RESEARCH ARTICLE

Preferences of Lay Persons and Dental Professionals Regarding the Recurring Esthetic Dental Proportion

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ABSTRACT

Background: This study evaluated the preferences of dental professionals and lay persons with respect to the Recurring Esthetic Dental (RED) Proportion, an objective mathematical tool used in treatment planning the ''apparent'' widths of maxillary anterior teeth.

Materials and Methods: Stock dentofacial and facial images of a prototypical smiling male and female were digitally altered to demonstrate five different RED proportion relationships (0.62, 0.65, 0.70, 0.75, and 0.80). Four sets of the five altered images were presented to dental professionals and lay persons using a web-based survey site. The professional group included dentists and dental laboratory technicians. The lay group included anyone without previous dental education or experience. Study participants were asked to rank each series from most to least esthetic and their preferences were extracted from the data.

Results: Preference data from the five RED proportion relationships was consolidated into two categories: a narrow group including 0.62, 0.65, and 0.70 and a broad group including 0.75 and 0.80. Analysis shows that the level of professional training or experience does not play a significant role in the RED proportion preferences of study participants. Only in the prototypical male facial views was there any significant difference between professional and lay groups. For that view, a greater percentage of the layperson group preferred the narrow RED proportions. However, for the male dentofacial views that difference disappeared and both participant groups showed a slight preference for the broad proportion category. This may be due to the traditional esthetic stereotype for males to have broader, more vigorous appearing anterior teeth. For the prototypical female images, all participants expressed a clear, statistically significant preference for the narrower RED proportions in both full face and close up views.

Conclusions: Based on the results above, dental professionals who are developing a treatment plan should attempt to utilize a RED proportion ≤ 0.70 for both male and female patients.

CLINICAL SIGNIFICANCE

The RED proportion is an objective numeric tool for relating the apparent widths of maxillary anterior teeth. It may be used by dental professionals to help diagnose and develop an optimal esthetic treatment plan. This paper offers insight into whether there are specific RED proportions that are preferred, whether there is a difference in preference when considering the male or female smile and whether professional educational training changes those preferences.

(J Esthet Restor Dent 00:00–00, 2015)

INTRODUCTION

The Golden Proportion, which has sometimes been referred to as the divine proportion, golden ratio, golden section, or PHI is a well-known concept in the fields of art, mathematics, astronomy, philosophy, and architecture. Two quantities are said to be in golden proportion if their numeric ratio is equivalent to the

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 DOI 10.1111/jerd.12187

ratio of their sum to the larger of the two quantities (Figure 1). Solving that equation yields an irrational mathematical constant with a value of approximately 1.62. For centuries, it has been believed that this concept plays a significant role in the human perception of beauty and ideal form. Leonardo da Vinci's famous illustrations for the book, *De Divina Proportione*, published in 1509, applied these concepts to human anatomical form. In the 20th century (1978), Edwin Levin first proposed applying the Golden Proportion to "dental esthetics."[1] Although his paper was purely anecdotal, Levin theorized that for optimal dental esthetics, the apparent widths (frontal projections) of adjacent maxillary anterior teeth should be in golden proportion to one another (Figure 2). That is, the apparent width (aw) of the right central incisor should be in golden proportion to the aw of the right lateral incisor and that aw should be in golden proportion to its adjacent canine, and so on. The advantages of having such an objective metric standard to use when planning restorative dental treatment are obvious. Later papers by several authors challenged this concept and proposed alternate

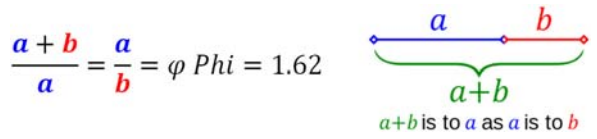

FIGURE 1. Mathematical equation and graphical description of the Golden proportion (PHI).

