FACE SYMMETRY ASSESSMENT: EDUCATIONAL AND CLINICAL IMPLICATIONS OF EXPERTISE IN ORTHODONTISTS

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A thesis submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Science in the School of Dentistry (Orthodontics**).**

Chapel Hill
2013

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ABSTRACT

TATE H. JACKSON: Face Symmetry Assessment: Educational and Clinical Implications of Expertise in Orthodontists
(Under the direction of Dr. Tung Nguyen)

The accurate assessment of face symmetry is necessary for the development of a dentofacial diagnosis in orthodontics. The enhancement of this ability is an important component of dental education, and an understanding of individual differences in perception of face symmetry between patients and providers is needed to facilitate successful treatment. Orthodontic residents and faculty, dental students, general dentists, and control participants completed a series of tasks to assess face symmetry. Judgments were made on pairs of upright faces (similar to the longitudinal assessment of photographic patient records), inverted faces, and dot patterns. Participants completed questionnaires regarding clinical practice, education level, and self-confidence ratings for symmetry assessment abilities. Orthodontists showed expertise compared to controls ($p<0.001$), while dentists showed no advantage compared to controls. Orthodontists performed better than dentists, however, in only the most difficult face symmetry judgments ($p=0.006$). For both orthodontists and dentists, accuracy increased significantly when assessing symmetry in upright vs. inverted faces ($t=3.7$, $p=0.001$; $t=2.7$, $p=0.02$). Residents showed a significant advantage in assessing face symmetry compared to control participants ($p=0.002$), while faculty members were better only in the most difficult face symmetry judgments compared to controls ($p<0.001$), and dental students showed no advantage over controls. Both residents and faculty members were better able to assess their own performance than other groups. The diagnostic skill of face symmetry assessment appears to be determined by

more than just experience over time and may be subject to the testing effect, and accurate self-assessment may be one important benchmark of clinical skill acquisition. Orthodontists show expertise in assessing face symmetry compared to both laypersons and general dentists and are more accurate when judging upright than inverted faces. When using longitudinal photographic records to assess changing face symmetry, orthodontists are likely to be incorrect in less than 15% of cases, suggesting assistance from some additional technology is infrequently needed for diagnosis.

ACKNOWLEDGEMENTS

I thank the members of my thesis committee, Dr.'s Nguyen, Proffit, Lee, and Mitroff for their guidance support, and mentorship.

Thank you to Elise Darling, Shanley Lestini, Caroline Albea, Sasha Malinchoc, and Adam Biggs for their invaluable help in collecting data.

Very special thanks go to Kait Clark and Steve Mitroff for taking a chance on collaborating with me and embarking on the journey that has resulted in the work contained here in this thesis. Without you this would not have been possible.

This work was supported in part by grant T90DE-021986-01 from the National Institute of Dental and Craniofacial Research. The TSA data were collected through support from a subcontract with the Institute for Homeland Security Solutions, a research consortium sponsored by the Human Factors Division in the Department of Homeland Security (DHS). This material is based upon work supported by the DHS under Contract No. HSHQDC-08-C-00100. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the official policy or position of DHS or of the U.S. Government. The study is approved for public release.

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1. Introduction

A comprehensive diagnosis necessitates more than just inspection of the teeth and oral cavity, and includes facial form analysis for symmetry and proportions. The close inspection of a patient's face for significant or subtle asymmetry is recommended throughout all fields of dentistry to identify problems ranging from minor esthetic concerns to severe pathologic problems.[1-4] Faces are ubiquitous visual stimuli, and are thought to be perceived using specialized processes in the brain.[5] Both neuroimaging and behavioral research indicates that the perception of face symmetry is a process that is distinct from the perception of symmetry in non-face objects, such as mouths or teeth.[6, 7] Accordingly, the diagnostic assessment of face symmetry is a perceptual process that is unique compared to other visual-spatial tasks in dentistry and should be investigated both for this fact and because of its clinical significance.

The specific aims of the first paper, *Clinical Skill Acquisition: Test-Enhanced Learning of Symmetry Assessment in Dental Education*, were to 1) explore whether dental professionals do, in fact, demonstrate expertise in assessing face symmetry and to 2) characterize the nature and development of this ability in the hopes of informing both pre- and post-doctoral education in dentistry. The aims of the second manuscript, *Clinical Implications of Face Symmetry Assessment Abilities: Diagnostic Skill Using Longitudinal Patient Photographs*, were to determine if orthodontists posses expertise in assessing face symmetry compared to general dentists and laypersons and to explore the nature of this ability with the hope of informing clinical practice and patient communication.

2. Clinical Skill Acquisition: Test-Enhanced Learning of Symmetry Assessment in Dental Education

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2.1 INTRODUCTION

Successful dentistry requires the accurate diagnosis of oral health problems and the formulation of a treatment plan before finally rendering care to the patient. It is this final step, the delivery of clinical care, which has been the primary focus of research exploring the spatial reasoning and perceptual abilities of dentists and dental students. A large number of studies have attempted to correlate performance on varying perceptual and motor tests with the ability to perform manual and operative procedures in a clinical setting.[8-10] Other investigations have focused on visual skills in the context of new technology or diagnostic schemes.[11-15] Fewer studies have focused on perceptual ability alone as a key component of diagnosis or on how visual perception change over the course of dental education and experience.[16, 17]

A comprehensive diagnosis necessitates more than just inspection of the teeth and oral cavity, and includes facial form analysis for symmetry and proportions. The close inspection of a patient’s face for significant or subtle asymmetry is recommended throughout all fields of dentistry to identify problems ranging from minor esthetic concerns to severe pathologic problems.[1-4] Faces are ubiquitous visual stimuli, and are thought to be perceived using specialized processes in the brain.[5] Both neuroimaging and behavioral research indicates that the perception of face symmetry is a process that is distinct from the perception of symmetry in non-face objects, such as mouths or teeth.[6, 7] Accordingly, the diagnostic assessment of face symmetry is a perceptual process that is unique compared to other visual-spatial tasks in dentistry and has been investigated both for this fact and because of its clinical significance.

