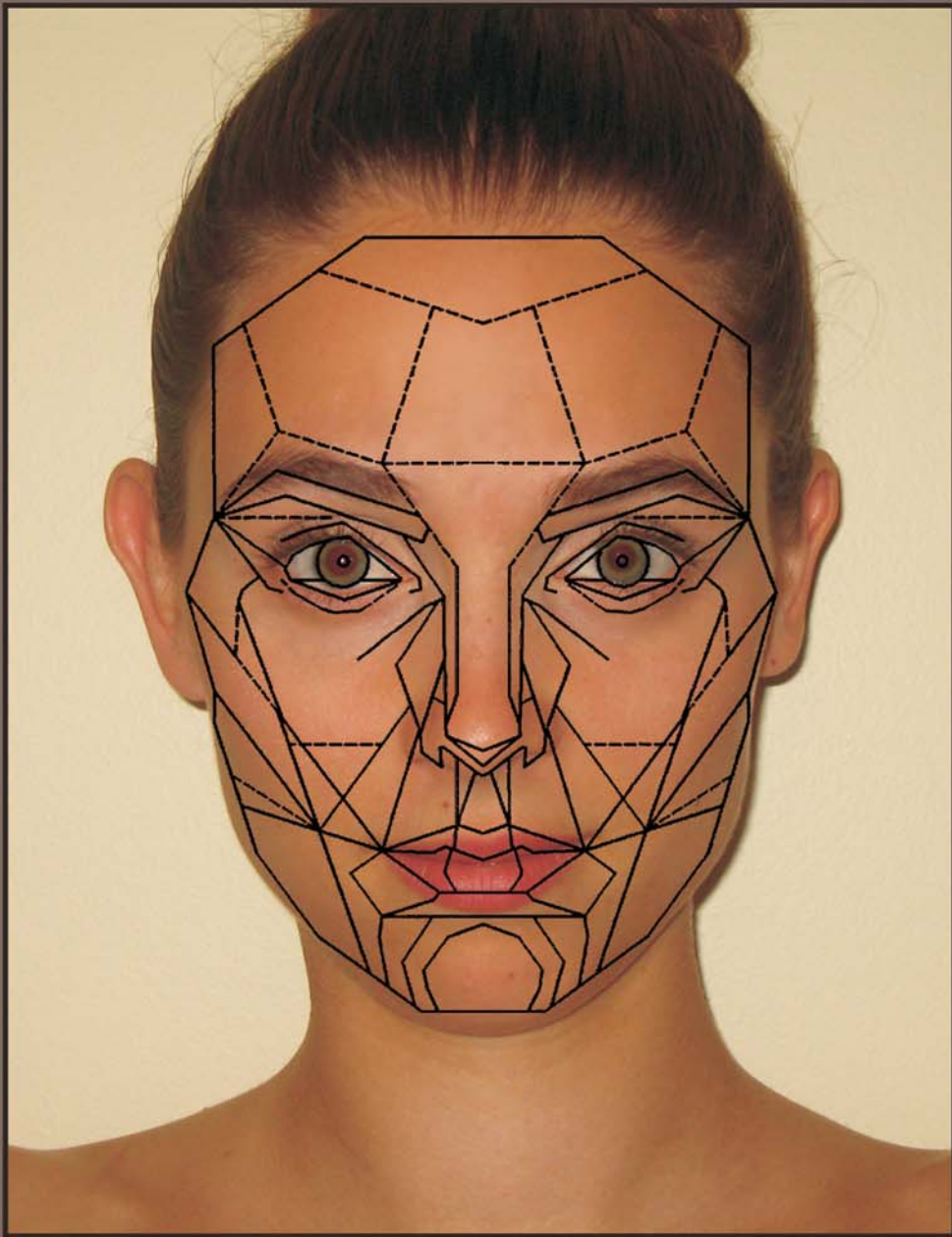


IS AN OBJECTIVE MEASURING SYSTEM FOR FACIAL ATTRACTIVENESS POSSIBLE?



MOUNIR BASHOUR, MD, CM, PHD, FRCSC, FACS

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Is an Objective Measuring System for Facial Attractiveness Possible?

MOUNIR BASHOUR, MD, CM, PhD, FRCSC, FACS

A thesis originally submitted in conformity with the requirements

for the degree of Doctor of Philosophy

Institute of Medical Sciences in collaboration with

Institute of Biomaterials and Biomedical Engineering

University of Toronto

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Abstract

There exists a need for the creation of an objective system for measuring facial attractiveness and along with it a detailed mathematical analysis and understanding of facial sexual dimorphism. Both the areas of ophthalmic and facial plastic and reconstructive surgery and the areas of facial attractiveness and recognition research in psychology would greatly benefit from achieving these goals. The objective of this work has been to: develop and test a system for measuring facial attractiveness in an objective manner; and analyze orbital and facial sexual dimorphism.