theories and recommendations on the ideal widths of the teeth and their dimensional relationships to each other.[2–5] To date, there has been much discussion of the theories. There is general agreement that the concept is very useful, but no real consensus as to which is most ideal. Based on earlier work by Lombardi,[6] Ward proposed an iteration which he called the "Recurring Esthetic Dental" (RED) Proportion.[7] The RED proportion theorem states that the ratios of the apparent widths of adjacent maxillary anterior teeth, as one moves distally from the midline, are a constant (Figure 3). The implications of this are that dentists or lab technicians would be free to use any width ratio that seems to fit the case so long as the ratios for two adjacent teeth remain constant. It is particularly interesting to note that the Golden Proportion of Levin is a special case of the RED proportion where the constant $c = 0.62 = 1/\varphi$. It is important to note that all of these theories and measurements deal only with the "apparent" widths of anterior teeth and do not give any consideration to their actual mesial-distal widths nor their lengths. While lengths of teeth and width/length ratios may vary significantly due to age, diet, parafunctional habits, and other factors, the widths of teeth are more consistent from person to person and over a lifetime.[8] Regardless of the tooth length, a smaller RED proportion requires a more rapid decrease in apparent width as you move from the dental midline distally around the arch. In other words, a smaller RED

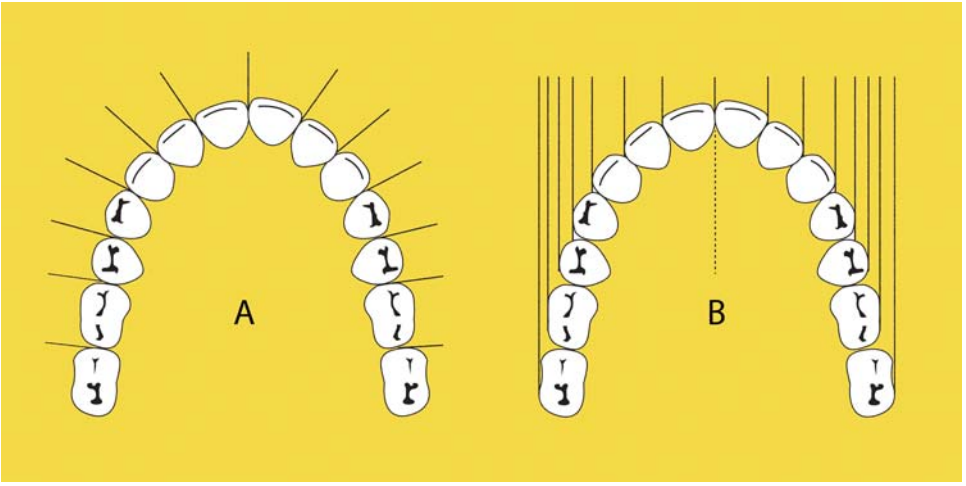

FIGURE 2. Actual widths (A) versus apparent widths (B).

DOI 10.1111/jerd.12187

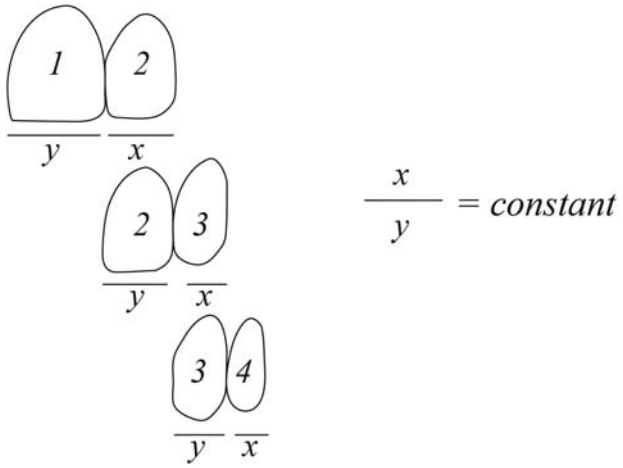

FIGURE 3. Graphical and mathematical representation of the RED proportion.