A recent study in which participants were asked to objectively compare asymmetry between different individuals’ faces suggests that orthodontists and oral and maxillofacial surgeons might judge facial symmetry more accurately than other groups.[18] This study is suggestive, but leaves room for alternative explanations due to the nature of the stimuli and tasks. Specifically, the faces that were used as stimuli had pathologic deviations from normal symmetry and from normal proportions. Since the participants were asked to rate how the faces differed in terms of deformity from normal rather than in symmetry explicitly, the role of symmetry in their judgment was not clear. Another investigation related to the perception of face symmetry similarly reports dental expertise but suffers from the fact that participants were asked to rate attractiveness rather than symmetry itself.[19] Finally, a study using simulated "three-dimensional" face stimuli suggests that orthodontists and oral surgeons show no meaningful advantage in judging face symmetry when compared to laypersons.[20] Importantly, none of these investigations were designed to explore expertise explicitly, but rather preferences and thresholds for the detection of problems. In short, current evidence is equivocal at best as to whether dental professionals actually possess expertise in assessing face symmetry compared to laypersons.

The aims of the current study were to 1) explore whether dental professionals do, in fact, demonstrate expertise in assessing face symmetry and to 2) characterize the nature and development of this ability. In an effort to overcome the limitations of previous research and to address the first aim, we used visual cognition tests designed specifically for the task of evaluating face symmetry assessment. To address the second aim, we compared performance on these tasks across dental students, orthodontic residents, orthodontic faculty members, and untrained controls. With an understanding of if and how expertise in face symmetry assessment can be developed, curricula and methodology in dental education may be improved.

2.2 MATERIALS AND METHODS

Participants

This study was deemed exempt from IRB review by the Office of Human Research Ethics at the University of North Carolina at Chapel Hill and approved as an addendum to an ongoing study by the Institutional Review Board of Duke University. Participants with face symmetry training were recruited from the Department of Orthodontics at the University of North Carolina School of Dentistry (UNC). Residents were all from the Department of Orthodontics (n=16, 5 female, mean age=30.65 years, SD=2.94) in various stages of the three-year program (6 in first year, 5 in second year, 5 in third year) that includes formal didactic training (a total of two lecture hours) and practical experience in assessing facial symmetry (during treatment planning for each of ~100 patients treated over the course of the program). Full and part-time faculty members were recruited from the Department of Orthodontics at UNC (n=15, 3 female, mean age=57.31, SD=11.46). This group reported an average of 27.4 years of clinical practice (SD=12.45 years). Dental students, four each in their second, third, and fourth years of training, (n=12, 6 female, mean age=26.49, SD=2.58) were also recruited from the UNC School of Dentistry. All dental students had received minimal training in face symmetry assessment via textbook readings and online teaching modules as a part of the pre-doctoral orthodontics curriculum. Orthodontic residents, orthodontic faculty, and dental students were all compensated $10/hour for their time.

Control participants without symmetry training were recruited from two sources: non-professional laypersons from the Duke University community (non-professionals) and TSA officers employed at Raleigh-Durham International Airport. Non-professionals represent a population from which dental professionals might be developed since pre-professional study is required to matriculate to dental school. Non-professionals (n=23, 13 female age=20.87 years, SD=4.5) were compensated with course credit or paid $10/hour for their participation. TSA officers represent a population that is know to have enhanced visual cognition abilities unrelated to face symmetry assessment. [21] The TSA officers (n=10, 2 female, age=42.33 years, SD=10.20) were not directly compensated since their data were collected during normal working hours as part of their employment. Their participation was completely voluntary and confidential (see Biggs et al for details).[21] Two additional participants in the TSA group and one in the Duke student group had overall face accuracy scores that fell two standard deviations below the mean overall face accuracy score for all participants, and their data were excluded from all analyses. All participants confirmed 20/20 vision or the use of corrective lenses at the time of data collection.

Apparatus

Data were acquired in three separate locations using identical protocols and environments: orthodontic resident, orthodontic faculty, and dental student data were collected at the UNC School of Dentistry, Duke student data were collected at Duke University in the Visual Cognition Laboratory, and TSA officer data were collected at Raleigh-Durham International Airport in a private testing room. The experiment was run in a dimly lit room; participants at Duke and UNC viewed the experiments on a Dell Inspiron computer with a 20-inch CRT monitor, and participants at RDU viewed the experiments on Dell Vostro 260 computers and 23.6-inch computer displays that were adjusted so all participants were presented with stimuli of the same physical size. Participants were seated at a viewing distance of approximately 57 cm with no head restraint. Stimuli were presented and responses were recorded using MATLAB

(The MathWorks, Natick, MA) using the Psychophysics Toolbox (Version 3.0.8, Brainard, 1997; Pelli, 1997; Kleiner, Brainard, & Pelli, 2007). Questionnaire data were collected using the Qualtrics Research Suite (Qualtrics Labs, Inc., 2012).

Procedures and Stimuli

All participants completed three visual cognition tasks related to symmetry and presented in a blocked design; order was counterbalanced across all participants and tasks. Each task began with a series of practice trials that were immediately followed by the experimental segment during which trial-by-trial accuracy and response time were recorded. At the start of each trial, a fixation cross was presented for 500ms, followed by the stimulus. Participants responded to each trial with one of two possible keys, and no feedback was provided.

Task 1: Symmetry assessment of upright faces

Participants assessed symmetry in 96 trials of upright faces by making a two-alternative forced-choice judgment between two versions of the same face presented side by side (see Figure 2.1A). Stimuli were presented on a black background, and the participant was instructed to press the 'z' key if the face on the left appeared more symmetric and the '/' key if the face on the right appeared more symmetric. Stimuli were displayed on the screen until the participant responded. Trials were counter-balanced for each participant as to whether the right or left face was more symmetric. Stimuli consisted of black-and-white photographs of faces of sixteen (8 female) Caucasian individuals morphed to varying levels of asymmetry while preserving averaged proportions (see Rhodes, Proffit, Grady, & Sumich, 1998 for details on stimuli generation).[22] Veridical hairstyles (*i.e.* the hairstyles from the unaltered faces) were maintained for all versions of each face by editing the original stimuli set from Rhodes using Adobe® Photoshop

Elements10®. This modification was made so that the hair could not be used as a cue to symmetry. Four versions of each face, varying in symmetry were used: the veridical face, the face with perfect symmetry, the face with symmetry increased 50% from the veridical, and the face with symmetry decreased 50% from the veridical (See Figure 2.2). By pairing each face version with all the iterations of that face, six possible pairings were created (veridical with perfect symmetry, veridical with high symmetry, veridical with low symmetry, high symmetry with perfect symmetry, high symmetry with low symmetry, and low symmetry with perfect symmetry). These stimuli were presented at random in terms of both the levels of symmetry being compared and the individual's face that was used. Participants viewed all possible pairings of each face over the course of Task 1.

