1-1983

A Correlation of Subjective Ranking of Facial Esthetics and the Golden Section Analysis

Timothy Robin York

Abstract

A CORRELATION OF SUBJECTIVE RANKING OF
FACIAL ESTHETICS AND THE GOLDEN SECTION ANALYSIS

by

Timothy Robin York

The objective of this study was to determine if faces which fit the golden sections as proposed by Ricketts were considered more esthetic to the layman than faces which did not fit the golden sections as well.

Frontal facial photographs of 92 individuals from the normal occlusion sample of Andrews were measured for facial proportions according to Ricketts application of the golden section. Seven facial proportions were computed from the photographs. Ten photographs were selected, five of males and five of females, representing a range of mean percent deviation from the golden section proportion (1.618). Randomly arranged sets of these photographs were shown to 99 people ranging in age from 11 to 72 years. They were asked to rank the male and female sets of photographs in the order of esthetic facial appeal. Rank order correlations between the orders in which people ranked the

photographs and the golden section rankings were determined.

The statistical analysis indicated that rankings of the photographs of women showed the closest correlation to the golden section ranking. The younger groups of observers showed better agreement with the golden section ranking than did the older group. Overall, the correlation between the ranking of photographs by observers and the golden section ranking was statistically significant at the .01 level. It was concluded that the golden section analysis of soft tissue proportions of the face does correlate with the people's judgment of facial esthetics.

LOMA LINDA UNIVERSITY

Graduate School

A CORRELATION OF SUBJECTIVE RANKING OF FACIAL ESTHETICS AND THE GOLDEN SECTION ANALYSIS

by

Timothy Robin York

A Thesis in Partial Fulfillment of the
Requirements for the Degree of Master of Science
in Orthodontics

January 1983

Each person whose signature appears below certifies that this thesis in his opinion is adequate, in scope and quality, as a thesis for the degree of Master of Science.

J. Milford Anholm, Chairman
J. Milford Anholm, Associate Professor of Orthodontics

Lawrence E. McEwen, Assistant Professor of Orthodontics

Lee E. Olsen, Assistant Professor of Orthodontics

Thomas L. Robertson, Assistant Professor of Orthodontics

Gary A. Engel, Director of Research Rocky Mountain Data Systems

ACKNOWLEDGEMENTS

A thesis is the result of the efforts of many people. It is with sincere appreciation that the author cites the efforts of the following people:

To the members of my research committee: Drs. J. Milford Anholm, Lawrence E. McEwen, Lee E. Olsen, Thomas L. Robertson, and Mr. Gary A. Engel. Special thanks to Gary Engel for the many hours of discussion which kept the author's thoughts centered on important issues.

To the Foundation for Orthodontic Research and Rocky Mountain Data Systems for their invaluable assistance.

To Dr. Larry Andrews, for the use of his records. Also, to two members of his staff, Jackie Nevelow and Patty Knecht for their help in reproducing the records and for making a stranger feel welcome.

To Lucie Hills, for her help in translations.

To my classmates, for their support and encouragement.

To Len, Katy, and Sally Baker; Tom and Kathleen York; and Mildred and Jennifer Green for their help with the pilot study.

To David Scalletta, Dr. Thomas A. York, Kathleen York, Mark York and Sharon York for their help in providing observer groups.

To all of the others who took the time to be a part of this study.

And, above all, to my family for paying for all of this in so many ways.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The golden section has been known since the time of the Egyptians[1] and was of great interest to the ancient Greeks! It is a ratio found when a line is divided at a certain point to yield segments whose ratio to each other equals the ratio of the longer segment to the original line. This ratio turns out to equal approximately 1.618. The ancient Greeks noted the esthetics of this proportion which was later called the "divine proportion" by Kepler, as reported by Huntley.[2] This proportion has been considered particularly satisfying from an esthetic standpoint because of its combination of "unity and dynamic variety,"[3] and can be seen in the art and architecture of the Greeks.[2,4] Dr. Robert M. Ricketts has advanced the idea that there are certain facial proportions which will fit the golden section when the face is in greatest harmony and balance.[4,5,6,7] He believes that these proportions will evoke an instinctive response of beauty in an observer. Ricketts sees the golden section as another approach to aid the orthodontist in achieving an esthetic result. He suggests the use of the golden section in determining proper vertical relationships of the jaws, the height of the lower incisor, and as a planning tool for orthognathic surgery.

The purpose of this study is to investigate Ricketts' basic premise regarding the golden section. That is, to determine if facial proportions close to the golden section result in more appealing faces.

REVIEW OF THE LITERATURE

The term aesthetics came from a series of discussions by German philosophers in the eighteenth and early nineteenth centuries from the Greek word for perception. It came to signify a branch of philosophy dealing with beauty and esthetic value.[8] Plato, following the ideas of Socrates, believed that beauty was universal, that there is a common quality in things which make them beautiful.[9] These views of beauty (in which beauty is thought to be within an object) are known as objectivism, as opposed to subjectivism in which beauty is seen only as a matter of personal feeling--an emotional or mental response to an object. Munro[8] believes that a common sense view of beauty lies between these two views. Beauty is partly a matter of personal feeling, background, and taste; but some things are more beautiful than others, regardless of differences in taste. This brings us to the Platonic question: What is the common factor within all beautiful things which renders them beautiful? Some look to the golden section as part of the answer.

Pythagoras, who is credited with the discovery of the golden section, looked to numbers to explain the harmony and order of nature.[1] It is interesting to note that

Pythagoras' regular solids (a solid with all its faces, edges, and angles the same--a perfectly symmetrical solid, of which there are only five) are related geometrically to the golden section, as is the symbol of the Pythagoreans, the five-pointed star. Turnbull[1] suggests that this is the reason that the Pythagoreans became interested in this ratio.

