate.

The eyes were the least accurate and generic looking. I think the left eye is 1-2 mm smaller than the right.

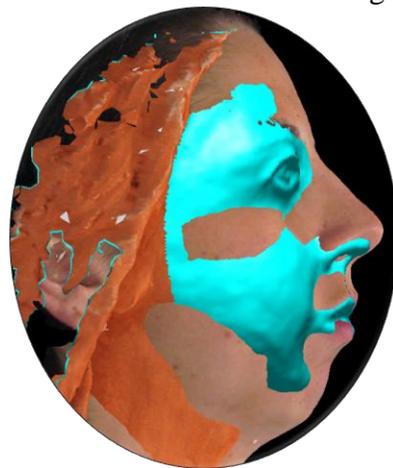


Figure 40 Resident 10 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 76	Resident Self Evaluation (Q10x10): 70
RMS: 2.7358	Degree Accentuated (histogram mm range): -12.031 → +11.199

Table 11 Resident 10 Correlation of Accuracy

5.1.11 Resident 11

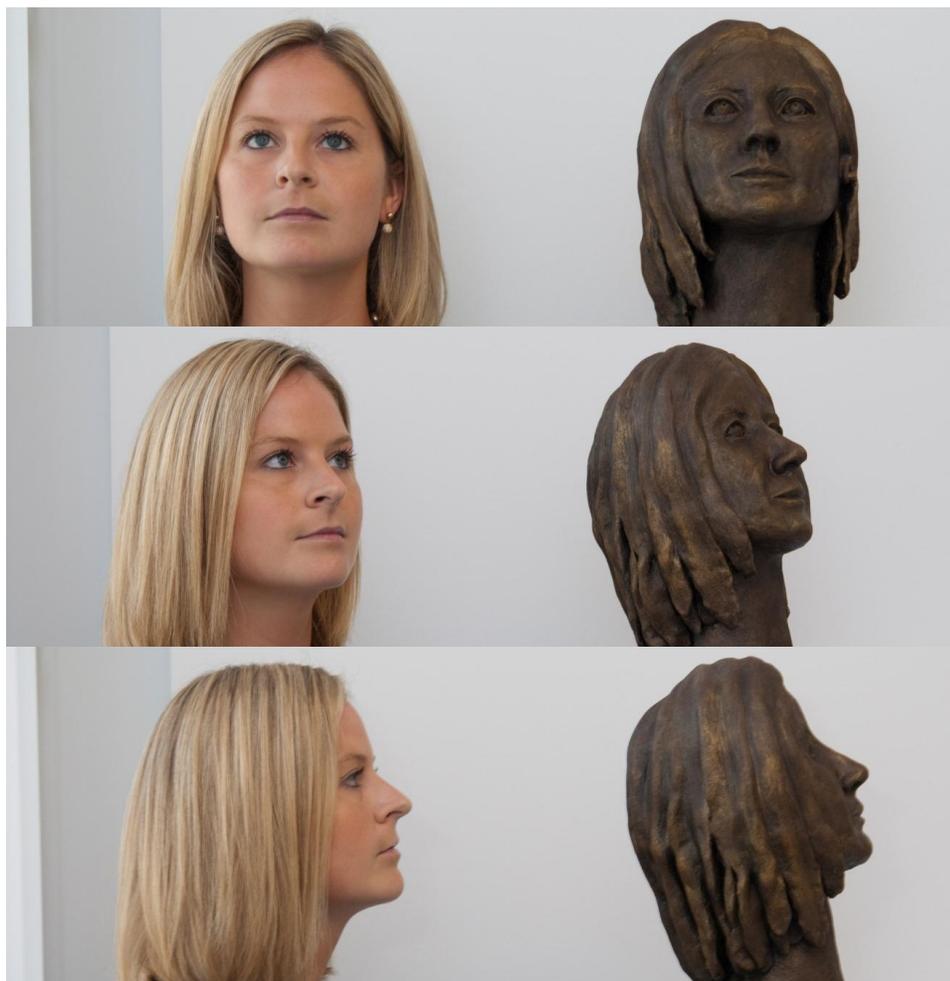


Figure 41 Resident 11 Composite 2-D Images

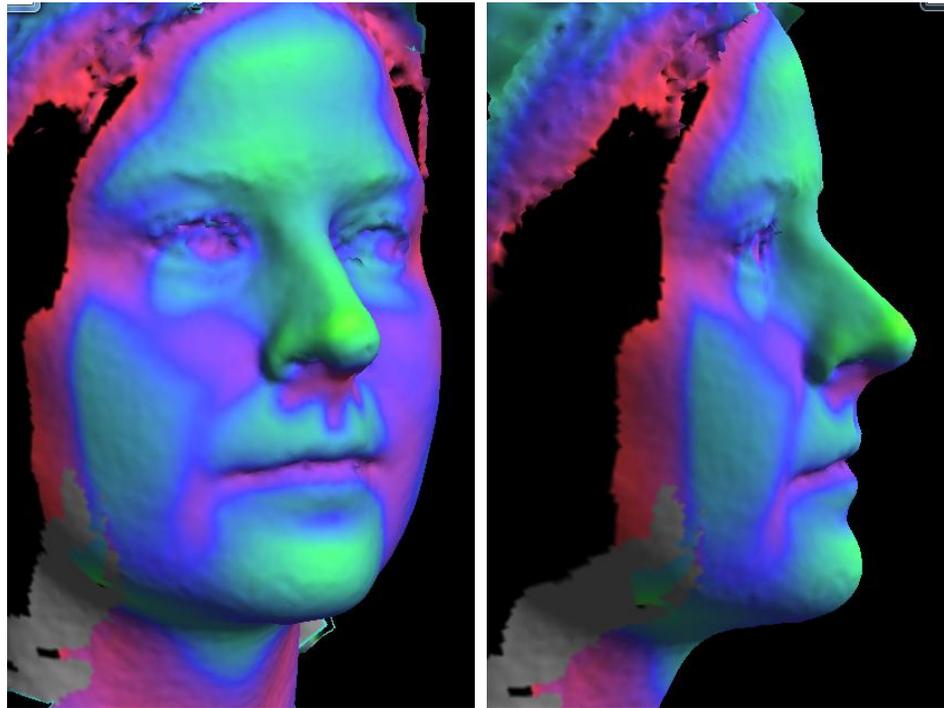
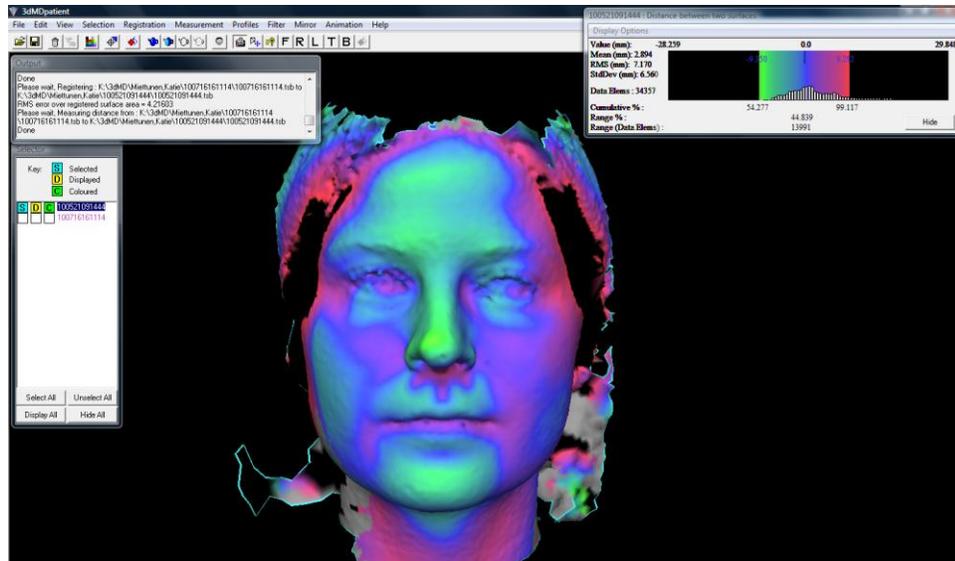