Task 2: Symmetry assessment of inverted faces

This task was identical to Task 1, but all stimuli were presented upside-down. The sequence of presentation was randomized separately from Task 1. Faces were presented upside-down both because clinicians often view patients this way when administering care and because inverted faces are processed by different cognitive mechanisms compared to upright faces.[23]

Task 3: Symmetry detection in dot patterns

Participants judged whether a dot pattern presented as a centered image on a black background was perfectly symmetric about its vertical axis (see Figure 2.1B). Each dot image was displayed for 2000ms, after which participants were asked to make a response using the 'z' key to indicate that the dot pattern was symmetric and the '/' key to indicate that the dot pattern was not symmetric. The 2000ms display time was used to maintain consistency with a previously used experimental protocol.[24] Stimuli were 18 dot patterns based on the body patterns of animal with bilaterally symmetric bodies (see Evans, Wenderoth, & Cheng, 2000 for details).[25] Each pattern was presented in random order in both upright and inverted conditions for a total of 36 trials.

Immediately following the completion of all visual tasks, each participant completed a web-based questionnaire that asked about demographic information, strategies employed during symmetry assessment, and subjective confidence self-ratings for the tasks completed using the Royal College of Physicians Confidence Rating Scale.[26] Residents, faculty, and dental students were asked whether the patient is most frequently upright or inverted when they assess face symmetry clinically and about duration of training or clinical practice. Non-professionals and TSA officers were asked whether they had any training or experience in symmetry assessment.

2.3 RESULTS

Descriptive statistics for accuracy, response time, and confidence ratings for each task may be found in Table 2.1. Normality of data were confirmed using Q-Q plots and homogeneity of variance was confirmed using Levene's test. Accuracy and response times were compared among groups using one-way analysis of variance and Tukey's HSD. Paired t-tests or Wilcoxon Signed Rank tests (for confidence ratings) were used to make within subject comparisons; statistical significance was set at $p=0.05$.

Orthodontic residents showed a statistically significant advantage in judging face symmetry overall ($F=4.9$, $p=0.002$) and in both upright ($F=4.0$, $p=0.006$) and inverted ($F=3.7$, $p=0.009$) face conditions compared to both non-professionals and TSA officers (Tukey's HSD $p<0.05$ for all comparisons). Accuracy did not vary significantly among residents in different years within their program. Neither orthodontic faculty nor dental students showed a significant difference in accuracy for assessing symmetry in faces, whether upright or inverted, when compared to non-professionals or TSA officers. In the most difficult trials (those in which the differences in symmetry between faces were smallest; *e.g.* perfect symmetry compared to high symmetry; see Figure 2.2), orthodontic faculty showed a significant advantage in accuracy ($F=6.6$, $p<0.001$) over both non-professionals ($p=0.03$) and TSA officers ($p=0.05$).

There was a significant difference in response time overall ($F=9.5$ $p<0.001$), and for both upright ($F=8.6$, $p<0.001$) and inverted ($F=5.5$, $p=0.001$) faces between orthodontic residents and faculty compared to non-professionals ($p<0.02$ for all comparisons), but not between orthodontic residents and faculty compared to TSA officers. Non-professionals took less time to judge symmetry than residents, faculty, or TSA officers. There were no other differences in response time among any groups.

There were no statistically significant differences in accuracy or response time for dot stimuli among any of the groups as expected for this control task.

Orthodontic residents and faculty also both reported confidence ratings for each task that mirrored their performance. For example, these groups respectively showed significant within-subject differences in accuracy between upright faces and dot patterns ($t=10.0$, $p<0.001$; $t=6.0$, $p<0.001$). Likewise, there were statistically significant differences in confidence ratings for residents between upright faces and dots ($z=3.3$, $p=0.001$) and for faculty between upright faces and dots ($z=2.9$, $p=0.004$). The other participant groups did not show the same consistent association of confidence with accuracy (see Figure 2.3 A, C).

All but six total participants - two each in the resident, faculty, and dental student groups - responded that when they assess face symmetry clinically, the patient is in an upright position. No non-professionals or TSA officers reported training or experience in judging face symmetry.

2.5 DISCUSSION

Our results seem to defy the common sense logic that the ability to assess face symmetry would simply continue to improve with increased training and practice over time, and research peripherally related to our study is equivocal as to whether previous experience with visual diagnosis provides an advantage in accuracy on related tasks.[11-17] Why do faculty members with decades of experience not outperform dental students who have minimal training? Across orthodontic faculty, residents, and dental students, there were no significant differences in face symmetry assessment abilities (see figure 2.3A). In fact, orthodontic residents demonstrated a clear advantage in assessing face symmetry over untrained controls while orthodontic faculty showed an advantage only in the most difficult cases, and dental students showed no advantage compared to controls. It appears that experience alone may not be enough to develop robust expertise in face symmetry assessment. In the absence of longitudinal data following individuals from pre-doctoral studies, to a graduate residency program, and then to a faculty position, examining each of our experimental groups in sequence does give some insight to the apparent nature of face symmetry assessment as an ability and how it might best be enhanced as a clinical skill.

Dental Students

Participants in the dental student group did not statistically differentiate themselves in accuracy from any other group. They were neither better than untrained controls nor worse than orthodontic faculty with decades of clinical experience. One might suggest that this lack of difference is a product of inadequate statistical power, but we show significant differences in this study between groups with fewer participants. A better explanation might be that dental student performance simply lies near the center of a continuum. They have training in face symmetry assessment but almost no practical experience. So while dental students are more accurate than non-professionals and TSA officers (see figure 2.3A), but less accurate than residents, these differences are not large enough to be statistically significant.