In a related context, Leonardo of Pisa, also known as Fibonacci, published a book, Liber Abbaci, in the year 1202. With this book he brought the Arabic system of numerals to Europe.[2,10] He also introduced what is now known as the fibonacci series in which each number of the series is derived from the sum of the two preceding numbers in the series. For example, the fibonacci series begins 1, 2, 3, 5, 8 . . . . Curiously, the ratios of adjacent numbers approach the proportion 1.618. This proportion has since been named Phi in honor of Fibonacci.

This proportion can be related to a number of naturally ocurring forms. It is seen in the structure of leaves, flowers, and in the logarithmic spiral of the nautilus sea shell.[2,10,11] (Figure 1) The golden section and the fibonacci series are both associated with this spiral. Golden triangles and golden rectangles can be used in the construction of a logarithmic spiral. It is of special

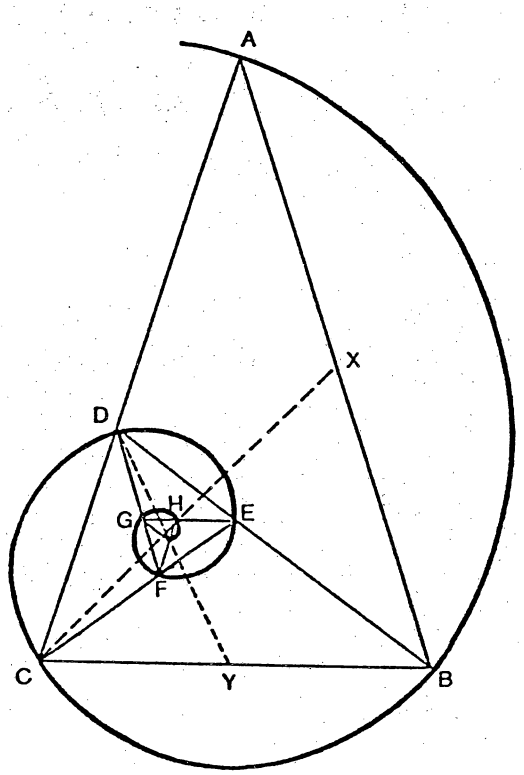

Figure 1. The Logarithmic Spiral
(copied from reference 5)

interest that the mandible has been shown to grow on the same logarithmic spiral.[12,13] (Figure 2) The golden section has also been of esthetic interest in art and architecture seen most notably in the Parthenon[1] and the great pyramids of Egypt.[3]

In 1509, Paccioli, a monk in Venice, published Divina Proportione, a treatise on esthetic proportions.[14] The golden section figured greatly in these proportions and rapidly became known to artists and scientists of the era.

Fechner, the German psychologist, was the first to examine experimentally esthetic claims regarding the golden rectangle. In his work, Vorschale der Aesthetik, published in 1876, Fechner examined people's preferences for rectangles of varying proportions, as reported by Plug.[15] The rectangle selected as most preferred was found to be the golden rectangle whose ratio of length to width was 1.62. Stone and Collins[16] suggest that the size of the average visual field fits the proportions of the golden rectangle and believes this a possible reason for the preference for this proportion. Godkewitsch[17] and Piehl[18] suggested that the preference for golden rectangles in Fechners' and other investigators' experiments was because of the position of those rectangles in the range of stimuli presented to the subjects in those experiments. Benjafield[19] refutes this,

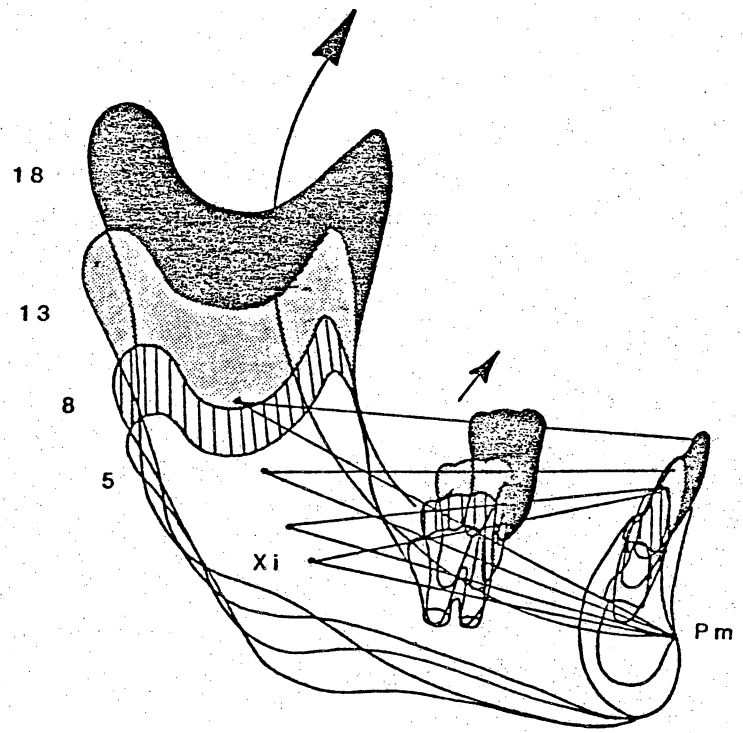

Figure 2. Arcial growth of the mandible
(copied from reference 5)

noting that Godkewitsch did not keep the size of the rectangles the same in his experiment while varying the proportion and also did not give subjects enough time to consider all of the rectangles before choosing the most preferred. Benjafield finds his data consistent with the notion that rectangles in the area of the golden proportion may be preferred to those which deviate markedly from it.