A facial overlay system or mask variously called the phi, archetypal, golden, or golden ratio mask has been claimed to be capable of being adapted to create an objective system for measuring facial attractiveness. The central hypothesis of the thesis is that the phi mask can be used to create an objective measurement system for facial attractiveness.

Over a period of seven years, we have created a standardized high resolution photographic facial database of 18-30 year old male and female adults, as well as database of linked facial anthropometric and photogrammetric measurement data. We have also designed a system using the phi mask that attempts to measure facial attractiveness objectively, and tested it against our facial database. Finally, we have made a detailed analysis of the measurement data and previous literature with respect to precisely defining sexual dimorphism around the eyes and face.

Results support our central hypothesis in that the phi mask in its current form does yield a measure for objective attractiveness that correlates to the current “gold standard” measure of attractiveness – ‘truth of consensus’. However, while the mask is capable of explaining a major portion of the variance in facial attractiveness, it is not the final complete answer. Strengths, weaknesses and limitations of the approach and the model used are discussed, and ideas and directions for further research to develop a more accurate system are suggested.

The analysis of the orbits and the face for sexual dimorphism yielded a great deal of new data and have lead to an understanding of sexual differences that have practical implications for both surgery and further facial research.

Applications of the research include: Preoperative aids for planning plastic and reconstructive surgery, cosmetic surgery, and sex-altering surgery; standards for analyzing the eyes for academic study; standards for quantifying the features of the eyes for use in an identification system; aid in application of cosmetics; aid in understanding the psychological impact of eyes on the judgment of attractiveness; creation of a standardized database of digital high-resolution facial photographs and linked anthropometric and demographic database to be made available to the world community of facial researchers; use of the databases by researchers for face recognition research, facial attractiveness research etc.

Publications

Chapter 1 and Appendix A – contain elements from

Bashour, M. History and current concepts in the analysis of facial attractiveness. *Plast Reconstr Surg.* 2006 Sep;118(3):741-56.

Chapter 2 – contains elements from

Bashour, M. An objective system to measure facial attractiveness. *Plast Reconstr Surg.* 2006 Sep;118(3):757-74; discussion 775-76.

Chapters 3 – contains elements from

Bashour, M. Orbital and facial sexual dimorphism and attractiveness. *Ophthal Plast Reconstr Surg.* (Submitted June 2007).

Appendix I – contains an early draft of

Bashour, M., Geist, C. Is medial canthal tilt the most important cue for facial attractiveness? *Ophthal Plast Reconstr Surg.* 2007 Jan-Feb;23(1):52-6.

I am responsible for all material reported in this dissertation and all data collection, except for data collected by Dr. Leslie Farkas and used with his permission and appropriately cited in every instance and various cited excerpts in the Appendices.

Acknowledgments

This study was partially funded by a scholarship from the Natural Sciences and Engineering Research Council of Canada. All methodology was approved by the Ethics Review Committee of the University of Toronto. Thank you to the Institute of Biomaterials and Biomedical Engineering, Institute of Medical Sciences and Department of Ophthalmology for resources and cooperation. I thank Drs. Martin Steinbach and Morris Moscovitch for being part of my supervisory committee, and for generously providing guidance, support and editorial comments.

I would especially like to thank Dr. Hans Kunov for taking a risk on an unknown surgeon while providing him with the opportunity to study and experience the intricacies of the human face. I know that I have tested your patience during my time here by continuing to work full-time as a professional surgeon and as a result taking an extremely long time to complete this PhD, so long in fact that you had retired yourself by the time I was done.

A special thank you goes as well to the great Dr. Leslie Farkas whom many researchers term the father of modern anthropometrics. You gave me your wise counsel and shared with me your 50 years experience of this field in which I am but a youngling. You inspired me more than you can know, simply by my watching you in your mid 80's still publishing three or more papers a year in the field, and maintaining a sharp, fresh and excited perspective. You are truly an amazing man.

I want to thank Shavir Irani for his help in recruiting subjects for the study and in help morphing some of the male faces, and his brother for help in creating the Internet survey system.