proportion means the dental arch appears narrow with smaller more slender teeth displayed whereas a larger RED proportion means the arch appears broader and displays fewer and larger teeth. This was one of the criticisms for applying the golden proportion to the widths of teeth as it tends to produce a very narrow arch display. In his paper, Ward concluded that for teeth of normal lengths, a RED proportion of 0.70 was preferable to the 0.62 Golden proportion. He attempted to validate his views with a 2007 study comparing the preferences of some North American Dentists for different RED proportions.[9] In his conclusions for that paper, he stated, "Duplication of these surveys with patients would be useful to determine if their preferences are similar to dental practitioners. Future studies evaluating variables such as gender, ethnicity, tooth shapes, lip characteristics, gingival architecture, posterior teeth, and mandibular teeth may also be useful to better define an objective standard for smile design." The value of understanding and comparing the preferences of lay persons versus professionals for esthetic parameters was demonstrated by Kokich in his landmark paper on altered dental esthetics.[10] Our investigation sought to confirm Ward's RED proportion preferences for dentists as well as to expand the analysis to the preferences of patients (lay persons). As dental laboratory technicians may play a significant role in the diagnosis, design, and fabrication of indirect anterior restorative dentistry, we elected to include them with dentists as a consolidated dental professionals group. It is certainly useful for all dental professionals to understand whether their education or training has imposed any bias and whether lay patients possess the same preferences as they do when it comes to esthetic parameters. We also noted that Ward's preference study (as were many others) was limited to evaluating a prototypical female smile in a dentofacial view.[11] So our study was expanded to include preferences for a prototypical male smile and to test the consistency of the preference we also examined full facial smiling views for both male and females.

MATERIALS AND METHODS

We evaluated and compared the esthetic "preferences" of two sample groups; lay persons (patients) and dental professionals (dentists and dental technicians) for male and female smiles with different RED proportions. Modern preference studies for esthetic dental parameters often make use of computer imaging which allows photographs of features in a smile to be digitally altered to demonstrate specific conditions or dimensional relationships.[12,13] The digitally modified images are then presented to test subjects who express their preferences by rating or ranking the various images using various survey techniques. In our study, we digitally modified photos to display different RED Proportions. We utilized two primary template views, a "Dentofacial Smiling View" (lips and teeth only) as was used by Ward and a "Facial Smiling View" (full face). These two template views are shown in Figures 4 and 5. As dentofacial views may appear genderless whereas facial views demonstrate male or female gender more clearly, we thought it would be very interesting to determine if there is a positive correlation between the dentofacial and facial template views as well as to test for any differences in preferences for the male or female smile.

To accomplish this, the two primary template views (dentofacial, facial) were subdivided into male and female subsets for a total of four template views (i.e., male dentofacial and facial, female dentofacial, and facial). To create the templates, two stock photos of a smiling female and male face were purchased from a

 DOI 10.1111/jerd.12187

FIGURE 4. Dentofacial template views: smiling male and female.

FIGURE 5. Full facial template views: smiling male and female.

Stock Photography Agency (Bigstock, New York, NY). The stock photos were carefully selected for male/female faces which met all or most generally accepted criteria for ideal esthetics (i.e., facial symmetry, dental midline coincident with facial midline, soft tissue health and harmony, incisal edges paralleling the lower lip line, etc.).[14,15] A graphic artist digitally altered the template images using Photoshop CS5 Software to remove all teeth and intraoral soft tissues leaving only the lips and facial soft tissues as a visual scaffold. A series of digital graphical inserts of the anterior teeth at different RED Proportions (0.62, 0.65, 0.70, 0.75, and 0.80) was created by the graphic artist. Each of the graphical dental inserts was then pasted back into the facial template so that the observer could view a completed smile and face with a series of different RED Proportions. The dentofacial views were created in similar fashion by cropping and enlarging only the lips, teeth, and perioral anatomy of the previously prepared facial views (Figure 6). This means that there were a total of 20 computer modified images for the viewer to rate/rank: dentofacial view, female (0.62, 0.65, 0.70, 0.75, 0.80); dentofacial view, male (0.62, 0.65, 0.70, 0.75, 0.80); facial view, female (0.62, 0.65, 0.70, 0.75, 0.80); and facial view, male (0.62, 0.65, 0.70, 0.75, 0.80). The 20 views were presented to the viewer as four sets of five images with the different RED proportions. We chose this specific set of RED Proportions because we wanted to cover a broad range of smile widths and also include the Golden Proportion as described by Levin (0.62). For uniformity, preference data were collected using a

 DOI 10.1111/jerd.12187

FIGURE 6. Complete male dentofacial series with RED proportions of 0.62, 0.65, 0.70, 0.75, and 0.80 (left to right).