In 1981, Ricketts noticed the connection between the esthetic perception of the golden section and facial esthetics.[5,6] Ricketts[4] studied ten photographs in the frontal view taken from advertisements in magazines. Certain facial proportions in both horizontal and vertical planes were seen to follow the golden section (Figure 3). Other esthetic facial proportions have been proposed. Da Vinci in 1590[20], studied the face and the proportionality of its parts. There have been any number of cephalometric studies involving skeletal norms and proportions, as well as studies involving the soft tissue profile; however little has been written about soft tissue proportions from the frontal view. Watson[21] points out the value of a photographic analysis. Dongieux and Sassouni[22] note that knowledge of facial esthetics helps the clinician to treat the total face. They varied the vertical position of the mandible in photographs of faces and obtained an esthetic response from observers. It was found that, although there

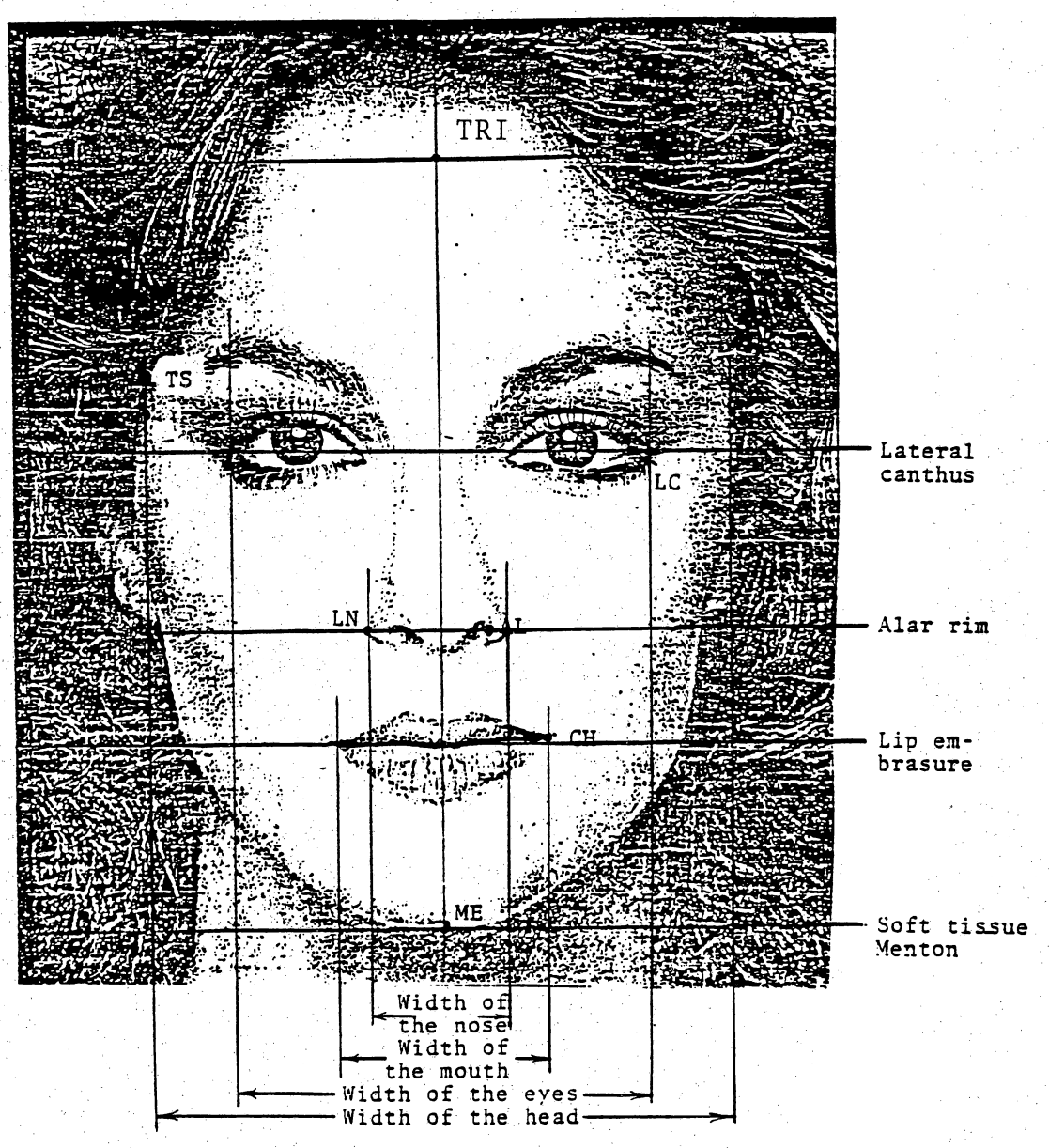

Figure 1. Soft Tissue Vertical and Horizontal Measurements and Landmarks (From Ricketts[4] as adapted by Sutliff[29])

is some general thought that facial esthetic opinion is a subjective and personal feeling varying the mandibular position influences the opinion of observers. Peck and Peck[23] pointed out that a person's concept of facial esthetics is external and that the skeletal pattern means little to them. People decide instantly if a face is pleasing or displeasing on the basis of a subconscious, unstructured decision. Proffit, et al, present a proportional soft tissue analysis in Surgical Correction of Dentofacial Deformities by Bell et al,[24] and Belinfante[25] presents a similar analysis. Epker[26] and Epker and Fish[27] present a lateral soft tissue analysis, as do Legan and Burstone.[28] The derivations of these analyses have not been presented nor has the validity of the esthetic preference of the analyses in the eye of the observer been shown.

Baud,[14] using angular sectors of the face derived from the three equal sections described by Da Vinci, found proportions corresponding to the golden section. Ricketts believes that the "dynamic symmetry" of the golden section will evoke an instinctive response of beauty, harmony, and balance from the observer, and faces with these proportions will be considered beautiful.[4] This also has not been evaluated experimentally. It is the purpose of this study

to investigate whether faces which fit the golden section are considered more esthetic to people than faces which do not fit the golden section.