Figure 42 Resident 11 Composite 3-D Image Color Histograms and Statistics

This project gave me a different perspective. I never looked at myself in a three dimensional way. I am used to seeing myself in the mirror and photographs from the front.



I was able to capture certain features but not my personality. I see myself as a smiley person and not as serious as I look in the bust.

I have a square shaped jaw, a round face, a really big nose and nostrils, and small lips. I have good proportions to my face.

I focus on my nose because it is the center of my face and I don't like it. In others, I focus on eyes because it is generally people's best feature and I am drawn to them. My nose is too prominent. I spent the most time on my nose because it is unique and the most defining characteristic of my face. I wanted to do my best to replicate it because it's the first thing I see.

I spent a lot of time on the eyes due to technical difficulty. I am most pleased with the eyes.

I think the chin is the most accurate.

I focused a lot on the frontal view when sculpting the bust and consequently made my face too flat. Although I do have a flat face, I made it too flat and my cheeks too full by 10mm.



Figure 43 Resident 11 Composite 3-D Image Superimpositions with Resident's Comments in Text

Grade (Q4): 76	Resident Self Evaluation (Q10x10): 80
RMS: 4.21603	Degree Accentuated (histogram mm range): -9.350 → +9.282

Table 12 Resident 11 Correlation of Accuracy

CHAPTER 6

DISCUSSION

6.1 Facial Alterations by Resident

6.1.1 Resident 1

Resident 1 said he likes and focuses on eyes. This feature was enlarged in his bust. He doesn't like his chin because it is too retrognathic and he exaggerated this perceived lack of a chin. He feels his nose differentiates him and he spent the most time on this feature. The length of the nose was made too long on the bust. The resident found the lips and eyes to be the most difficult to recreate. Additionally, these features were perceived by the resident to be the least accurate and the nose and chin as the most accurate. The color histogram displays that the resident was able to accurately determine that the lips and eyes were the most inaccurate and that the nose and chin were the most accurate. The resident's alterations of decreased jaw size and chin prominence, pronounced eyes and cheekbones, narrow or small nose, and fuller lips make the face more youthful and feminine. The face was also shown to be thinned transversely.

6.1.2 Resident 2

Resident 2 described himself as having a slender face with a gaunt look. He perceived his eyes as set back with puffiness below them, ears that stick out, and a small hump on his nose. The puffiness below the eyes was accentuated and the dorsal hump on his nose was removed in the bust. He spent the most time on the eyes because he had difficulty with the symmetry and making them look like his own. He was most pleased with the nose and accurately identified it as the most accurate feature. This resident

discussed his greatest difficulties were in capturing the proportions of the face, specifically the mid-face region between the lips and eyes. This area and the lips, eyes and forehead were shown to be the most inaccurate in the color histogram and confirmed the resident's assessment as being the least accurate regions. The thinned lips, accentuated brow ridge, and decreased contrast around the eyes (which were made more shallow), all create a more masculine look.

6.1.3 Resident 3

Resident 3 felt that his bust reflected his personality more than his features. He described himself as possessing a long face, large nose, and cupid lips. He focuses on eyes and lips in others because they are the most prominent features that stick out to him. He also made these features larger (more prominent) in his own bust. He dislikes his own neck and jawline because they lack definition. These features were decreased (less defined) in his bust. He was most pleased with the accuracy of the nose, which was reduced in prominence but slightly lengthened. He correctly identified the lips as inaccurately enlarged. A more youthful and feminine looking bust was created by the decreased jaw size and chin prominence, pronounced eyes and cheekbones, narrow or small nose, and fuller lips. This resident also thinned the face transversely.

6.1.4 Resident 4

Resident 4 believed the bust captured his stern, intimidating, military look and personality more than his features. He likes his smile and eyes and enlarged his eyes and lips in his bust. He doesn't like the lack of a bridge on his nose and improved upon this feature in his sculpture. He correctly judged that the greatest accuracy was in the nose

and mouth areas, and that the cheeks and malar processes were made too flat. The embellishment of the chin and brow ridge, and decreased contrast around the eyes (due to the lack of depth), all produce a more masculine face. The sculptured face was thinned.

6.1.5 Resident 5

Resident 5 felt she was unsuccessful in capturing her kind personality or her features. The lack of expressiveness was seen as scary. She described herself as having a long, symmetrical face with high cheekbones. She likes to focus on people's eyes and smile because they are the most expressive features. She was most pleased with the recreation of the cheekbones and felt this was the most accurate element. The color histogram displays a heightening of the cheekbones and eyes and the circumoral region and forehead were diminished in size. These alterations present a more juvenile and feminine face. Due to her difficulty in capturing the expression in the eyes, she spent the most time on this aspect of the bust. She correctly perceived that the chin was made too strong and the eyes were too close together, more masculine features that perhaps coupled with the lack of expression led her to conclude that the bust looked scary.

6.1.6 Resident 6

Resident 6 also felt that the serious look of her bust resulted in an angry expression. She expressed that most of her experience with viewing her face and awareness was from posed and smiling frontal views in photographs and the mirror. She believes she can tell the most about a person from their eyes and smile. She described her face as long, with a slightly larger than average nose, a high forehead, a slightly retrognathic chin, and a little chin strain. In the bust she decreased the size of her chin.

She dislikes that her eyes are not symmetric when she smiles with one eye squinting more than the other. She also feels that the tip of her nose and columella are too long. She exaggerated both of these features that she stated she did not like about herself. She liked the cheekbones in her bust and felt they were the most accurate. The cheekbones were enhanced in the bust which is a more feminine trait. She accurately recognized that the forehead was too small and the eyes were too close together and too deeply set. Again, these masculine features could have contributed to the bust looking angry to her. She also thinned the face.