Residents

Supporting the idea that face symmetry assessment ability follows pattern of subtle change, residents did not statistically outperform dental students in accuracy. Yet they show robust expertise when compared to untrained controls. Why did the residents demonstrate clear expertise compared to controls while other groups did not? One possibility is that motivation bias affected resident performance: they were simply trying harder. Since the experimental assessment of face symmetry took place with no time constraints, one might expect to see participants who are trying harder take more time on each trial. In fact, residents did take more time to assess face symmetry than non-professionals, and the residents were more accurate. Response time between residents and TSA officers, however, was nearly identical, and residents still were significantly more accurate (see Figures 2.3A, 2.3B). So, the increased response time that residents showed compared to non-professionals does not appear to be significant confounder. Instead, their performance appears to be the result of some real advantage.

Orthodontic Faculty

The orthodontic faculty group's abilities in assessing face symmetry were again statistically indistinguishable from either dental students or residents. Faculty did show an advantage compared to untrained controls, but only in the most difficult cases. It is unexpected that faculty members, who had on average nearly thirty years of clinical experience, would not perform better in most cases (as the residents did) than control participants with no formal training or experience at all. How is it possible that residents appear to be more adept at face symmetry assessment than their faculty? Certainly one possibility is that their training was different. Faculty members who were residents decades ago may not have benefitted from the same basic skill training as residents today. Another explanation centers on one important aspect of residents' current clinical education: they are actively tested on their ability to assess face symmetry.

Test-Enhanced Learning

Residents in the Department of Orthodontics at UNC follow a curriculum that includes, from the beginning of the program, individual case presentations of routine orthodontic patients to faculty members. Residents also present patients to groups of orthodontists and oral surgeons when surgical-orthodontic treatment might be required. In both settings, the resident must prepare and offer his or her assessment of the patient's face symmetry as it relates to diagnosis and treatment planning. Attending faculty members confirm or reject the resident's assessment based on their own inspection of the patient, either clinically or using photographs. In this way, the resident is tested repeatedly on his or her ability to assess symmetry in a face. The resident is given immediate feedback from the faculty member(s), who serve as the authority as to whether the resident was accurate. If the resident disagrees with the faculty assessment, then he or she has the opportunity to present countering evidence. This pattern of preparation, presentation, and feedback constitutes a testing situation, and the positive effects of testing as a learning tool are well documented.[27-29] Students show enhanced learning when testing is used as compared to other effective methods of education, and more is gained from a test with timely feedback than simply studying or practicing.[30, 31] While much of the research evaluating testing as an educational tool has focused on classroom settings, including those in dental education,[32] the same principle may apply in clinical learning environments. In fact, a recent study of medical education methodology suggests that test-enhanced learning is effective not only in didactic, but also in patient care settings.[33] Another study further proposes that the effect of test-enhanced learning on skill acquisition may be long lasting.[34] Together, this framework of knowledge offers the rational to suggest that the residents' expertise is the product of test-enhanced learning rather than simply training and repeated experience over time.

Confidence as a Component of Expertise

Despite the fact that faculty members did not show the robust advantage in symmetry assessment that residents had over untrained controls, both residents and faculty members demonstrated their expertise by accurately assessing their own abilities. As seen in Figure 2.3 (A and C), both resident and faculty groups showed decreasing confidence in their performance as their actual performance dropped. Non-professionals, TSA officers, and dental students all failed to show the same ability to consistently assess their own performance. For example, TSA agents rated their confidence in assessing symmetry in upright face equivalent to their ability to detect symmetry in a dot pattern despite the fact that their accuracy scores for these two tasks were drastically different. The ability to accurately self-evaluate performance is correlated with expertise,[35] and our data suggest that this is indeed the case when it comes to assessing face symmetry.

2.6 CONCLUSIONS

Implications for Dental Education

Longitudinal data following individuals from pre-dentistry, through dental school, residency, and clinical practice is required to make definitive statements regarding the relative contributions of training, experience, and potential inherent ability to the acquisition of clinical skills. Until that data is available, clinical dental education, whether pre- or post-doctoral, should be targeted to provide more than simple repeated experiences.

When considering the acquisition of a diagnostic skill, such as face symmetry assessment, the effect of testing by providing critical feedback during training may enhance learning in a meaningful way. Accurate self-assessment is one facet expertise and may be an important end-point for the evaluation of clinical skill acquisition. Incorporating these principles into clinical curricula and methodology will enhance dental education.

2.6 TABLES AND FIGURES

Table 2.1

Table 1. Accuracy (%correct), Response Time (sec.), and Confidence Scores

	DDS Students	Orthodontic Residents	Orthodontic Faculty	Non-Professionals	TSA Officers
Accuracy *mean (std. dev.)*					
All Faces	84.11 (7.95)	86.88 (3.69)	83.96 (3.43)	79.73 (6.74)	79.1 (6.04)
Upright Faces	84.55 (10.0)	88.41 (3.90)	91.67 (3.97)	80.84 (7.93)	79.79 (6.66)
Inverted Faces	83.68 (8.61)	85.35 (4.38)	82.43 (4.8)	78.62 (7.08)	78.39 (6.21)
Dots	65.05 (10.2)	64.76 (8.94)	62.78 (11.87)	65.82 (10.77)	63.89 (9.07)
Response Time *mean (std. dev.)*					
All Faces	5.51 (2.0)	7.56 (3.17)	7.38 (2.96)	3.26 (1.46)	7.68 (3.92)
Upright Faces	5.15 (2.1)	7.54 (2.92)	7.58 (3.77)	3.19 (1.55)	7.74 (4.44)
Inverted Faces	5.88 (2.73)	7.58 (5.07)	7.17 (3.3)	3.34 (1.51)	7.63 (3.95)
Dots	0.78 (0.45)	0.89 (0.49)	0.86 (0.3)	0.64 (0.26)	0.93 (0.46)
Confidence *% repsonses indicating confidence* [a] *(n)*					
Upright Faces	75 (9)	100 (16)	100 (15)	91.3 (21)	70 (7)
Inverted Faces	41.7 (5)	50.1 (8)	73.4 (11)	52.1 (12)	50 (5)
Dots	58.4 (7)	25 (4)	60 (9)	52.1 (12)	70 (7)