MATERIAL AND METHODS

Records of 92 untreated Caucasian orthodontic normals (individuals who, by professional judgement needed no orthodontic treatment[30]) were obtained from Dr. Larry Andrews. Frontal facial photographs were examined and those displaying eyeglasses or facial hair were deleted. The remaining photographs were measured as described by Ricketts.[6] These measurements were recorded using the landmarks shown in Figure 1. Horizontal measurements:

1. Width of head at the level of the eyebrows
2. Width of the eyes at the lateral canthus
3. Width of the nose
4. Width of the mouth at the lip embrasure

Vertical measurements along the midline of the face at the following levels:

1. Lateral canthus of the eyes
2. Alar rim of the nose
3. Lip embrasure, or stomion
4. Soft tissue menton

Measurements involving the point trichion (the point at the beginning of the wrinkling that takes place with the lifting of the eyebrows[4]) were not included in this study due

to the difficulty in locating that landmark on the photographs.

The landmarks were traced on a sheet of tracing acetate. Distances were measured with a millimeter rule and recorded on each photograph's analysis card. For each photograph seven ratios, three horizontal and four vertical, were computed to determine the soft tissue golden sections as described by Ricketts.[6] The ratios were calculated in the following manner.

Horizontal Ratios:

1. Forehead width : Eye width
2. Eye width : Mouth width
3. Mouth width : Nose width

Vertical ratios from measurements along the midline:

1. Lateral canthus to lip embrasure : Lip embrasure to menton
2. Ala of nose to menton : Lateral canthus to ala of the nose
3. Lateral canthus to ala of the nose : Ala of the nose to lip embrasure
4. Lip embrasure to menton : Ala of the nose to lip embrasure.

The percent deviation from 1.618 was calculated for each ratio, and from these the mean percent deviation for

the seven ratios was determined for each face. The faces were ranked in order of mean percent deviation.

EXPERIMENTAL PROCEDURE

A preliminary selection of photographs was made consisting of five photographs of males and five photographs of females, each group of five showing a range of mean percent deviations from 1.618. At this time, it became necessary to decide if similar hairstyles should be chosen in selecting the photographs or if the hair should be trimmed from all photographs. Trimming of the forehead also needed to be considered since measurements involving the point trichion could not be used in this study. For these reasons, a pilot study was undertaken.

Using this preliminary photograph selection, two sets of photographs were made. One set consisted of photographs trimmed to the outline of the face, with the forehead removed at the level of the eyebrows. The other set consisted of untrimmed photographs. Each photograph was mounted on 8 X 10 inch mounting board. Four individuals were asked to rank the untrimmed photographs in the order which they felt looked the best. One to two days later they were asked to rank the photographs which had been trimmed. The results showed no obvious difference in rankings between the trimmed and untrimmed photographs. Trimming the hair allowed greater choice in selecting the faces, since similar

hairstyles did not need to be chosen; therefore, it was decided to use trimmed photographs. It was also decided to trim away the forehead to the level of the eyebrows.

The final selection of photographs was now made. The selection was narrowed by removing faces which were heavily wrinkled, had heavy makeup, or showed any other marked difference from other photographs. Five male photographs were chosen ranging from 6.67 mean percent deviation to 33.71 mean percent deviation from the golden section. (Figure 4) Five female photographs were chosen ranging from 6.58 mean percent deviation to 18.12 mean percent deviation. (Figure 5) From this point, the mean percent deviation ranking will be referred to as the golden section ranking.

Five by seven inch photographs were trimmed and mounted on four by five inch mounting board. Each group of five photographs was randomly ordered by the use of a random number table. One male set and one female set were placed in each of 40 envelopes, each set being independently and randomly ordered to avoid a stimulus range selection bias as reported by Godkewitsch[17] and Piehl.[18] Initials were placed on the backs of the photographs for future reference.

In trying to determine what age groups to select as observers of the photographs, I took into account the fact