6.1.7 Resident 7

Resident 7 felt that he successfully recreated his charismatic personality and his features. He described himself as tall, humorous, charismatic, vivacious, smart, intellectual, and pedantic. He was the only resident to describe himself almost exclusively by personality. He struggled most in reproducing the lips, due to the difficulty in gauging their transverse depth. He was able to recognize the forehead as the least accurate feature. The bust emphasized more feminine features such as decreased chin prominence and brow ridge, high contrast surrounding the eyes, heightened cheekbones and forehead, narrow or small nose, and fuller lips. Women have been shown to seek less masculine feature when concerned with personality (as this resident sees himself).

6.1.8 Resident 8

Resident 8 did not feel the bust was an accurate representation of his features but did feel that it captured his dominant personality and assuredness. He described his looks

as above average. He doesn't like exceedingly large lips but enlarged them on the bust. He found the eyes and nose to be very difficult to recreate. He made the nose longer and wider at the alar base. The lips and cheeks were accurately identified as being too robust and are the least accurate. The increase in volume in the cheekbones and lips together with the decrease in chin and brow ridge prominence display a more feminine facial appearance.

6.1.9 Resident 9

Resident 9 believed he was able to capture a few specific features in his bust that made it somewhat recognizable. He described himself as a handsome man with angular features. He focused a lot of his efforts on the nose and eyes because they are defining characteristics. He was most pleased with the nose and felt it was the most accurate. The nose was thinned and lengthened. His receding hairline bothers him and this feature was improved in the bust. The chin and forehead were correctly recognized as being the least accurate. This increase in jaw size, along with the deep set eyes and thin lips, creates a more masculine appearance. He also thinned the face.

6.1.10 Resident 10

Resident 10 thought that she was able to capture her features but not her personality in the bust. The sculpture and self study process made her more aware of her face and confirmed that she wants to undergo cosmetic facial surgery. She described herself as having a small chin, chubby cheeks and large eyes. All of these features were exaggerated in her bust, although she mistakenly believed the cheeks were the most accurate aspect. She doesn't like her nose because it has a bump. This bump was

removed in the bust and she reported that she was most pleased with the results of the diminutive nose. The other feature that she found most pleasing was her face shape, which she spent the most time replicating. She feels this is her most distinct facial characteristic. She found the eyes to be the most difficult to recreate and felt they looked too generic. She accurately perceived the eyes as the least accurate feature. The enlarged eyes and cheeks and reduced nose and chin contribute to a more youthful appearance.

6.1.11 Resident 11

Resident 11 reported that she never looked at herself in a three dimensional way before the sculpture project. She was accustomed to seeing her face from a frontal view in the mirror and photographs. She felt that she was able to capture certain features but not her personality in the bust. She considers herself a smiley person and not as serious as the bust portrays her. She describes her features as a square shaped jaw, a round, flat face, a really big nose and nostrils, and small lips, with good facial proportions. She focuses on people's eyes. She dislikes her nose because it is too prominent. She spent the most time working on her nose because she finds it unique and the most defining characteristic of her face. It is the first thing she sees when looking at her face. The nose in the bust lacked prominence and was lengthened considerably. She spent the most time on the eyes and was most pleased with the outcome. She feels the chin is the most accurate feature, although it is reduced in the bust. Her vantage point when working on the bust was primarily from a frontal view, and consequently, she made the face too flat. She recognized the lack of adequate depth of the face as the most inaccurate, when assessing the final result. Additionally, the asymmetry created in the cheeks was recognized. The cheekbones and lips were too prominent and the nose, forehead and chin

were lacking in depth. These features all create a more feminine appearance. The face was again thinned in this bust.

6.2 Trends Observed in Facial Alterations

Previous research has shown that internal features such as eyes, nose, and mouth/lips are more important for the recognition of the face than external features like face shape, head size, neck and hair (Ellis, Shepherd, and Davies 1979). The eyes, nose, and oral region are also the most important predictors of attractiveness. The interview process revealed that these same features were predominantly discussed and given as answers to the various questions. These internal features were the primary focus of the residents when constructing their busts and were therefore more accurate than the external features. The internal features were also the most time consuming aspects. Despite the resident's best efforts to replicate these important features, as accurately as possible, the majority were enlarged in the final busts. The relative importance of the eyes, nose and mouth features could have influenced their increase in size when being recreated in clay. In life, cosmetics are used to create contrast and alter the face, to draw attention to or detract from, various features. Without the ability to enhance or accentuate areas of the face by traditional means, residents made them physically larger in dimension.

The nose was a common feature that residents described as important, defining or distinct. Eight of the eleven residents stressed this feature. Eight residents made the noses less prominent and eight made it longer. Seven distinguished the nose as a feature that they were most pleased with in the sculpture of themselves. Of these residents, two

reported that they had a bump on their nose. When attempting to replicate their features in the sculpture, this bump was removed in both cases. Interestingly, these residents also chose the altered noses as the feature that they were most pleased with in the resultant bust.

Six residents described the eyes as a feature they liked or focused on either in themselves or others. Seven residents discussed their difficulties in replicating the eyes and spent the most time on this feature. Some of the cited difficulties involved their inability to give the eyes expressiveness and avoid them looking too generic (“those could be anyone’s eyes”). This phenomenon and other similarly nonspecific sculpted features could be influenced by the inherently desired tendency toward averageness. Also called prototypicality, faces that are low in distinctiveness are conversely rated high in attractiveness.

Five of the residents identified the eyes as the least accurate feature with six of the residents making the eyes larger in their busts. Seven of the residents also increased the fullness of the lips. This commonly observed increase in the size of the eyes and lips creates a more feminine appearance. The uniform color of the clay bust could also have influenced this increase in size to create greater luminance contrast between the eyes and the lips with the surrounding skin. An increase in contrast also increases the feminine look. In fact, the feminization of facial features was examined in eight of the busts, belonging to four female and four male residents. Four of the seven males used physically imposing words such as, dominance, stern, intimidating, and tall, or specified that they were a man, in their self descriptions. Only three of the seven male busts exhibited more masculine enhanced features like large jaw size (wide mandible), strong

chin, small deep set eyes, thin lips and brow ridge prominence. Additionally, two of the female busts contained features that reflected some masculine enhancements.

Coincidentally, these busts were also reported as looking scary and angry by their female sculptors. Testosterone dominated features have been shown to convey a cold, insincere and aggressive look. Furthermore, the busts were designed to recreate the resident's facial features at rest. The lack of expression could have influenced these women to perceive that the sculptured face looked scary or angry in a neutral, relaxed state.

Overall, the vast majority of sexually dimorphic alterations were feminine traits. Attractive females display youthful traits in the central region (large eyes, slender nose, and full lips), and sexual maturity in the peripheral areas (high cheekbones). Resident 7, a male who described himself exclusively by his personality, had made the facial features of his bust more feminine. Furthermore, three of the four male residents who made feminine enhancements to their features stated that the bust was able to capture their personality. The tendency for women to prioritize a less masculine looking long term partner when concerned with personality has been investigated in the literature. Conversely, all of the female residents, who participated in this study, declared that their busts did not reflect their personality. Although three of the four female residents felt they were successful in capturing their features in the bust, none of the women in this study felt that the bust reflected their personality. This finding can possibly be interpreted as a limitation of the static nature of the bust, as well as the face being captured in repose. Again, the relative high value that the females place on expressiveness is evident. Women rely heavily on the dynamic ability to convey their

feelings, emotions and personality in their facial features. The women explicitly stated the importance of the expressive qualities of the eyes and smile.