[a] Royal College of Physicians Confidence Rating Scale - 4: Fully Confident in most cases 3: Confident in some cases 2: Satisfactory but lacking confidence 1: Not confident (responses of 3 or 4 indicate confidence)

Figure 2.1A

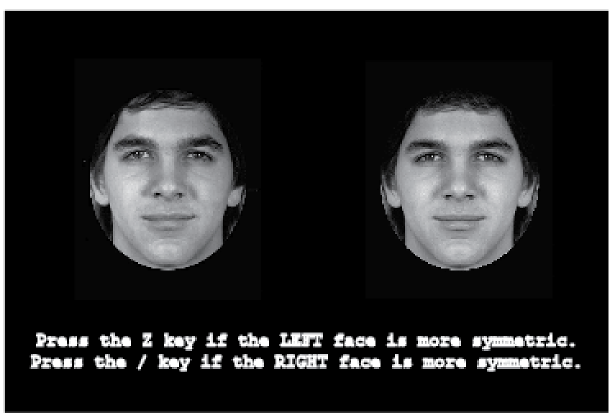
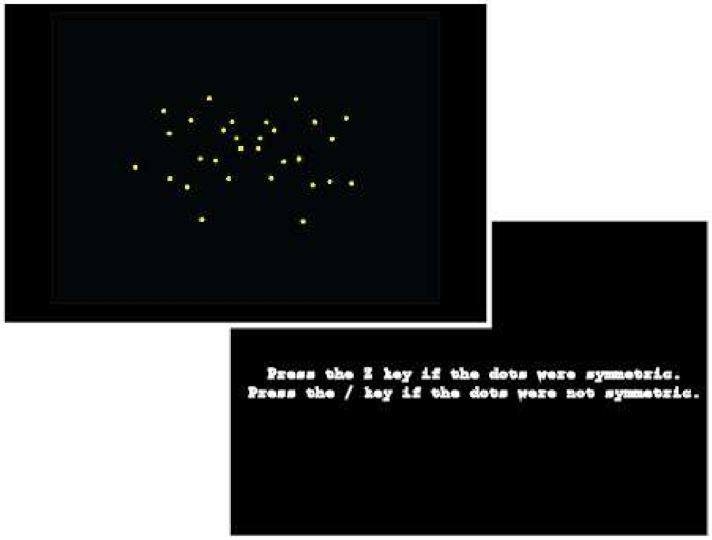
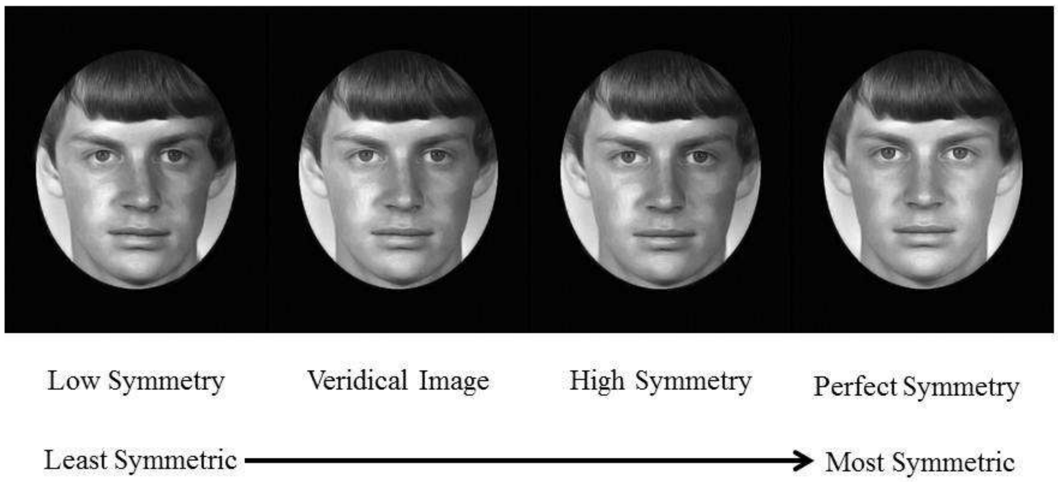


Figure 2.1B



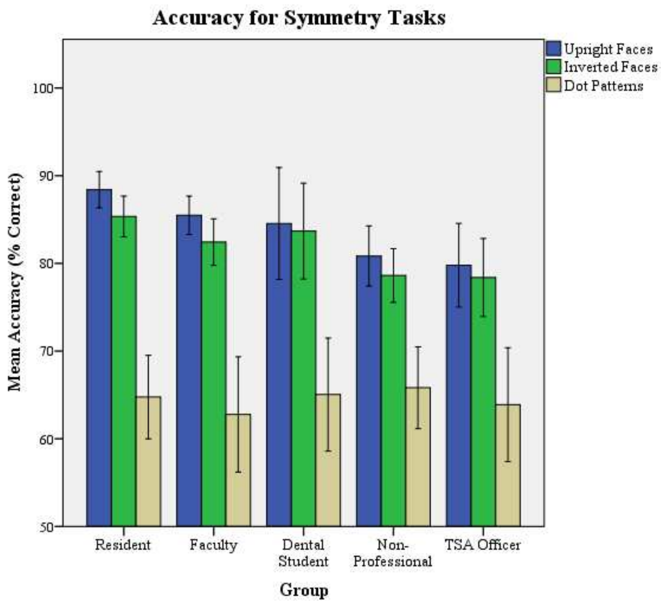
Example stimuli and instructions presented to participants for (A) Tasks 1 and 2 and (B) Task 3. The face stimuli of Tasks 1 and 2 were presented with no time constraints, whereas the dot patterns used in Task 3 were presented for 2000ms (followed by the instructions screen that remained until response).