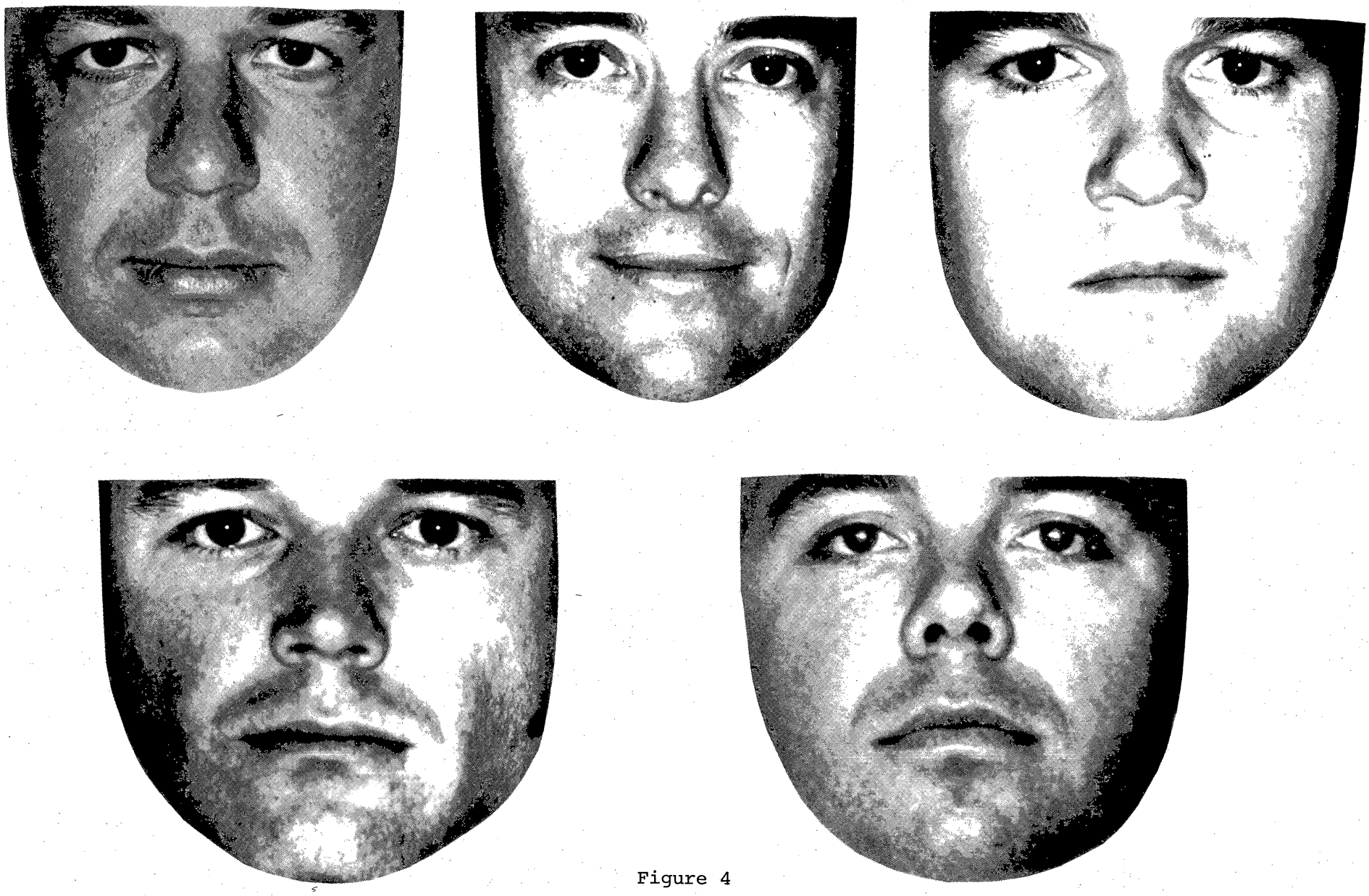

Figure 4

Figure 5

that a major reason for evaluating facial proportions is to help in the diagnosis of orthognathic surgery cases. One hundred forty five orthognathic surgery cases sent to Rocky Mountain Data Systems for computer diagnosis were surveyed to determine the mean age of surgical patients. This was found to be 22.78 years. Several orthodontists were also questioned in this regard and their estimate was similar in all cases. They felt that mid to late twenties was the average age for orthognathic surgery.

With this in mind, it was decided to employ the use of a college age group and a group over the age of 30. In addition, the responses of orthodontic patients were noted.

Forty-nine freshman psychology students (mean age=18.7) at California State University, Northridge, thirty-three people over the age of 30 in a church group (Central Church of Christ, Sacramento, California. Mean age=48.6) and seventeen orthodontic patients (mean age=14.6) were given an envelope containing one set of male photographs and one set of female photographs. Along with the photographs they were given a sheet containing instructions and questions (Figure 6). After filling in the data on sex, age, race, and occupation, the instructions were read to the observers who were asked to follow the text. The instructions were as follows:

> In the envelope there are two sets of photographs. Please rank each set, face up, from what you consider most appealing (on top) to least appealing (on bottom). Ignore any differences in skin tone, complexion, make-up, or skin blemishes. There is no right or wrong order. It is purely a matter of personal preference.
>
> Please do not discuss the photographs with others, or view another's choice. Note how long it takes you to rank each set. (See Figure 6)

They were also told to take their time, that there was not a specific time limit, but that it should take them less than ten minutes total. In all cases, the task was completed within seven minutes. After ranking the photographs, they answered questions on the time it took, the difficulty, and any notable features of the faces, and then returned the envelope containing the ranked photographs along with the questionnaire sheet.

Date _____

PLEASE DO NOT OPEN THE ENVELOPE UNTIL TOLD TO DO SO.

Code Number (on front of envelope) _____

Sex _____

Age _____

___ Caucasian ___ Hispanic ___ Black ___ Asian ___ Other _____

College major or occupation _____

In the envelope there are two sets of photographs. Please rank each set, face up, from what you consider most appealing (on top) to least appealing (on bottom). Ignore any differences in skin tone, complexion, make-up, or skin blemishes . There is no right or wrong order. It is purely a matter of personal preference.

Please do not discuss the photographs with others, or view another's choice. Note how long it takes you to rank each set.

How long did it take? Female photos _____ Male photos _____

On a scale of 1 to 10, 10 being most difficult,how difficult was it for you to rank the faces?

Female photos _____ Male photos _____

If there is any feature of a face which significantly affected your decision on where to rank that face, please note that feature below. The initials on the back of each photograph correspond to the letters below.

FEMALES	MALES
S.B. _____	S.T. _____
S.P. _____	J.P. _____
S.R. _____	B.G. _____
L.H. _____	W.A. _____
S.D. _____	B.S. _____

When you are finished please replace the rubber band on each set of 5 photographs, leaving them in the order you selected. Replace them in the envelope along with this form and return them.

Thank you for your cooperation.