web-based survey site, Survey Monkey (www.surveymonkey.com). No test subject was given any information about what parameter was being evaluated. For each group, all subjects were shown the four sets of five individual images followed by a photomontage of all five images and asked to rank them from most attractive to least attractive. As this data collection involved human subjects and the primary data collection site was Columbia University School of Dental Medicine, New York, NY, an IRB approval was obtained at the University (IRB-AAAI5151(Y1M00)). The top preference rankings by RED proportion were analyzed and collated by professional status/training and secondarily by narrow (0.62, 0.65, 0.70) or broad (0.75, 0.80) preference categories. Our data are presented as the percentage of the study participants whose top preference was a particular RED proportion category.

SUBJECT RECRUITMENT AND SAMPLE SIZE

Dentist subjects for the Dental Professionals group were mainly recruited from the Columbia University College of Dental Medicine as well as external dentists in the NY/CT/NJ tristate area. Dental technician subjects were recruited from several large dental laboratories located throughout North America. Formally trained as well as informally on-the-job trained technicians were included in this group. The target sample size was 100 dental professionals. We were successful in recruiting 89 dentists and 17 dental technicians for the dental professionals group for a total of 106.

Subjects for the Lay Persons group were recruited from the clinic floors at Columbia University College of Dental Medicine as well as external lay-persons in the NY/CT/NJ tri-state area. Any person who did not possess an educational background or work history in either dentistry or dental laboratory technology was included in this group. The target sample size was 100 lay-persons and we were successful in recruiting 49 for this group. Basic demographic information was obtained from each subject in order to determine which group they qualified for as well as determine their gender, age, race, and educational level allowing us the possibility to analyze the data collected for these variables. All subjects signed an informed consent prior to participation. We believe that the lower participation level in the lay group may have been partially due to rigorous IRB requirements as to informed consent and the amount of documentation that participants were required to read before completing the survey. There were many partially completed lay surveys which we were not able to include in the final data.

STUDY RESULTS

For this study, we attempted to answer three questions. (1) Is there a specific RED proportion range that was preferred for male or female images? Note: this is a different question than asking is there a difference expressed by the gender of the participants. While both males and females participated in our preference study, the number of subjects in each gender was disproportionate and their data were ultimately pooled. (2) Would this preference be expressed at both a dentofacial and facial level and if so are they the same? (3) Is there agreement or differences in preferences between the dental professional group and lay-persons? To simplify the analysis and provide a more usable clinical context, we consolidated the five RED proportion preferences into

 DOI 10.1111/jerd.12187

two groups; narrow (0.62, 0.65, 0.70) and broad (0.75, 0.80). The selection of these two groupings was based on Ward's work. Any preference value ≤ 0.70 was assigned to the narrow category because these RED proportions tend to yield a narrow arch display composed of more slender appearing teeth. Any value ≥ 0.75 was assigned to the broad category because of the opposite effect.

The data are illustrated in the four charts shown in Figures 7–10 and are summarized in Table 1. Figures 7 and 8 show the charts for the male facial and dentofacial views, respectively. Figures 9 and 10 show the charts for the female facial and dentofacial views, respectively. To determine if there were any differences in esthetic preference based on dental training, we used a Two-Sided Fisher's Exact Test. Of the four data sets, the male facial view (Figure 7) was the only one which showed a small but statistically significant difference in preference by level of professional training ($p = 0.0204$; Table 1). Here, the lay-person group chose the narrow over broad RED proportions with a greater percentage than dental professionals (lay persons; 69% versus 31%) and professionals; 52% versus 48%), (Figure 7; Table 1). However, for that chart there was qualitative agreement and no statistical differences between the two group's overall preferences for broad and narrow proportions ($p = 0.2563$; Table 1). A two-way analysis of variance (ANOVA) also revealed no significant interaction between preference and training ($p = 0.4332$). This difference by training disappeared when participants were presented with the male dentofacial images (Figure 8, Table 1). Figures 8–10 all showed no qualitative or significant quantitative differences in preference due to professional training