Figure 2.2



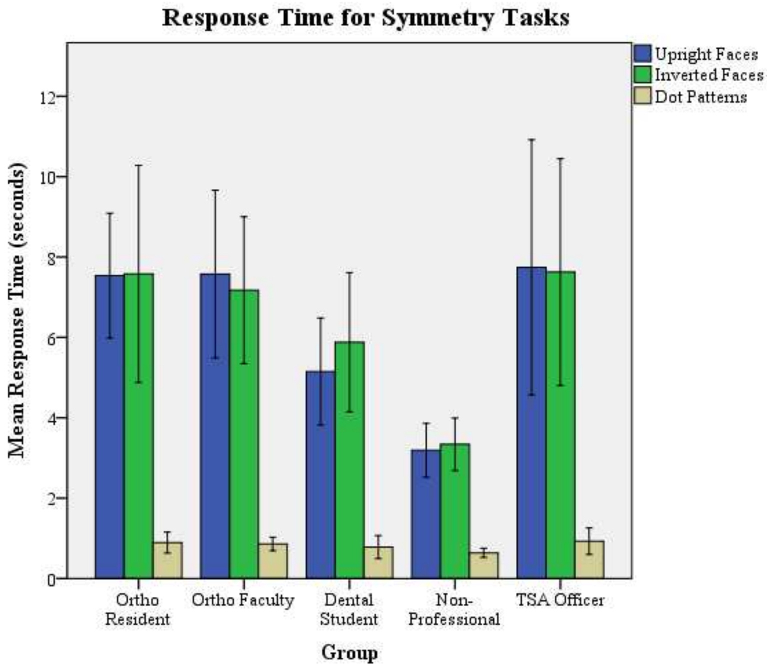
Example of face stimuli showing four morphed versions of one individual’s face: the actual face (veridical), a version 50% less symmetric (low symmetry), a version 50% more symmetric (high symmetry), and a version with perfect symmetry. Note that the hairstyle for each version of the face is the identical, veridical hairstyle.

Figure 2.3 A



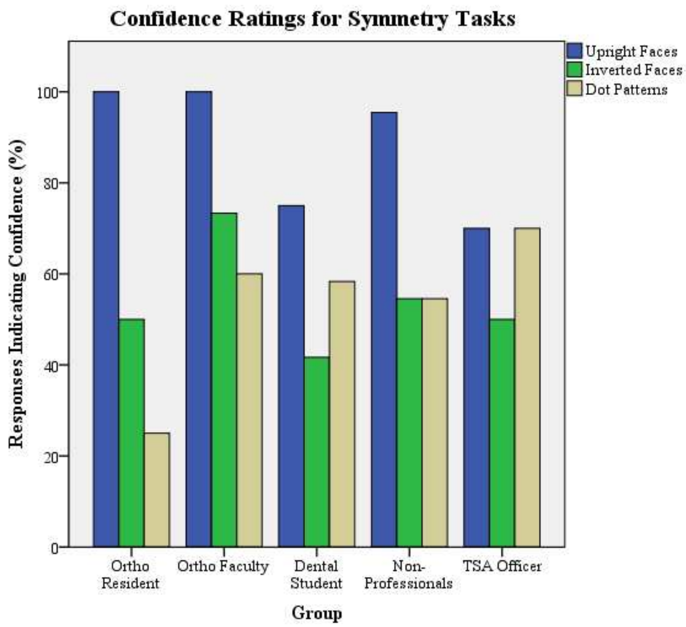
Mean accuracy scores for each symmetry task (% correct) by group. Error bars represent 95% confidence intervals.

Figure 2.3B



Mean response time for each symmetry task (seconds) by group. Error bars represent 95% confidence intervals. Note that only dot pattern tasks had a restricted presentation time of 2000ms.

Figure 2.3C



Proportion of responses indicating confidence for each symmetry task by group. Royal College of Physicians Confidence Rating Scale – Responses indicating confidence: 4) Fully confident in most cases 3) Confident in some cases; Responses not indicating confidence: 2) Satisfactory but lacking confidence 1) Not confident

3. Face Symmetry Assessment Abilities: Clinical Implications for Diagnosing Asymmetry

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3.1 INTRODUCTION

Symmetry is an important biologically-based determinant of facial attractiveness,[36] and assessment of symmetry in a patient’s face is paramount to the development of a complete dentofacial diagnosis. In an era of modern orthodontics when the soft-tissue paradigm and patient perception often dictate the success of treatment outcomes, it is not acceptable for the orthodontist to simply identify problems and proceed with treatment.[1] An understanding of individual differences in perception of face symmetry across orthodontists, their patients, and other providers of dental care is needed to facilitate communication among these groups and to ensure optimal treatment results. To these ends, recent research has attempted to establish thresholds for the perception of a problem in face symmetry in different professional and non-professional groups.

Huisinga-Fischer and co-workers asked participants to objectively compare asymmetry between different individuals’ faces.[18] Their results suggest that orthodontists and surgeons might judge facial symmetry more accurately than other groups but leave room for alternative explanations due to the nature of the stimuli and tasks. Specifically, the face stimuli they used had pathologic deviations from normal symmetry and from normal proportions, and the participants were asked to rate how the faces differed in terms of deformity from normal rather than in symmetry explicitly. Accordingly, the role of symmetry in the participant’s judgment was unclear. Another study related the perception of face symmetry suffers from the fact that participants rated attractiveness rather than symmetry itself.[19] Finally, a study using virtual “three-dimensional” face stimuli suggested that while thresholds for the perception of an asymmetric nose or chin exist, orthodontists and oral surgeons show no meaningful advantage in judging face symmetry when compared to laypersons.[20] It is important to note that none of these studies were designed to investigate expertise explicitly.

Of equal importance to the threshold for detection of a problem is an understanding of the orthodontist's perceptual ability in general and in relation to the patient. Are orthodontists experts at assessing face symmetry? To date, the data are equivocal at best because studies have not been adequately designed to answer that question. [18, 19, 20] If an orthodontist is better at judging face symmetry than the patient, then he or she may confidently help the patient decide if treatment is warranted. If the orthodontist is not better at assessing face symmetry, then treatment outcomes as viewed by the patient may not meet their goals. With the availability of three-dimensional imaging of facial surfaces, which allows for the exact quantification of facial symmetry,[37, 38] understanding perceptual differences actually may become increasingly relevant. If an orthodontist understands his or her abilities in relation to the patient, he or she may better be able to determine when the use of such technology is needed to assist in diagnosis.

The aims of this study were to determine if orthodontists posses expertise in assessing face symmetry and to explore the nature of this ability with the hope of informing clinical practice and patient communication. To accomplish these goals, we compared performance on symmetry judgment tasks across orthodontists, general dentists, and control participants with no training in face symmetry assessment.