Figure 6. Questionnaire Used in Study

ANALYSIS OF THE DATA

The Spearman's rank order correlation[31] test was used in order to determine the correlation between the rankings given the photographs by the observers and the rankings as determined by percent deviation from 1.618. The analysis was divided into four groups as follows:

1. Orthodontic Patient Sample
2. College Student Sample
3. Over Age 30 Years Sample
4. Overall Sample

These were further divided into nine subgroups as follows:

1. Male Observers Ranking Male Photographs
2. Male Observers Ranking Female Photographs
3. Female Observers Ranking Male Photographs
4. Female Observers Ranking Female Photographs
5. Male Observers Ranking Male and Female Photographs
6. Female Observers Ranking Male and Female Photographs
7. Males Photographs Being Ranked By Both Male and Female Observers
8. Female Photographs Being Ranked By Both Male and Female Observers
9. Overall Ranking--Male and Female Observers Ranking Both Male and Female Photographs

Means and standard deviations of the rank order correlations

TABLE I

MEANS AND STANDARD DEVIATIONS OF RANK ORDER CORRELATIONS

	Orthodontic Sample		College Sample		Older Sample		Overall Sample	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Male Observers Rating Male Photographs	.42	.26	.08	.64	-.02	.43	.10	.55
Male Observers Rating Female Photographs	.50	.45	.39	.45	.20	.36	.34	.44
Female Observers Rating Male Photographs	.13	.51	.15	.48	-.04	.38	.09	.47
Female Observers Rating Female Photographs	.41	.42	.38	.36	.26	.48	.34	.42
Male Observers Rating Male and Female Photographs	.46	.37	.24	.58	.39	.41	.22	.51
Female Observers Rating Male and Female Photographs	.27	.49	.27	.44	.11	.46	.22	.46
Male Photographs Rated by Male and Female Observers	.21	.47	.13	.54	-.03	.24	.09	.50
Female Photographs Rated by Male and Female Observers	.44	.43	.38	.39	.24	.44	.34	.42
Overall Rating	.32	.46	.26	.49	.11	.44	.22	.48

were calculated (Table 1). Student's T-test[31] was performed to see if the mean rank order correlations were significantly different from 0.0.; 0.0. being a value which would indicate a random selection (Table 2). In two of the groups, there were insufficient numbers of observers to use the T-test, so the non-parametric Sign Test[31] was used.

The data were further analyzed to see if there were any simple correlations between the following:

1. Between the rank order correlations and the difficulty of ranking the photographs perceived by the observers (Table 3)
2. Between the rank order correlations and the time it took the observers to rank the photographs (Table 4)
3. Between the perceived difficulty of ranking the photographs and the time it took to rank them. (Table 5)

Because of an insufficient number of responses on the questionnaires, these last three correlations were not tested in the sample of orthodontic patients.

TABLE II

T-TESTS--TO SEE IF MEAN CORRELATIONS ARE SIGNIFICANTLY DIFFERENT FROM O.O

	Orthodontic Patient Sample		College Student Sample		Older Sample		Overall Sample	
	t-value	sig. level	t-value	sig. level	t-value	sig. level	t-value	sig. level
Male Observers Rating Male Photographs	3.18	.05	sign test	---	sign test	---	1.02	---
Male Observers Rating Female Photographs	2.21	.05	sign test	---	sign test	---	4.44	.01
Female Observers Rating Male Photographs	0.81	---	1.81	.05	.43	---	1.51	---
Female Observers Rating Female Photographs	3.25	.01	5.94	.01	2.53	.01	6.74	.01
Male Observers Rating Male and Female Photographs	3.71	.01	2.35	.05	1.01	---	3.48	.01
Female Observers Rating Male and Female Photographs	2.63	.01	4.87	.01	2.98	.01	5.41	.01
Male Photographs Rated by Male and Female Observers	1.80	.05	1.67	.10	-.43	---	1.82	.05
Female Photographs Rated by Male and Female Observers	4.05	.01	6.80	.01	3.09	.01	8.10	.01
Overall Rating	4.00	.01	5.18	.01	1.93	.05	6.42	.01

TABLE III

SIMPLE CORRELATIONS* BETWEEN RANK ORDER CORRELATION AND PERCEIVED DIFFICULTY OF RANKING THE PHOTOGRAPHS

	College Student Sample		Older Sample		Overall Sample	
	Correlation	Sig. Level	Correlation	Sig. Level	Correlation	Sig. Level
Male Observers Rating Male Photographs	-.34	---	.19	---	-.16	---
Male Observers Rating Female Photographs	.43	.05	.73	.01	.55	.01
Female Observers Rating Male Photographs	.47	.01	.17	---	.36	.05
Female Observers Rating Female Photographs	-.35	.05	-.10	---	-.18	---
Male Observers Rating Male and Female Photographs	.02	---	.48	.01	.14	---
Female Observers Rating Male and Female Photographs	.18	---	-.01	---	-.09	---
Male Photographs Rated by Male and Female Observers	.14	---	.16	---	.16	---
Female Photographs Rated by Male and Female Observers	-.01	---	.17	---	.10	---
Overall Rating	.10	---	.15	---	.14	---

*Positive Correlation = the higher the rank order correlation, the easier it was to rank.

TABLE IV

SIMPLE CORRELATIONS* BETWEEN RANK ORDER CORRELATIONS AND THE TIME IT TOOK TO RANK THE PHOTOGRAPHS

	College Student Sample		Older Sample		Overall Sample	
	Correlation	Sig. Level	Correlation	Sig. Level	Correlation	Sig. Level
Male Observers Rating Male Photographs	.09	---	.19	---	-.16	---
Male Observers Rating Female Photographs	.20	---	.73	.01	.55	.01
Female Observers Rating Male Photographs	.10	---	.17	---	.36	.05
Female Observers Rating Female Photographs	-.36	.05	-.10	---	-.18	---
Male Observers Rating Male and Female Photographs	.17	---	.48	.01	.14	---
Female Observers Rating Male and Female Photographs	-.05	---	-.01	---	-.09	---
Male Photographs Rated by Male and Female Observers	.09	---	.16	---	.16	---
Female Photographs Rated by Male and Female Observers	-.03	---	.17	---	.10	---
Overall Rating	.05	---	.15	---	.14	---

*Positive Correlation = the higher the rank order correlation, the less time it took.