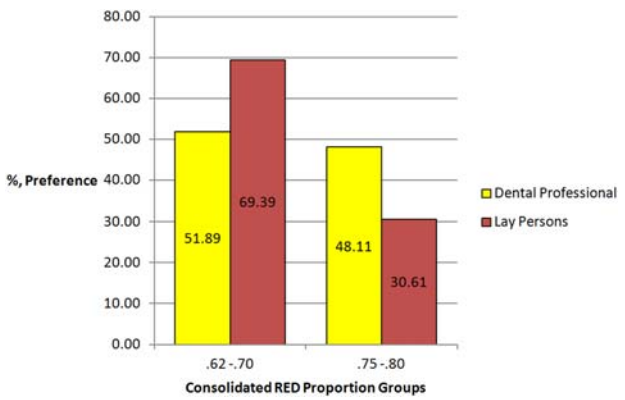

FIGURE 7. RED proportion preferences (%): male full face view.

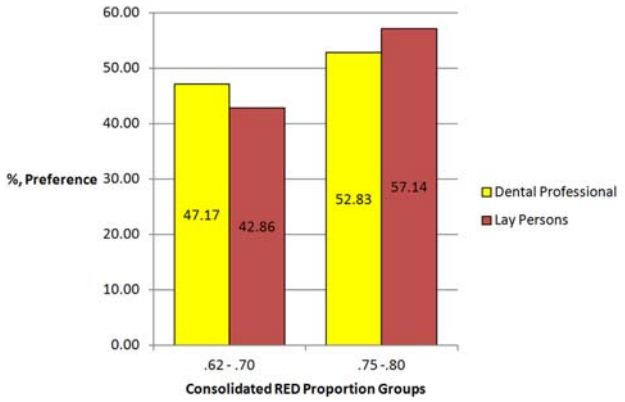

FIGURE 8. RED proportion preferences (%): male dentofacial view.

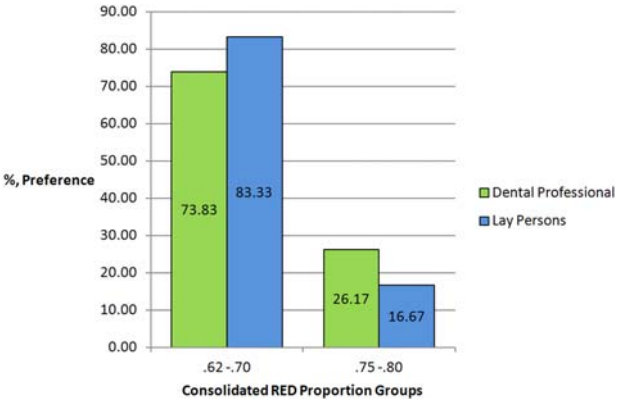

FIGURE 9. RED proportion preferences (%): female full face view.

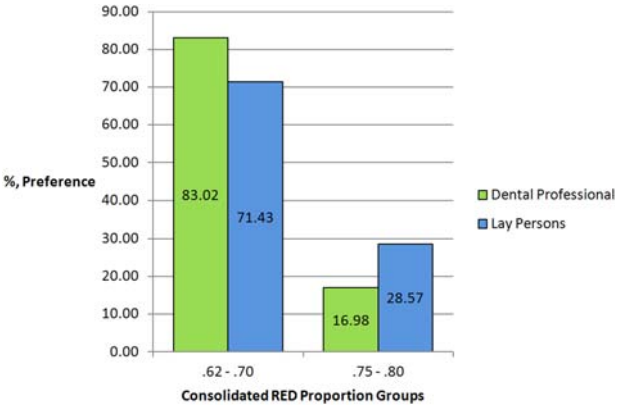

FIGURE 10. RED proportion preferences (%): female dentofacial view.

DOI 10.1111/jerd.12187

TABLE 1. Summary of all data with statistical analysis applied

Preferences	Male Facial		Male Dentofacial		Female Facial		Female Dentofacial	
	0.62-0.70	0.75-0.80	0.62-0.70	0.75-0.80	0.62-0.70	0.75-0.80	0.62-0.70	0.75-0.80
Dental Professional %	52	48	47	53	74	26	83	17
Lay Person%	69	31	43	57	83	17	71	29
Two-sided Fisher's Exact Test P < 0.05 (= significant) Difference in choice by professional training	0.0204(sig.)		0.6699		0.1681		0.0638	
Two-sided Chi Square Test P < 0.05 (= significant) Difference in RED Prop. preference	0.2563		0.4965		0.0001(sig.)		0.0001(sig.)	