3.2 MATERIALS AND METHODS

Participants

This study was considered exempt from IRB review by the Office of Human Research Ethics at the University of North Carolina at Chapel Hill and approved as an addition to a separate ongoing study by the Institutional Review Board of Duke University. Orthodontists (n=31, 8 female, mean age=43.5 years, SD=15.8) were recruited from the University of North Carolina at Chapel Hill School of Dentistry (UNC) and included residents in various stages of the three-year program as well as full and part-time faculty members. The faculty participants reported an average of 27.4 years of clinical practice (SD=12.45). General dentists were also recruited from the UNC School of Dentistry and included residents and faculty members (n=12, 3 female, mean age=53.1 years, SD=13.2). Orthodontic residents, orthodontic faculty, and general dentists were all compensated $10/hour for their time.

Control participants without symmetry training were recruited from two sources: non-professional laypersons from the Duke University community (non-professionals) and TSA officers employed at Raleigh-Durham International Airport. Non-professionals represent a population of laypersons without any known special visual skills. Non-professionals (n=23, 13 female age=20.87 years, SD=4.5) were compensated with course credit or paid $10/hour for their participation. TSA officers represent a population that is known to have enhanced visual cognition abilities unrelated to face symmetry assessment. [21] The TSA officers (n=10, 2 female, age=42.33 years, SD=10.20) were not directly compensated as their data were collected during normal working hours as part of their employment. Participation in this study by the TSA officers was entirely confidential and voluntary.[21] Two additional participants in the TSA group and one in the non-professional group had overall face accuracy scores that fell two standard deviations below the mean overall face accuracy score for all participants, and their data were excluded from all analyses. All participants confirmed 20/20 vision or the use of corrective lenses at the time of data collection.

Apparatus

Data were acquired in three separate locations using identical protocols and environments: orthodontic resident, orthodontic faculty, and general dentist data were collected at the UNC School of Dentistry, Duke student data were collected at Duke University in the Visual Cognition Laboratory, and TSA officer data were collected at Raleigh-Durham International Airport in a private testing room. The experiment was run in a dimly lit room; participants at Duke and UNC viewed the experiments on a Dell Inspiron computer with a 20-inch CRT monitor, and participants at RDU viewed the experiments on Dell Vostro 260 computers and 23.6-inch computer displays that were adjusted so all participants were presented with stimuli of the same physical size. Participants were seated at a viewing distance of approximately 57 cm with no head restraint. Stimuli were presented and responses were recorded using MATLAB (The MathWorks, Natick, MA) using the Psychophysics Toolbox (Version 3.0.8, Brainard, 1997; Pelli, 1997; Kleiner, Brainard, & Pelli, 2007). Questionnaire data were collected using the Qualtrics Research Suite (Qualtrics Labs, Inc., 2012).

Procedures and Stimuli

All participants completed three visual cognition tasks related to symmetry and presented in a blocked design; order was counterbalanced across all participants and tasks. Each task began with a series of practice trials, which were immediately followed by the experimental segment during which trial-by-trial accuracy and response time were recorded. At the start of each trial, a fixation cross was presented for 500ms, followed by the stimulus. Participants responded to each trial with one of two possible keys, and no feedback was provided.

<u>Task 1: Symmetry assessment of upright faces</u>

Participants assessed symmetry in 96 trials of upright faces by making a two-alternative forced-choice judgment between two versions of the same face presented side by side (see Figure 3.1A). Stimuli were presented on a black background, and the participant was instructed to press the ‘z’ key if the face on the left appeared more symmetric and the ‘/’ key if the face on the right appeared more symmetric. Stimuli were presented until the participant responded. Trials were counter-balanced for each participant as to whether the right or left face was more symmetric. Stimuli consisted of black-and-white photographs of faces of sixteen (8 female) Caucasian individuals morphed to varying levels of asymmetry while preserving averaged proportions (see Rhodes, Proffit, Grady, & Sumich, 1998 for details on stimuli generation).[22] Veridical hairstyles (*i.e.* the unaltered hairstyle) were maintained for all versions of each face by editing the original stimuli set from Rhodes using Adobe® Photoshop Elements10® so that the hair could not be used as a cue to symmetry. Four versions of each face, varying in symmetry were used: the veridical (original) face, the face with perfect symmetry, the face with symmetry increased 50% from the veridical, and the face with symmetry decreased 50% from the veridical (See Figure 3.2). By pairing each face version with all the iterations of that face, six possible pairings were created (veridical with perfect symmetry, veridical with high symmetry, veridical with low symmetry, high symmetry with perfect symmetry, high symmetry with low symmetry, and low symmetry with perfect symmetry). These stimuli were presented at random in terms of both the levels of symmetry being compared and the individual’s face that was used. Participants viewed all possible pairings of each face during Task 1.

Task 2: Symmetry assessment of inverted faces

This task was identical to Task 1, but all stimuli were presented upside-down. The sequence of presentation was randomized separately from Task 1.

Task 3: Symmetry detection in dot patterns

Participants judged whether a dot pattern presented as a centered image on a black background was perfectly symmetric about its vertical axis (see Figure 3.1B). Each dot image was displayed for 2000ms, after which participants were asked to make a response using the 'z' key to indicate that the dot pattern was symmetric and the '/' key to indicate that the dot pattern was not symmetric. The 2000ms display time was used to maintain consistency with a previously used experimental protocol.[24] Stimuli were 18 dot patterns based on the body patterns of animal with bilaterally symmetric bodies (see Evans, Wenderoth, & Cheng, 2000 for details).[25] Each pattern was presented in random order in both upright and inverted conditions for a total of 36 trials.

Immediately following the completion of all visual tasks, each participant completed a web-based questionnaire that asked about demographic information, strategies employed during symmetry assessment, and subjective confidence self-ratings for the tasks completed using the Royal College of Physicians Confidence Rating Scale.[26] Orthodontists and general dentists were asked whether the patient is most often upright or inverted when they assess face symmetry clinically and about duration of training or clinical practice. Non-professionals and TSA officers were asked whether they had any training or experience in symmetry assessment.