I want to thank all my family and friends – as I have always said in the final analysis after everything is tallied “absolutely, nothing is more important than family and friends.” Thank you to my parents -- you never told me “Stop already! Don’t you already have too many degrees” as many others have, but rather you always encouraged my ever seeking mind. Thank you to my sister for being my best friend for so many years. Thank you to my nieces for reminding me to look at the world with innocent eyes. Thank you to all my friends all over the world, you are too many to mention all by name, but you know who you are! A special thank you to my mates from Flat 510 Graduate House -- Dan, Matt, and Nick; the three of you more than anyone gave me the sensation of the graduate life, and I hope we remain friends forever.

I want to offer a general thank you to all the people in the many levels of the University of Toronto structure that I have questioned, pestered, and challenged to allow me to finish this PhD while working at a full-time and arduous job.

Thank you to my perpetual puppy Princess for forcing me to remember to play instead of constantly working on this thesis. Finally, thank you to my wife Christina, for your never ending support, and particularly for the tremendous amount of work helping me with data entry and putting the last touches to this work. We met during the final 3 years of my PhD; and you endured the difficult trek through the writing of this dissertation, I hope now, we can bask in the afterglow.

I dedicate this dissertation to my parents Samir and Hiyam, my wife Christina and my sister Maya.

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Chapter 1 -

General Introduction

"The butterfly's attractiveness derives not only from colors and symmetry: deeper motives contribute to it. We would not think them so beautiful if they did not fly, or if they flew straight and briskly like bees, or if they stung..."

-- Primo Levi, (1919 - 1987) Italian writer, chemist

Introduction

Surgeons have as their mission to restore function and health to the patient, while minimizing morbidity and mortality, and maintaining or improving the final aesthetic outcome. In the last twenty years the emphasis on aesthetic outcome has moved into the forefront, not just in plastic surgery, but in all fields of surgery. Personally, as a facial plastic surgeon the most important thing to all my patients is the aesthetic outcome of the operation. This holds true even when I am performing reconstructive and functional facial plastic surgery, and not just when performing pure cosmetic surgery. Patients are very concerned about their facial appearance, and as surgeons (in the last few decades especially) we too have made aesthetic outcome a primary concern.

Coinciding with this new emphasis on aesthetic outcome, dramatic drives in cost containment and quality assurance have also been implemented in the health field. Administrators and managers utilizing as their major tools various objective outcome measurement systems have helped bring these changes about. In tandem with them, physicians have found these same tools to be an excellent means of self monitoring, allowing discrepancies and problems to be quickly picked up, and permitting objective surveillance of outcomes as changes in practice and technique are implemented.

Mostly as a result of the fact that cosmetic surgery is an elective procedure not paid for by third party payers, it has managed to largely escape the outcomes knife and its associated good and bad spin-offs. Surgical aesthetic outcome is currently evaluated by completely subjective methods¹. Patient and surgeon subjectively decide if the aesthetic outcome is acceptable or not. The subjective nature of this evaluation does not allow for statistical outcomes analysis of surgical results, or for quality control. Little has been done to quantify these qualitative results in an objective manner²⁻⁴. Surgeons and patients and likely health administration and health payers would all benefit from an objective outcome measurement system.

Recently some investigators have begun to talk about the need for outcomes analysis in the aesthetic surgery field¹. The approach they use is to create outcomes scales, and preliminary data indicates that they may have some utility²⁻⁴. However, the scales are still based on patient subjective evaluation, and while we agree that this is a very relevant measure, a purely objective outcome scale would be extremely desirable.