Other more peripheral facial features were also altered in the sculptures. Six of the residents thinned the faces transversely. The correlation between a thin appearance and attractiveness has been significantly demonstrated in the literature. The ubiquitous strive to look thin has influenced behaviors such as dieting, exercise, cosmetics use and cosmetic surgery.

The chin and forehead were also diminished in nine of the eleven busts. The individuals with retrognathic chins all accentuated this deficiency (made even smaller) in their busts. Resident 10, who is considering cosmetic surgery to correct her “small chin”, also further decreased the size of her chin in the bust. This lack of chin depth, seen in many of the busts (along with making her “chubby cheeks” even chubbier), has a youthful influence on the face.

In the case of resident 10, the over exaggeration of disliked features could be very telling of her desire to seek surgical correction. Discontent with her self-image can negatively influence her interpretation and assessment of her outward appearance and motive her to explore an appearance related improvement. The majority of cosmetic surgery patients derive much of their self-esteem from their self-image (high self image valence) and are dissatisfied with their self-image (low self-image value). A diminished self-image value could lead to a perception that a problem feature is worse than it actually is in reality.

The diminished prominence in the chin, forehead and nose (the most prominent features) coupled with the lack of depth in the eyes and ocular and circumoral concavities contribute to a relatively flatter face. Many of the residents spoke of the difficulties in recreating their faces in all three dimensions. Some even expressed that their work was done almost exclusively from a frontal perspective. This head-on exchange between sculptor and bust is consistent with the majority of human interactions. Most people experience their own face in two dimensional (2-D) space, whether seeing themselves in photographs or their image in the mirror. Since the majority of times the facial self-image is seen in a frontal view in 2-D, this lack of depth and limited vantage point can produce an incomplete and often distorted view of oneself. Perhaps, this lack of three dimensional awareness also led residents to unconsciously enlarge their noses, not in depth, but in length, the more clearly observed dimensional change when seen from a frontal view. Facial recognition of others has been previously shown to be best from a slightly off-center angle.

Most of the residents expressed their intentions to make their face or certain distinguishing features recognizable. As discussed in earlier studies, the goal of observing another's faces is identification, whereas the goal of self perception focuses on inspection of facial features. This self perception is not necessarily accurate. In past studies, the average subject was unable to accurately define the dimensions of their own face within five centimeters. Even the worst graded busts in this study were comparatively much more accurate. The busts that were evaluated as having the poorest representation had a maximum discrepancy of 14.732 millimeters. This is less than one and a half centimeters as compared to the five centimeters found in other published studies. This significant

disparity could be due to the participants involved in this study being orthodontists and highly trained individuals. Another possibility is the ability of the residents to utilize measurement instruments such as rulers and calipers during the sculpture course to transfer the size and dimensions of the face to bust. The relatively high accuracy in most dimensions represents a commonly expressed discovery of the residents who participated in this study. Almost universally, the residents explained that this learning process showed them that even minute millimetric changes can drastically change a face and its perception.

In the areas where the bust features were inaccurate, the following perceptual distortions and influences could have played a part. A caricaturing of the face may have occurred to exaggerate certain features to accentuate their distinctiveness. This alteration can make a face more recognizable and help differentiate or distinguish the face from the norm.

The perceptual inability to accurately judge the size and shape of certain facial features could also lead to self-enhancements. The perceptual process of self-face recognition can create a more desirable self image that is positively distorted. This may be the reason that people rarely seem to like photographs of themselves and why many of the residents reported being unhappy with the results of their bust despite the relative accuracy of the final product. Subjects of other studies have been shown to automatically recognize or identify attractively enhanced distracter versions of their face before their own. In this study, the removal or correction of aspects that are disliked and the volumetric addition or improvement of liked features suggests the presence of self enhancement perceptions.

Many of the residents also discussed the importance of symmetry in the face and facial features. Perceived asymmetries in their own face were exaggerated and slight unintentionally fabricated asymmetries were detected in the bust. This finding substantiates previously documented evidence of the importance of symmetry in facial attractiveness.

All but one resident reported that they were more aware of their face and others facial features as a result of the sculpture project.

6.3 Trends Observed in Questionnaire Responses

Question 4 and 5 showed a general correlation between the amount of hours spent on the sculpture construction and the grade received in the sculpture course. The four residents, who received a grade below 70, answered Question 10 (Are you happy with the results of your bust?) as 0, 2, 5, and 6 out of a possible 10. These four residents also had relatively low RMS error values of 3.40668, 3.88406, 3.262, and 4.29928 showing a poor match between their superimposed images of their face and bust. Additionally, their histogram ranges (indicating the amount of millimeters of discrepancy between the two) were $-9.414 \rightarrow +8.863$, $-10.254 \rightarrow +11.175$, $-11.391 \rightarrow +8.459$, and $-14.732 \rightarrow +11.214$. When compared to the two highest graded busts that both received a score above 90, these two residents had low RMS error values of 2.18846 and 2.03862. Their color histogram ranges were also much lower at $-6.091 \rightarrow +8.316$ and $-7.523 \rightarrow +7.190$. These results suggest that the four values given in the “correlation of accuracy” tables above show relative agreement between a third party observer’s perspective of accuracy (course

grade), the resident's self evaluation, the RMS error value calculated during superimposition, and the color histogram millimetric range.

In Question 17, all of the residents rated their self awareness between a 7 and 10 except one. The outlier that answered 5 was also the lowest graded bust. Other publications have reported that individuals with a higher self esteem tend to have a less accurate idea of their own facial dimensions. This has been attributed to these individuals needing less reassurance of their appearance in a mirror.

Question 18 asked for a self description. This question was purposefully left open ended and did not specify what type of description. Almost every resident answered with a physical self description detailing their bodily characteristics. Very little behavioral traits or personality distinctions were shared. This could be evidence of both sexes' prioritization of physical characteristics over personality traits.

Question 22 inquired if the resident had a previous history of orthodontic treatment. All but one resident had undergone orthodontic therapy, some of them multiple times. The one resident that had not had any prior treatment was planning on being treated in the future. It has been shown that facial preferences are not influenced by a personal history of orthodontic treatment. Although the importance of the teeth and smile has been discussed extensively as a predictor of attractiveness none of the residents commented that they disliked their own teeth or smile. This could be interpreted as their satisfaction with prior treatment.

When asked question 23 (What facial features do you like or focus on?), almost every resident answered eyes and/or smile. There was no gender difference in response.

This is consistent with the literature and shows that orthodontic residents, although trained professionals, value these features no differently than everyone else.