TABLE V

SIMPLE CORRELATIONS* BETWEEN THE TIME IT TOOK TO RANK THE PHOTOGRAPHS AND THE PERCEIVED DIFFICULTY OF RANKING THE PHOTOGRAPHS

	College Student Sample		Older Sample		Overall Sample	
	Correlation	Sig. Level	Correlation	Sig. Level	Correlation	Sig. Level
Male Observers Rating Male Photographs	-.20	---	.16	---	.04	---
Male Observers Rating Female Photographs	.58	.05	.69	.05	.60	.01
Female Observers Rating Male Photographs	.53	.01	.38	.05	.47	.01
Female Observers Rating Female Photographs	.20	---	.16	---	.12	---
Male Observers Rating Male and Female Photographs	.31	.05	.54	.01	.41	.01
Female Observers Rating Male and Female Photographs	.41	.01	.27	.01	.33	.01
Male Photographs Rated by Male and Female Observers	.36	.05	.44	.01	.39	.01
Female Photographs Rated by Male and Female Observers	.34	.05	.38	.01	.35	.01
Overall Rating	.35	.01	.41	.01	.37	.01

*Positive Correlation = the less time it took to rank the photographs, the easier the task was to perform.

RESULTS

The mean and standard deviations of the rank order correlations and the T tests are shown in Tables 1 and 2. The observers from the orthodontic sample showed the highest mean rank correlation to the golden section ranking, showing significance at the .01 level. The rankings of photographs by college students also showed significance at the .01 level. Ranking of photographs by the older age group sample showed significant correlation to the golden section ranking at the .05 level. The older group showed a sigificant correlation at the .01 level only when females were ranking the photographs and when the photographs of females were being ranked. Looking at the overall sample, the ranking of male photographs did not show a significant correlation when being ranked by male or female observers. The rank order correlation when male observers ranked male and female photographs was significant at the .01 level. When females were ranked by males, by females, and by the combined males and females, the correlation was significant at the .01 level.

In summary, the younger groups did better than the older group and females were more accurately ranked than were males. Overall, the combined observers' ranking of the

photographs showed a mean rank correlation to the golden section ranking which was significant at the .01 level.

Table 3 shows the simple correlation between the rank order correlations and the difficulty of performing the task as perceived by the observers. When females ranked photographs of males and when males ranked photographs of females, it is seen that the higher the rank order correlation between the golden section ranking and the ranking by the observers, the easier it was for the observers to rank the photographs. Or to put it another way, when these groups found it easy to rank the photographs, their ranking of the photographs was in closer agreement with the golden section ranking.

In the college age sample, when females ranked photographs of females, it was seen that the more difficult they found the task to be, the higher the rank order correlation. In the older age group sample, when male observers ranked female photographs, the easier they found the task, the higher the rank order correlation was. The interesting point here is that when ranking the opposite sex, the easier the observers found the task of ranking the photographs, the higher the correlation to the golden section ranking.

Table 4 shows the correlation between the rank order

correlations and the time it took the observers to complete the task of ranking the photographs. When females ranked female photographs, the longer it took them, the higher the rank order correlation in the younger and combined samples. In the older sample, the less time that it took males to rank photographs of females, the higher the rank order correlation. In general, the less time it took males to rank the photographs, the higher the rank order correlation.

Table 5 shows the correlations between the time it took to rank the photographs and the perceived difficulty of the task. It can be seen that except when males ranked photographs of males and when females ranked photographs of females, the less time that it took, the easier the observers perceived the task.

DISCUSSION

Although the rank order correlations were not perfect, it was seen that the difference between the mean rank correlation and a 0.0 rank correlation (which would indicate a random ranking by the observers) was statistically significant at the .01 level. Several possible reasons for the relatively low rank order correlations can be hypothesized. Since normal occlusions were needed to eliminate any orthodontic treatment bias, the selection of cases was limited. Photographic quality varied slightly between the photographs which could have had some influence. Among the women, there were also some differences in the amount of makeup used. Although observers were instructed to ignore differences in skin tone, complexion, makeup, and skin blemishes; it was obvious from their comments that they did not always do so. The fact that the younger groups showed a higher correlation to the golden section ranking was quite interesting. Common sense would tell us that younger people might have more interest in facial appearance. But what makes this even more interesting is a study done by Nienstedt and Ross[30] which shows a difference between the proportions preferred by college students and the proportions preferred by an

older group (mean age=78.36). The college age group in their study preferred ratios in the area of the golden section (.62), whereas the older group preferred greater width-length ratios in the area of .75. Another interesting point is brought up by the fact that photographs of females were ranked closer to the golden section ranking than males. This might be due to the emphasis we place on the beauty of women in our society.

The correlations between the rank order correlations and the perceived difficulty of ranking the photographs also brought forth an interesting point. In ranking the opposite sex, when observers found it easy to rank the photographs, their rankings showed a higher correlation to the golden section ranking. Could this suggest that when individuals follow their instinctive responses they come the closest to agreeing with the golden section ranking?

Another question arises in examining the correlation between the time it took to rank the photographs and the perceived difficulty. When ranking the same sex, observers found it easier to perform the task when they took less time. Could this mean that we tend to make more snap judgments regarding the esthetics of the same sex?

Although many questions have resulted from this study, the most important is the first question asked. Are

faces which most closely fit the golden section ratios more appealing to people than faces which do not fit those ratios as well? To this question an answer was found. The mean rank order correlation was shown to be statistically significant at the .01 level.