(Table 1). Given that professional training did not affect preference, we next examined RED proportion preferences across study participant categories using a two-Sided Chi-Square analysis with raw data. In the male dentofacial views (Figure 8), both professionals and lay persons show a similar slight preference for the broad RED proportions subgroup (Professionals; 47% versus 53% and Lay persons; 43% versus 57%), but these preferences were not statistically significant ($p = 0.4965$; Table 1). Figure 9 is the chart of the female facial view and Figure 10 is the female dentofacial view. The preference values are similar in both data sets and show that both professional and lay groups had a strong preference for the narrow RED proportion range. Both charts were statistically significant with the Chi Square analysis ($p < 0.0001$ for both views). In the female facial view, dental professionals favored a narrow smile by 74% versus 26% while lay-persons were even higher at 83% versus 17%. The Fisher's Exact test had a p value = 0.1681 indicating that the professional status played no effect on the preference for the narrow smile parameters. The dentofacial views of females showed a similar preference profile. Professionals expressed a 4/1 preference (83% versus 17%) while lay persons expressed nearly a 3/1 preference (71% versus 29%) for the narrow proportion range (Figure 10; $p < 0.0001$). Again professional experience did not influence the preference for the narrow proportion ($p = 0.0638$).

DISCUSSION

The RED proportion is an objective numerical concept that can be used by the dentist or laboratory technician to help design a single or multiple tooth dental restoration, set up a removable denture or to orthodontically move teeth into a more pleasing esthetic arrangement. It must be considered in context with other metrics such as width/length ratios of the individual teeth and non-numeric considerations such as occlusion and lip position. In this study, we sought to answer several questions regarding the clinical application of the RED proportion and to confirm and expand upon a previous preference study by Ward. While Ward surveyed only dentists, we included both dentists and laboratory technicians as a single dental professional group and contrasted their preferences with those of lay-persons. Following a pattern of many other investigators, Ward utilized only a prototypical female dentofacial smile, while we included both dentofacial male and female smiles. Our study also included full facial prototypes of the smiling male and female in an effort to evaluate the consistency of the preference and to help demonstrate any gender differences. We grouped the RED proportion categories into narrow and broad, to provide a useful clinical context. This allowed us to clearly demonstrate that for dental professionals there was no RED proportion preference in either the male full facial views or the male dentofacial views. Lay-persons did express a preference for a narrow RED proportion when viewing the male face but when the close-up dentofacial views were considered, that preference did not remain. Although it was not statistically significant, we found it interesting that both dental professionals and lay-persons showed a slight preference for the broader RED proportions (0.75, 0.80) in the male dentofacial views. This finding corresponds with the well-known esthetic stereotype for males to have

 DOI 10.1111/jerd.12187

larger, more squarely shaped teeth while females should have smaller more slender and delicate appearing anterior teeth. For all of the female views (facial and dentofacial), both dental professionals and lay-persons expressed a very strong preference for the narrow RED proportions (0.62, 0.65, 0.70) which again corresponds to the gender stereotype for female anterior maxillary teeth.

CONCLUSIONS

This study confirms the work of Ward who reported that 0.70 was the preferred RED proportion for the female smile. This study also indicates that professional training does not introduce a bias into the choice of RED proportion. The conclusion that can be drawn from our work is that dental professionals who are developing a treatment plan should attempt to utilize a RED proportion ≤ 0.70 for both male and female patients. This provides the clinician and the laboratory technician with an acceptable range of apparent width values which can help accommodate for variations in individual tooth length and lip position, etc. and which are likely to be esthetically accepted by their patients.

DISCLOSURE AND ACKNOWLEDGEMENTS

The authors do not have any financial interest in the companies whose materials are included in this article. The authors would also like to acknowledge the contributions of Debra Pitel and Austin Be (for graphic design of the images) and Joseph Wang (for survey website/formatting design).

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 DOI 10.1111/jerd.12187