Another interesting finding was that Questions 23/24 were almost unanimously answered in a general fashion about what features they liked or focused on in others, whereas, Question 25/26 about what features they dislike were nearly universally answered about themselves. This could be attributed to the self critical nature of the individuals. Residents were most picky about themselves. The specific features cited were deviations from normal, that is to say not average or prototypical (ie., large nose, small chin, etc.). This urge to become average/beautiful can be seen in the response to Question 22 above. Teeth/smile variation was corrected to a standard. Since the teeth were no longer an issue for them, their focus began to shift onto improving other facial features. People will always continue to look for ways to improve their physical appearance, starting with their inherited features and then moving towards rejuvenation once the aging process has begun.

In Question 27/28 most residents answered either nose or eyes as the feature they spent the most time to recreate. Of those who responded “nose”, most all answered Q28 (Why?), as it was an important or differentiating feature. Most all who answered “eyes” declared the reason was they were technical difficult.

Question 30-31 showed a strong correlation between the features the resident was most pleased with and the features that they felt were the most accurate.

The distortions observed in self perception further illustrate the importance of psychological analysis through carefully structured interviews and evaluations. The

objectives of facial enhancement procedures, including orthodontic treatment can only be achieved once these perceptions are properly elucidated.

CHAPTER 7

CONCLUSIONS

The conclusions of this study are as follows:

- The internal features (nose, eyes, and mouth) that were the most liked, important, and defining were enlarged.
- Self enhancements were observed as thinned faces and improvements in the shape and size of certain features.
- Symmetry, averageness, and sexual dimorphic alterations (primarily feminine traits) were prioritized.
- Women rely heavily on expression to convey personality.
- Facial features were caricatured or cartoonized to accentuate liked or defining features and over-exaggerated in disliked features to increase distinctiveness.
- Residents' perceptions were most accurate in a frontal two dimensional view but decreased in accuracy in three dimensions.
- Physical characteristics are prioritized over personality traits.
- Residents were fairly successful in determining which features were the least accurate and by how much.

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APPENDIX A

Interview Questionnaire

Q1) Name:

Q2) Sex: M F

Q3) Age:

Q4) Sculpture Course Grade:

Q5) How much time (hrs) did you spend on the sculpture (hands on/preparation-thinking)?

Q6) What did you get out of the project?

Q7) What was your level of interest? 0 - - - - - 10

Q8) Did you enjoy the process? 0 - - - - - 10

Q9) What would you be missing without going through this course (what did you gain)?

Q10) Are you happy with the results of your bust? 0 - - - - - 10

Q11) Were you able to capture your features in clay?

Q12) Did your bust reflect your personality?

Q13) What expression did you want it to reflect? Were you successful?

Q14) Are you more aware as a result?

Q15) What features are you more aware of?

- Q16) Did you deliberately exaggerate or accentuate any features?
- Q17) How aware are you of your face? 0 - - - - - 10
- Q18) Describe yourself to me?
- Q19) Do you consider yourself artistic? 0 - - - - - 10
- Q20) In what capacity or medium?
- Q21) Do you appreciate art? 0 - - - - - 10
- Q22) Have you ever received orthodontic treatment?
- Q23) What facial features do you like or focus on? Q24) Why?
- Q25) What facial features do you dislike or bother you? Q26) Why?
- Q27) What areas did you spend the most time on? Q28) Why?
- Q29) What did you find the most difficult to recreate?
- Q30) What areas were you most pleased with?
- Q31) What do you feel were the most accurate?
- Q32) What areas are least accurate? Why? Off by how much (mm)?
- Q33) How would you analyze these results?

Interview 1

Q1) Resident 1

Q2) Male

Q3) 28

Q4) 58

Q5) 25 hours

Q6) I gained an appreciation for clay sculpting, and a more profound knowledge of my own facial features.

Q7) Extremely high- 9

Q8) Yes. I enjoyed the process- 9

Q9) I would be missing the opportunity to sculpt, and see how easily my facial features can be distorted with small changes in clay.

Q10) I am happy with the results- 6

Q11) I was unable to capture my features.

Q12) I was unable to capture my personality.

Q13) I wanted it to reflect a disciplined expression. I was unsuccessful, due to my lack of skill as a sculpture.

Q14) I am more aware as a result.

Q15) I am very aware of my face.

Q16) I did not deliberately accentuate any features. I did not pay enough attention to the lips, so I inadvertently exaggerated the lips.

Q17) I am very aware of my face- 9

Q18) I am an attractive man.

Q19) I am artistic yes-10

Q20) Music

Q21) I appreciate art- 10

Q22) Yes, I have received orthodontic treatment.

Q23) I focus on eyes.

Q24) I find them to be very unique amongst individuals.

Q25) I don't like my chin.

Q26) It's too retrognathic.

Q27) I spent the most time on my ears and my nose.

Q28) I thought that the nose would help to differentiate me from others.

Q29) I found the lips and the eyes the most difficult to recreate.

Q30) I was most pleased with the results of the nose and the ears.

Q31) I felt the nose and chin were most accurate.

Q32) The lips and eyes were the least accurate. I accidently exaggerated the fullness of the lips. The lips were puffed out 4-5mm and the eyes were 2mm too large.

Q33) I would superimpose my face and bust and with computer software find the mathematical differences.

Interview 2

Q1) Resident 2

Q2) Male

Q3) 29

Q4) 32

Q5) 40 hours

Q6) I tried to express myself in clay and found it difficult.

Q7) 5

Q8) Average- 5

Q9) It didn't help me. I knew going in that it would be difficult and that I am not artistic.

Q10) I am not happy. It is not very good and not a good replication- 0

Q11) I did not capture my features. I don't think it looks like me.

Q12) I was unable to capture my personality.

Q13) I wanted it to reflect a serious expression at rest. I was successful.

Q14) My awareness increased as a result.

Q15) Although I didn't capture it, I am more aware of my profile, my chin, and my nose and proportionality.

Q16) I did not deliberately accentuate any features.

Q17) average- 5

Q18) I have a slender face with a gaunt look. My eyes are set back with puffiness below my eyes. My ears stick out and I have a small hump on my nose.

Q19) I am not artistic no-1

Q20) I am not artistic in any way

Q21) I appreciate art and know it's difficult- 7

Q22) Yes, I have received orthodontic treatment.

Q23) I like the smile line and what a smile adds.

Q24) Someone with a good smile can overcome other features that aren't attractive.

Q25) I don't like ears.

Q26) Ears are not attractive.

Q27) I spent the most time on the eyes.

Q28) I had difficulty with the symmetry and making them look like mine. I had difficulty capturing the proportions of the face.

Q29) It was difficult to recreate the ears. The intricacy, fine lines and folds are hard to recreate.

Q30) I was most pleased with the nose.

Q31) I believe the nose was the most accurate.

Q32) The lips, ears, eyes, and forehead were the least accurate and the proportions were way off. The distance in the midface, between the lips and eyes, was excessive by 10mm.