With regard to future research, it would be of interest to determine if surgical cases which better fit the golden section ratios are considered more esthetically successful than those which do not; and if the golden section ratios show more esthetic results than other facial proportions now used.

SUMMARY AND CONCLUSIONS

Ninety-two frontal facial photographs were measured according to the golden section and seven ratios were computed as proposed by Ricketts.[4] Ten photographs, five of males and five of females were selected representing a range of mean percent deviation from the seven ratios. Rank order correlations between the rankings as determined by golden sections and the rankings given by 99 observers of varying ages were computed.

It was found that rankings of photographs by younger age groups showed a higher correlation to the golden section ranking than rankings by the older age group. It was also seen that rankings of female photographs showed a higher correlation than did the rankings of male photographs. Interesting questions were raised regarding ranking of the same sex and regarding ranking of the opposite sex. The overall mean rank order correlation to the golden section ranking was statistically significant at the .01 level.

It can be concluded that the closer facial proportions are to the golden section proportions, the more appealing that face will be to observers.

LITERATURE CITED

1. Turnbull, H. W.: The Great Mathematicians, In Newman, J.: The World of Mathematics, Vol. I, New York, 1956, Simon and Schuster.

2. Huntley, H. E.: The Divine Proportion, New York, 1970, Dover Publications.

3. Arnheim, R.: Art and Visual Perception, Berkeley and Los Angeles, 1974, University of California Press.

4. Ricketts, Robert M.: The Biologic Significance of the Divine Proportion and Fibonacci Series, Am. J. Orthod., 81:351-370, 1982.

5. Ricketts, R., Roth, R., Chaconas, S., Schulhof, R., and Engel, G.,: Orthodontic Diagnosis and Treatment Planning, Vol. 2., 1982. Rocky Mountain/Orthodontics.

6. Ricketts, R.: Perspectives in the Clinical Application of Cephalometrics: The First Fifty Years. Angle Orthod., 51:115-150, 1981.

7. Ricketts, R.: The Golden Divider. Journal of Clinical Orthodontics, 15:754-759, 1981.

8. Munro, T.: Toward Science In Aesthetics, New York, 1956, The Bobbs-Merril Company, Inc.

9. Carritt,: Philosophies of Beauty, Oxford, 1931, Clarendon Press

10. Thompson, D'Arcy W.: On Growth and Form, New York, 1944, The Macmillan Company.

11. Weyl, H.: Symmetry. Princeton, N. J., 1952, Princeton University Press.

12. Ricketts, R.: A Principle of Arcial Growth of the Mandible, Angle Orthod., 42:368-386, 1972.

13. Moss, Melvin L., Moss-Salentijin, L., and Ostreicher, H.: The Logarithmic Properties of Active and Passive Mandibular Growth, Am. J. Orthod., 66:645-664, 1974.

14. Baud, C.: Le Calcul de la beaute, Schueizerische Monatsschrift Fuer Zahnheilkunde, 83:1309-1326, 1973.

15. Plug, C.: The Golden Section Hypothesis, Amer. Journ. Psych, 93:467-487, 1980.

16. Stone, L. and Collins, L.: The Golden Section Revisited: A Perimetric Explanation, American Journal of Psychology, 78:503-506, 1965.

17. Godkewitsch, M.: The Golden Section: An Artifact of Stimulus Range and Measure of Preference. American Journal of Psychology, 87:269-277, 1974.

18. Piehl, J.: The 'Golden Section': An Artifact of Stimulus Range and Demand Characteristics Perceptual and Motor Skills, 43:47-50, 1976.

19. Benjafield, J.: The 'Golden Rectangle': Some New Data. American Journal of Psychology, 89:737-743, 1976.

20. Berkman, M.D.: Evaluation - Diagnosis - Planning. The Challenge in the Correction of Dentofacial Deformities, Alpha Omega, 71:18-26, 1978.

21. Watson, W.: The Art in Orthodontics, Am. J. Orthod., 78:571-573, 1980.

22. Dongieux, J. and Sassouni, V.: The Contribution of Mandibular Positioned Variation to Facial Esthetics. Angle Orthodontist, 50:334-339, 1980.

23. Peck, H., and Peck, S.: A Concept of Facial Esthetics, Angle Orthodontist, 40:284-318, 1970.

24. Proffit, R., Epker, B., Ackerman, J.: Systematic Description of Dentofacial Deformities: The Data Base, in Bell, W., Proffit, W., and White, R.,: Surgical Correction of Dentofacial Deformities, Philadelphia, 1980, W. B. Saunders Co.

25. Belinfante, L.: Total Treatment Planning for Esthetic Problems of the Face. J. Oral Surg., 37:178-186, 1979.

26. Epker, B.: Personal Communication 1983.

27. Epker, B., and Fish, L.: Surgical-Orthodontic Correction of Open-Bite Deformity. Am. J. Orthod., 71:278-299, 1977.

28. Legan, H. and Burstone, C.: Soft Tissue Cephalometric Analysis for Orthognathic Surgery. J. Oral Surg. 38:744-751.

29. Sutliff, R.: A Correlation Study of Facial Soft Tissue Proportions (Golden Sections) and Cephalometric Measurements of Golden Sections and the Eleven Factor Analysis. Masters Thesis, Loma Linda University, 1982.

30. Andrews, L.: The Six Keys to Normal Occlusion, Am. J. Orthod., 62:296-309, 1972.

31. Johnson, R.: Elementary Statistics, Third Edition. North Scituate, Mass., 1980, Dunbury Press.

32. Neinstedt, C. and Ross, S.: Preferences for Rectangular Proportions in College Students and the Aged. The Journal of Genetic Psychology, 78:153-158.