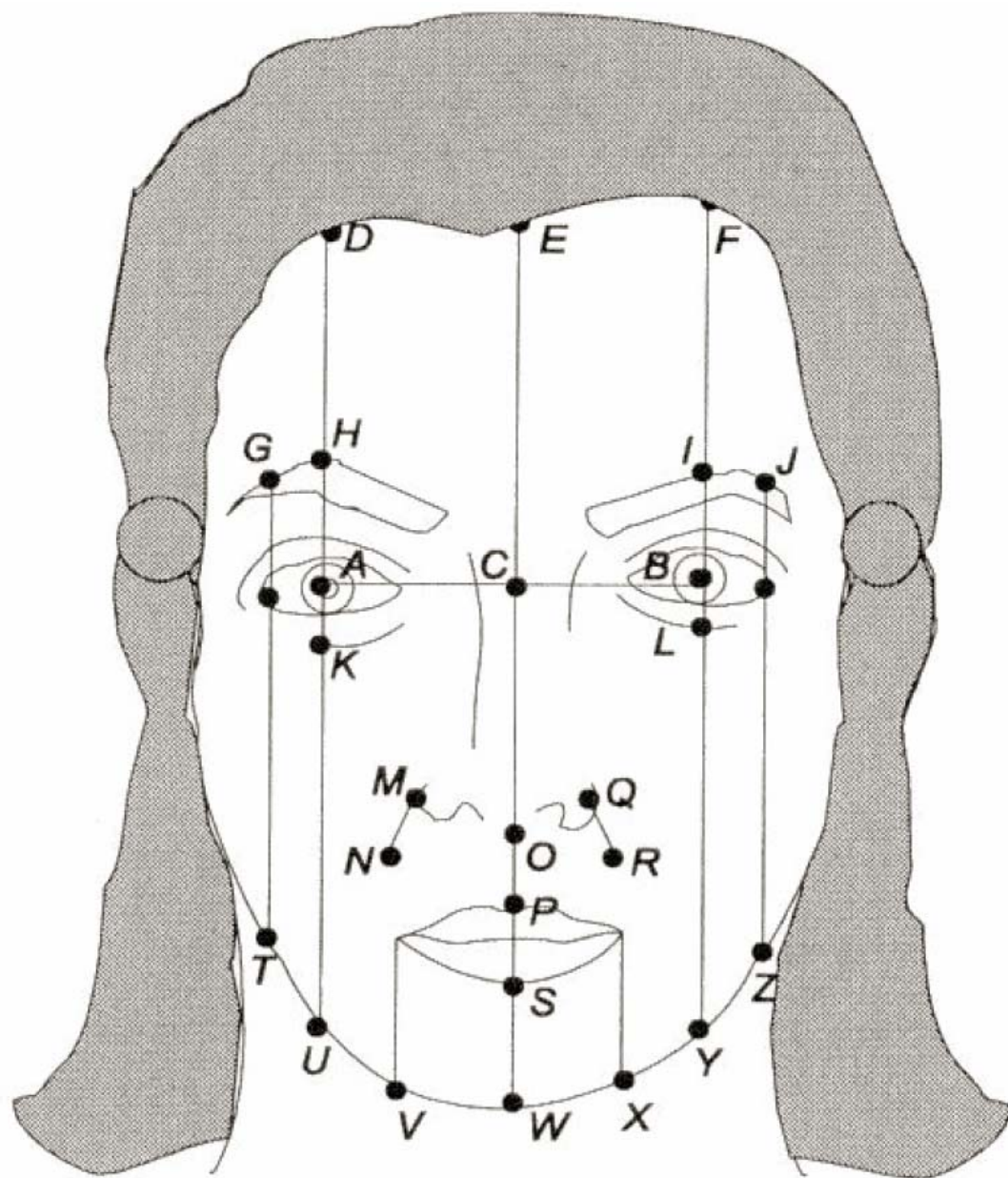
In a recent review by Ching et. al.¹ of outcomes measurements for aesthetic surgery (facial and otherwise) 53 identifiable instruments were found in the literature extending back to 1961. These

instruments were divided into four subtypes, satisfaction assessments (6 found), objective assessments (5 found), psychological assessments (34 found) and quality of life assessments (8 found). For assessment the most commonly used method in all 53 identified instruments is comparison of preoperative and postoperative photographs, usually by a surgeon or an independent observer. Ching et. al.¹ feel that this method is limited “because there are no validated and reliable means to quantify results to make meaningful comparisons.” For another identified satisfaction assessment instrument, facial halves comparison by Hamra⁵, where two halves of a face one preoperative and one postoperative are combined together in a photograph, Ching et. al. state that its “evaluation is subjective, without a numerical assessment.”

In their review of objective assessments only five methods were found, which we ourselves have looked at in detail. These included Tapia et. al.⁶ who looked at their results of 685 rhytidectomies (face-lifts) by analyzing 4110 preoperative and postoperative digitized photos. They create a scoring system on twelve aspects of facial aging, 3 surgeons visually and subjectively score the preop photos (average score 9.75) and postop photos (average score 2.84) using this scoring system, and note an average improvement of 6.91 points. Tapia et. al. also looked at two objective measurements, the cervicomental angle (which improved an average of 20 °) and lifting of the eyebrows (the medial eyebrow average lift was 0.1275 cm, the central eyebrow average lift was 0.2259 cm, and the lateral eyebrow average lift was 0.2877 cm). No correlation between the subjective score and objective measurements was attempted; furthermore no mention is made of how the change in cervicomental angle relates to the improvement in patient result, and for the eyebrow measurements all that is said is: “we noticed a clear relation of greater lifting of the eyebrow corresponding to more satisfactory overall final results.” No data, statistical or otherwise was provided.