Q33) Superimpositions

Interview 3

Q1) Resident 3

Q2) Male

Q3) 31

Q4) 78

Q5) 35 hours

Q6) I gained the ability to appreciate proportions, and how much difference it makes to add or remove a millimeter here and there.

Q7) 6

Q8) 8

Q9) I wouldn't be missing a lot without the course.

Q10) 8

Q11) The bust doesn't reflect my features.

Q12) The bust reflects my personality more than my features.

Q13) I wanted it to reflect despair and was successful.

Q14) I am not more aware as a result.

Q15) (no answer)

Q16) I did not deliberately exaggerate anything.

Q17) 7

Q18) I have a long face, large nose, cupid lips, dark hair and eye brows, brown eyes.

Q19) I am artistic yes-6

Q20) Music

Q21) I appreciate art.

Q22) Yes, I have received orthodontic treatment.

Q23) I focus on lips and eyes because I like them.

Q24) They are the most prominent features that stand out first when I look at others.

Q25) I dislike my neck and jawline.

Q26) I dislike the lack of definition.

Q27) I spent the most time on the eyes.

Q28) They were the most difficult to recreate.

Q29) The eyes were the most difficult.

Q30) I was most pleased with the results of the nose and the ears.

Q31) I felt the nose and ears were most accurate.

Q32) The lips were the least accurate. They are too pursed by 2mm.

Q33) I would analyze the results with 3dMD overlays.

Interview 4

Q1) Resident 4

Q2) Male

Q3) 33

Q4) 78

Q5) 35 hours

Q6) I am extremely critical of myself. I learned that a couple of millimeters here and there can make a huge difference in your facial features. It was applicable to what we do as orthodontists.

Q7) Initially pretty low (2) but my interest increased to 7.

Q8) I found it relaxing and enjoyed it- 7

Q9) I can now appreciate that a couple of millimeters here and there on any aspect of your face has a significant effect on your appearance.

Q10) I am happy with the results- 5 but wish I had more time allotted to work on it.

Q11) I was able to capture myself for the most part but looking back, side by side, the features were difficult to capture.

Q12) I think I captured my personality.

Q13) I wanted it to reflect a solemn, neutral expression and I was successful.

Q14) I am more aware and critical of facial features in my patients.

Q15) I am much more aware after the project- 8

Q16) I tried to capture the correct proportions.

Q17) I am very aware of my face- 8

Q18) I have a stern, intimidating, military look, but it is not coincident with my personality.

Q19) I am minimally artistic- 3

Q20) (no answer)

Q21) I appreciate art and am aware of the amount of skill involved- 9

Q22) No, I have never received orthodontic treatment.

Q23) I like my smile and my eyes.

Q24) People like my smile.

Q25) I don't like my nose.

Q26) I don't have much of a bridge on my nose because I've broken it so many times.

Q27) I spent the most time on the eyes and nose.

Q28) I feel these areas dictate the face so I wanted to accurately capture them.

Q29) It was hard to determine proportions, soft tissue profile, and topography. The malar processes are too flat in the sculpture.

Q30) I am most pleased with the hair, neck, eyes, nose, and mouth.

Q31) I feel the eyes, nose, and lips are the most accurate, and I did a pretty good job on the ears.

Q32) I over exaggerated the lower third and lost the proportionality. I also made the cheeks too flat near the malar processes by 1-2 mm.

Q33) I would use a qualitative approach.

Interview 5

Q1) Resident 5

Q2) Female

Q3) 28

Q4) 67

Q5) 50 hours

Q6) I realized that I am not a good artist. I look at faces a bit more.

Q7) 5

Q8) 6

Q9) I would not miss anything.

Q10) I am not happy with the results- 2

Q11) I was unable to capture my features.

Q12) I was unable to capture my personality.

Q13) I wanted the bust to reflect kindness but was unsuccessful. It looks scary and too artificial with no expression.

Q14) I am a little more aware of myself and others.

Q15) I am pretty aware of my face.

Q16) I did not deliberately accentuate any features. I accidentally made my chin a little big.

Q17) I am pretty aware of my face- 8

Q18) I have blue eyes, and a long, symmetrical face with high cheekbones.

Q19) I am not artistic- 0

Q20) (no answer)

Q21) I appreciate art- 10

Q22) Yes, I have received orthodontic treatment.

Q23) I like and focus on eyes and smile in people.

Q24) They are the most expressive.

Q25) Nothing. I accept myself.

Q26) (no answer)

Q27) I spent the most time on the eyes.

Q28) It was difficult to capture expression in them.

Q29) I found the eyes to be the most difficult to replicate.

Q30) I am most pleased with the hair, nose, and cheekbones.

Q31) The cheekbones are the most accurate.

Q32) I made the eyes too close together by 3mm, the lips are too pursed and 2mm too narrow, and the chin is 4mm too strong.

Q33) I would use a qualitative approach.

Interview 6

Q1) Resident 6

Q2) Female

Q3) 27

Q4) 70

Q5) 50 hours

Q6) I look at people with more detail and realized how very minor changes can make a big difference in the overall appearance of a person.

Q7) I was excited- 9

Q8) I enjoyed it- 9

Q9) I would be missing an appreciation for soft tissue changes. I pay more attention to the details of a face that I don't normally notice.

Q10) I am happy with the results and was graded fairly- 7

Q11) I was somewhat able to capture myself and my features in general.

Q12) No, I wasn't thinking about personality but more of a static representation.

Q13) I was trying to create a serious expression but it turned out angry looking. I don't see serious pictures of myself very often. I am used to seeing myself posed and smiling in photographs.

Q14) I am more aware as a result of myself and others. I am most aware of my face from a frontal view because you don't often see yourself in profile in the mirror or in many photographs.

Q15) I am more aware of my profile.

Q16) I did not intentionally exaggerate anything.

Q17) I am pretty aware of my face- 8

Q18) I have a long face, slightly larger than average nose, a high forehead, a slightly retrognathic chin, and a little chin strain. I describe myself very orthodontically.

Q19) I am somewhat artistic- 7

Q20) Photography and still life sketches- more 2D medium.

Q21) I enjoy art but am uneducated- 7

Q22) Yes, I have received orthodontic treatment.

Q23) I focus on the eyes and smile.

Q24) They are the most animated and you can tell the most about people from those features.

Q25) My eyes and the tip of my nose from the profile view.

Q26) I don't like that my eyes are not symmetrical and my one eye squints more than the other. The tip of my nose and columella are too long.

Q27) I spent the most time on the eyes and I still didn't get them right.

Q28) It was difficult to make the eyes and hair look realistic and not caked on. I worked from the bottom up and ran out of room when I got to my forehead.

Q29) The eyes were the most difficult to replicate.

Q30) I like the face shape and cheekbones. I am most pleased with the frontal view.

Q31) The general shape of the face and cheekbones are the most accurate.

Q32) The profile and detail in the eyes was less accurate. I made the forehead too short by 10 mm and the width of the eyes 8 mm too close together and too deeply set.

Q33) I would analyze the results with superimposition.

Interview 7

Q1) Resident 7

Q2) Male

Q3) 27

Q4) 92

Q5) 50 hours

Q6) I got lifelong fulfillment for my bust. I plan on keeping it in my office.

Q7) 10

Q8) 10

Q9) I would be missing an understanding of craniofacial esthetics.

Q10) 10

Q11) The bust reflects my features.

Q12) The bust reflects my personality.

Q13) I wanted it to depict a charismatic personality and was successful.

Q14) I am more aware of myself as a result.

Q15) My hair.

Q16) I did not deliberately accentuate anything.

Q17) 10

Q18) I am tall, humorous, charismatic, vivacious, smart, intellectual, and pedantic.

Q19) I am artistic- 10

Q20) Sculpture

Q21) I appreciate art- 10

Q22) Yes, I have received orthodontic treatment.

Q23) I focus on Focus on teeth.

Q24) I work with teeth.

Q25) Teeth bother me most.

Q26) I work with teeth.

Q27) I spent the most time on the profile.

Q28) It is a standard way that we look at faces.

Q29) I found the lips to be the most difficult to recreate because it was hard to gauge the depth transversely.

Q30) I am most pleased with the profile.

Q31) The hair is the most accurate.

Q32) The forehead is the least accurate in all dimensions by 10 mm.

Q33) I would analyze the results with 3dMD.

Interview 8

Q1) Resident 8

Q2) Male

Q3) 31

Q4) 58

Q5) 45 hours

Q6) I gained an appreciation of the millimetric differences in the facial soft tissue.

Q7) 9

Q8) 9

Q9) I would be missing a millimetric appreciation of the facial soft tissues.

Q10) No, it doesn't represent a true me but I exceeded what I thought I could achieve- 5

Q11) The bust does not depict an accurate representation of me or my features.

Q12) It captured my dominant personality and assuredness.

Q13) I wanted it to express ruling dominance over minions and I was successful.

Q14) I am more aware.

Q15) I am more aware of the millimetric soft tissue measurements of the face.

Q16) I exaggerated the hair because this feature was pronounced in Greco-Roman statues.

Q17) I am very aware of my face- 9

Q18) I would describe myself as having above average looks.

Q19) I am not artistic but I am creative- 8

Q20) Fashion and style, and artistic in dentistry

Q21) I appreciate art but I don't fully understand it- 9

Q22) Yes, I have received orthodontic treatment.

Q23) I focus on the entire package.

Q24) I don't focus on any specific feature.

Q25) I don't like thin dished in lips or exceedingly large lips.

Q26) I can't stop staring at them.

Q27) I spent the most time on the execution of the entire bust.

Q28) To recreate the facial package.

Q29) I found the eyes and nose to be very difficult to recreate due to my lack of ability.

Q30) I am most pleased with the chest and hair.

Q31) The chest and hair are the most accurate.

Q32) The lips and cheeks are too robust and are the least accurate. The cheekbone prominence and width are off by 3 mm.

Q33) I would use a qualitative analysis.

Interview 9

Q1) Resident 9

Q2) Male

Q3) 33

Q4) 92

Q5) 55 hours

Q6) I have a greater appreciation of sculpture.

Q7) 7

Q8) 5

Q9) I wouldn't be as cognizant of the intricacies of what goes into facial esthetics. It was a really good exercise to show how small changes over a surface can drastically alter your perception. I gained a greater awareness of facial esthetics.

Q10) I am not really happy with it- 5

Q11) I was able to capture a few specific features that made it somewhat recognizable but I don't think I was able to capture myself in it. Certain features I didn't capture at all.

Q12) I did not really capture my personality.

Q13) I was going for a relaxed expression in repose. I was moderately successful. It was not accurate due to a limitation of my skills.

Q14) I am definitely more aware as a result.

Q15) I am more aware of the contours of my chin and my jaw-line and the shape of my head.

Q16) I tried not to deliberately exaggerate anything.

Q17) 8

Q18) I am a handsome man with somewhat angular features.

Q19) Yes, I consider myself artistic yes- 8

Q20) Music

Q21) Yes, I appreciate art- 8

Q22) Yes, I have received orthodontic treatment.

Q23) I focus on my nose.

Q24) It is a very common feature in my family. We share the same facial features.

Q25) My receding hairline bothers me.

Q26) It is not as low as it once was.

Q27) I spent the most time on the nose and eyes.

Q28) They are the most defining characteristics of someone's image and personality.

People gravitate toward the eyes when identifying others.

Q29) I found the eyes and lips/mouth the most difficult to recreate because I couldn't get the proportions right. Even when I measured them and they looked like they were where they should be, they didn't seem right. It wasn't necessarily a dimensional problem but a perspective problem. Even though I thought that the width of my mouth and the height measured right, they didn't come out right.

Q30) I am most pleased with my ears and nose.

Q31) The nose was the most accurate.

Q32) The chin is inaccurate by 5 mm in width and the forehead is too short by 4-5 mm.

Q33) I would superimpose the images.

Interview 10

Q1) Resident 10

Q2) Female

Q3) 26

Q4) 76

Q5) 40 hours

Q6) I got a sculpture. I like doing art projects.

Q7) My level of interest was pretty high- 8

Q8) I enjoyed the process- 8

Q9) I am considering jaw surgery and this process confirmed that for me and how I see myself.

Q10) I am happy with the result- 5

Q11) I think I was able to capture my features in clay.

Q12) I could not capture my personality.

Q13) I was successful in creating a relaxed expression. I would like it if my head was straight. With my head up, I think it looks too pompous.

Q14) I am more aware of myself as a result.

Q15) (no answer)

Q16) I tried not to deliberately exaggerate anything.

Q17) I am very aware of my face- 10

Q18) I have a small chin, chubby cheeks and large eyes.

Q19) I consider myself artistic- 8

Q20) Arts and crafts

Q21) 4

Q22) Yes, I have received orthodontic treatment.

Q23) I like and focus on smiles.

Q24) They can change the whole way a person's face looks. It's the first thing that I look at in others.

Q25) In general, I dislike noses.

Q26) People's noses can vary drastically and a badly shaped nose is not attractive. I don't like my nose because it has a bump.

Q27) I spent the most time on the shape of the face.

Q28) It is my most distinct facial characteristic.

Q29) The eyes were the most difficult to recreate. I couldn't figure it out. They are three dimensional but set back, whereas the nose and lips come out. You are digging in to try to make it 3D.

Q30) I was most pleased with the nose and the shape of the face.

Q31) I think the cheeks were the most accurate.

Q32) The eyes were the least accurate and generic looking. I think the left eye is 1-2 mm smaller than the right.

Q33) I would use a qualitative approach.

Interview 11

Q1) Resident 11

Q2) Female

Q3) 26

Q4) 76

Q5) 50 hours

Q6) This project gave me a different perspective on analyzing my own facial esthetics. I never looked at myself in a three dimensional way. I am used to seeing myself in the mirror and photographs from the front. It gave me a different perspective. Now, when I am treating patients, I might turn their head a different way or analyze their case a little bit differently based on what I learned.