The second objective assessment identified by Ching et. al.¹ was in Pitanguy et. al.⁷ In fact Pitanguy and his Brazilian colleagues designed an elegant objective system to model soft tissue changes with aging, not an objective system for assessing aesthetic outcomes, or capable of measuring facial attractiveness. The study was conducted using 40 women who had photographs of their face at least 5 years apart in time. These photographs were marked with 26 characteristic points (see Figure 1) (of interest to us is that 24 of these points were identical by chance to the 24 of the 37 points we used in our study). These points were used to calculate various linear distances on the face in each photograph and the change in the distance was normalized by dividing by the interpupillary distance for that subject (again this is of interest to us, because we also normalized the placement of the phi mask using the interpupillary distance). These normalized changes in anthropometric distances over time were fit by least squares using the second order polynomial that produced the smallest error. (See Figures 2 and 3 and refer to Pitanguy et. al.⁷ for more details). Essentially their method allows, after measuring and normalizing a photograph of a woman, prediction with a known amount of error, the appearance of that woman at a different age. In fact their method has been used to create a warping (aging/de-aging) program for facial photographs.

Figure 1 - Characteristic points defining the aging parameters.⁷



The third objective assessment identified was in Yousif et. al.⁸ Yousif et. al. again did not directly create an objective system for assessing aesthetic outcomes, or capable of measuring facial attractiveness.

They looked at a very specific facial feature the nasolabial fold using photogrammetry (anthropometric measurements from photographs) noting that with “aging there is anterior, lateral, and inferior displacement of the cheek mass with a resultant deepening of the nasolabial fold, while relationships between the upper lip and the fold itself remain constant.”⁸ This evidence was used to support the theory that the nasolabial fold is created by loss of support of the cheek mass complex, through gravitation and aging.

The fourth objective assessment identified was in Mishima et. al.⁹ This paper essentially announces that the authors have created two software systems that allow them to: (i) use a 3-D digitizer to automatically identify (AI) facial landmarks from a wire frame model of a plaster cast (only the area around the nose is described) and capture their 3-D coordinates and (ii) allow automatic superimposition (AS) of a postoperative wire frame model and calculate the displacement of the 3-D coordinates. Again this paper does not directly describe an objective system for assessing aesthetic outcomes, or capable of measuring facial attractiveness. It is of interest in that it looks at the displacement of essentially a 3D anthropometric wire model to evaluate the face pre-and postoperatively looking at the change in fit of the model as an objective measure of improvement.

Figure 2 - General aging curves for (a) the eyelids; (c), (d), (e), and (b) the central and lateral pouches of the face; (f) width of the nose.⁷

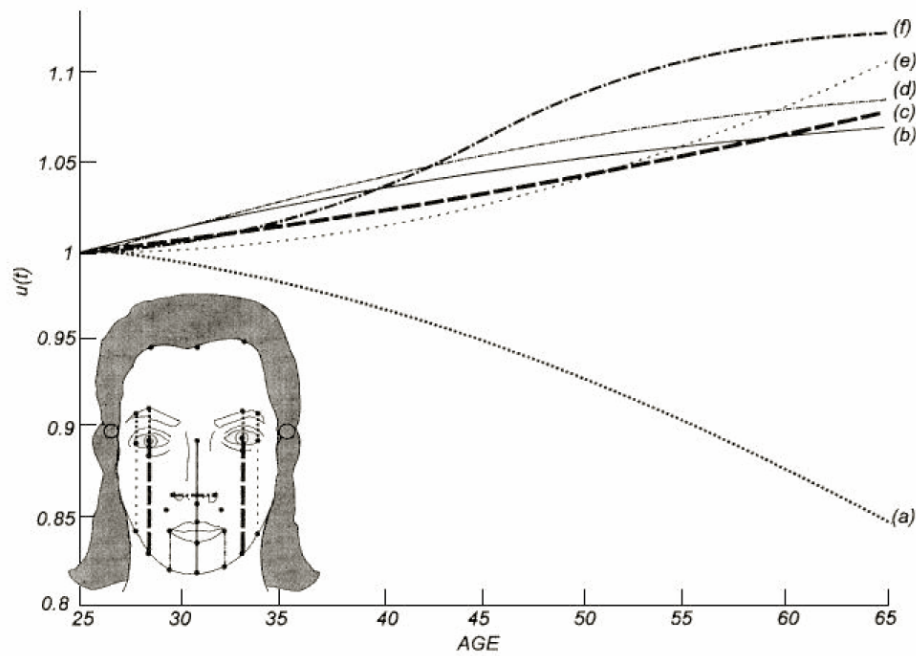


Figure 3 - General aging curves for (a) the height of the lips; (b) and (c) central and lateral height of the forehead; (d) height of the nose; (e) central midfacial tissues (height of the upper lip); (f) palpebral pouches; and (g) nasolabial fold.⁷