Q7) Very interested- 10

Q8) I enjoyed it but since I had no prior experience, I found it pretty frustrating sometimes-9

Q9) I have a new appreciation of the difficulty of sculpting and three dimensions.

Q10) I am happy with the result- 8

Q11) I was able to capture myself somewhat and certain features more than others.

Q12) I could not really capture my personality. I see myself as a smiley person and not as serious as I look in the bust.

Q13) I was going for a serious expression, and was successful.

Q14) Yes, I am more aware.

Q15) I am used to looking at myself from the front. I don't see many photos from the side and don't use side mirrors. I am now more aware in all dimensions.

Q16) I tried not to deliberately exaggerate anything.

Q17) I am pretty aware of my face- 8

Q18) I have a square shaped jaw, a round face, a really big nose and nostrils, and small lips. I have good proportions to my face.

Q19) I consider myself artistic but not necessarily with sculpture- 9

Q20) I am creative with projects and design and good at dental waxing

Q21) 9

Q22) Yes, I have received orthodontic treatment.

Q23) I focus on my nose and in others I focus on their eyes.

Q24) My nose is the center of my face and I don't like it. In others, I focus on eyes because it is generally people's best feature and I am drawn to them.

Q25) I dislike my nose.

Q26) It is too prominent.

Q27) I spent the most time on my nose and eyes.

Q28) My nose is unique and the most defining characteristic of my face. I wanted to do my best to replicate it because it's the first thing I see. I spent a lot of time on the eyes due to technical difficulty.

Q29) I thought the nose was the most difficult to position vertically in the right spot. I had to move it and initially made it too long. It was a challenge to get all of the dimensions to match.

Q30) I am most pleased with the eyes.

Q31) I think the chin and eyes were the most accurate.

Q32) I focused a lot on the frontal view when sculpting the bust and consequently made my face too flat. Although I do have a flat face, I made it too flat and my cheeks too full by 10mm.

Q33) I would superimpose and look at surface measurements to see how close they match.

APPENDIX B

	1	2	3	4	5	6	7	8	9	10	11
Q1											
Q2	M	M	M	M	F	F	M	M	M	F	F
Q3	28	29	31	33	28	27	27	31	33	26	26
Q4	58	32	78	78	67	70	92	58	92	76	76
Q5	25	40	35	35	50	50	50	45	55	40	50
Q6	knowledge of own face	knowledge of own face	milimetric/ minute changes	knowledge of own face/ milimetric/ minute changes	knowledge of faces in general	milimetric/ minute changes	bust	milimetric/ minute changes	milimetric/ minute changes	bust	knowledge of own face/ knowledge of faces in general
Q7	9	5	6	7	5	9	10	9	7	8	10
Q8	9	5	8	7	6	9	10	9	5	8	9
Q9	minute changes	nothing	nothing	minute changes	nothing	minute changes	esthetics	minute changes	esthetics/ minute changes	self awareness	3D appreciation
Q10	6	0	8	5	2	7	10	5	5	7	8
Q11	no	no	yes	yes	no	yes	yes	no	yes	yes	yes
Q12	no	no	yes	yes	no	no	yes	yes	no	no	no
Q13	serious/no	serious/yes	serious/yes	serious/yes	serious/no scary	serious/ no scary	serious/yes	serious/yes	serious/yes	serious/yes	serious/yes
Q14	yes/ general	yes/ self	no	yes/ general	yes/ general	yes/ general	yes/ self	yes/ general	yes/ self	yes/ general	yes/ self
Q15	face	profile/ chin + nose/ proportions		face	face	profile	hair	face	chin/ jawline/ shape of head		profile
Q16	no/ lips	no	no	no	no/ chin	no	no	yes/hair	no	no	no
Q17	9	5	7	8	8	8	10	9	8	10	8
Q18	physical-attractive man	physical-slender face/ eyes set back/ puffyness below eyes/ gaunt/ ears stick out/ hump on nose	physical-long face/ large nose/ cupid lips/ dark hair and eyebrows/ brown eyes	physical-stern military look/ nice smile / personality-intimidating	physical-blue eyes/ symmetrical face/ higher cheek bones/ long face	physical-longer face/ slightly large nose/ high forehead/ slightly Class II profile/ mesocephalic jaw/ slight chin strain	physical-tall/ personality-humorous/ charismatic/ vivacious/ smart/ intellectual/ pedantic	physical-above average looks	physical-handsome man/ angular features	physical-small chin/ chubby cheeks/ large eyes	physical-square jaw/ round face/ big nose and nostrils/ good proportions/ small lips
Q19	10	1	6	3	0	7	10	8	8	8	9
Q20	music	none	music	none	none	photography/ drawing	sculpture	creative/ fashion/ style/ dentistry	music	arts and crafts	creative/ design/ dentistry
Q21	10	7	6	9	10	7	10	9	8	4	9
Q22	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes
Q23	general-eyes	general-smile	general- lips and eyes	myself-smile and eyes	general-eyes and smile	general-eyes and smile	general-teeth	general package	myself- nose	general-smile	general-eyes
Q24	unique	overcomes other flaws	1st focus/ most prominent	receive compliments	most expressive	most telling and animated	line of work		common in family	1st focus/ most prominent	1st focus/ most prominent
Q25	myself-chin	general-ears	myself-neck and jawline	myself-nose	myself-nothing	myself-eyes and nose	general-teeth	general-lips	myself-hairline	myself-nose	myself-nose
Q26	retrognathic ears and nose	not attractive	lack of definition	broken 5x- no bridge left eyes and nose	I accept myself	eyes-asymmetric/ nose- pronounced tip	line of work	distracting if too large or too small	receding	bump	too prominent
Q27	important differentiate	eyes	eyes	important differentiate	eyes	eyes	profile	face	eyes and nose	face	nose
Q28	important differentiate	technical difficulty	technical difficulty	important differentiate	technical difficulty	technical difficulty	important differentiate	important differentiate	important differentiate	important differentiate	important differentiate
Q29	lips and eyes	ears	eyes	proportions	eyes	eyes	lips	lips and eyes	eyes	eyes	nose
Q30	nose and eyes	nose	nose and ears	nose and eyes	nose, hair and cheeks	cheeks and face shape	profile	hair	nose and ears	nose, face shape, hair	eyes
Q31	nose and chin	nose	nose and ears	nose and eyes	hair and cheeks	face shape	hair	hair	nose	cheeks	chin and eyes
Q32	lips= 5mm/ eyes=2mm	lips and eyes=10mm	lips=2mm	chin + cheeks=2mm	eyes=3mm/ lips=2mm/ chin=4mm	forehead=10 mm/ eyes=8mm	forehead=10 mm	cheeks=3mm	chin=5mm/ forehead=4 mm	eyes=2mm	cheeks=10mm
Q33	superimpose	superimpose	superimpose	qualitative	qualitative	superimpose	superimpose	qualitative	superimpose	qualitative	superimpose

Table 13 Compiled Interview Responses