3.3 RESULTS

Descriptive statistics for accuracy, response time, and confidence ratings for each task may be found in Table 3.1. Normality of data was confirmed using Q-Q plots and homogeneity of variance between groups was confirmed using Levenes's test. Accuracy and response times were compared among groups using one-way analysis of variance and Tukey's HSD. Within subject comparisons were made using paired t-tests or Wilcoxon signed rank tests (for confidence ratings); statistical significance was set at $p=0.05$.

Orthodontists showed a statistically significant advantage in judging face symmetry overall ($F=6.6$, $p=0.001$) and in both upright ($F=5.9$, $p=0.001$) and inverted ($F=4.8$, $p=0.004$) face conditions compared to both non-professionals and TSA officers (Tukey's HSD $p<0.05$ for all comparisons), but not compared to general dentists. General dentists did not show a significant difference in accuracy overall for assessing symmetry in faces, whether upright or inverted, when compared to non-professionals or TSA officers. In the most difficult trials (those in which the differences in symmetry between faces were smallest; *e.g.* perfect symmetry compared to high symmetry), orthodontists showed a significant advantage ($F=9.2$, $p<0.001$) over general dentists ($p=0.01$) as well as both non-professionals ($p<0.001$) and TSA officers ($p=0.002$).

There was a significant difference in response time overall ($F=7.2$, $p<0.001$), and for both upright ($F=7.9$, $p<0.001$) and inverted ($F=4.7$, $p=0.005$) faces between orthodontists and general dentists compared to non-professionals (Tukey's HSD $p<0.02$ for all comparisons), but not between orthodontists and general dentists compared to TSA officers. Non-professionals took less time to judge symmetry than orthodontists, general dentists, or TSA officers. There were no other differences in response time among any groups.

There were no statistically significant differences in accuracy or response time for dot stimuli among any of the groups.

Orthodontists showed within-subject differences in accuracy between each pair of tasks: upright vs. inverted faces ($t=3.7$, $p=0.001$), upright faces vs. dot patterns ($t=10.7$, $p<0.001$), inverted faces vs. dot patterns ($t=10.6$, $p<0.001$). General dentists also showed an advantage in accuracy for upright vs. inverted faces ($t=2.7$, $p=0.02$).

Orthodontists also demonstrated significant differences in confidence ratings for each pair of tasks: upright vs. inverted faces ($z=4.5$, $p<0.001$), upright faces vs. dot patterns ($z=4.3$, $p<0.001$), inverted faces vs. dot patterns ($z=2.5$, $p=0.01$). No other groups showed significant differences in confidence ratings for all pairs of tasks.

All but four participants in the orthodontist group (n=31) and two in the general dentist group (n=12) reported clinically assessing symmetry with the patient upright. No non-professionals or TSA officers reported training or experience in judging face symmetry.

3.4 DISCUSSION

Orthodontic Expertise

Our results indicate that orthodontists show a clear advantage in assessing face symmetry compared to laypersons, and an advantage over general dentists in the most difficult cases. One might suggest that the orthodontists' enhanced performance is the result of motivation bias; they were simply trying harder because this was an evaluation of a skill that they knew they should possess. An appraisal of response time rules out that possibility (see Figure 3.3B). Orthodontists took longer, on average, to respond when judging face symmetry than non-professionals. TSA officers took just as long as orthodontists, however, and they were significantly worse at assessing symmetry. Despite the fact that they took significantly longer to respond, the TSA officer group's accuracy matched that of the non-professionals. In short, increased response time, which is a logical indicator of motivation, does not equate to greater accuracy. Orthodontists truly appear to have an enhanced skill.

Faces as Special Visual Stimuli

It is important to note, however, that all participants, whether orthodontists, general dentists, or untrained controls, showed accuracy scores that indicate some aptitude in judging face symmetry. Even the lowest mean accuracy score of 78.4% (see Table 3.1) represents a real increase above the 50% score one might expect from random chance alone given that the face symmetry tasks all included only two possible responses. That all of our participants showed some skill may be due to the nature of faces and how humans tend to perceive them. Faces are ubiquitous visual stimuli, and behavioral and neuroimaging research has indicated that they are processed by special cognitive mechanisms in the brain which provide an advantage in perceptual abilities when it comes to looking at and evaluating faces (for a review see Kanwisher et al 2006).[5] Face symmetry also is likely to be governed by special processes which provide a perceptual advantage compared to the inspection of symmetry in non-face objects, such as dot patterns or teeth.[6, 7, 39]

Inverted Faces and Symmetry Assessment

One aspect of face symmetry processing that is of interest to orthodontists and general dentists is that the orientation of the face when symmetry is judged appears to have a significant effect. Both orthodontists and general dentists were significantly better at assessing symmetry in upright faces compared to inverted faces. This finding supports research that when a face is inverted, it is not fully processed by the usual neural pathways of the brain that provide a perceptual advantage.[7, 39, 40]It may be clinically meaningful that orthodontists and general dentists are better at judging symmetry when a face is upright. When administering dental care, the patient is often reclined, and their face is inverted. Our data support the recommendation that the patient should be upright when face symmetry is assessed in order to achieve maximum accuracy. Interestingly, all but four orthodontists and two general dentists reported that their routine clinical practice included assessment of face symmetry with the patient upright rather than inverted.

Implications for Clinical Practice

It is important to remark that the clinical setting for which our data are most applicable involves the longitudinal comparison of patient records when they are being monitored for a progressive asymmetric deformity. Our experimental design, comparing two versions of the same person's face, is most similar to the clinical activity of comparing accurate standardized photographic records taken over time for diagnostic purposes.

In an era when surface-scanning 3D technology allows the computer-assisted assessment of face symmetry and changes in it over time[41, 42] our data may also be an aid to understanding when technology such as this is needed. In a setting in which a patient's records are being compared over time, our data suggests that orthodontists will correctly identify symmetry in 87% of the cases, if the faces are viewed in an upright position using accurate photographs. So, perhaps less than 15% of these situations require the aid of additional tools, such as surface 3D superimpositions, to identify progressive aberrations in face symmetry.

Recent studies using 3D laser surface scanning estimate the overall asymmetry in normally developing child and adolescent faces to range on average from 8% - 68% with standard deviations as high as nearly 14%.[37, 38, 43, 44] Interestingly, our study used stimuli that varied the symmetry of the whole face from 50% less symmetric than the true face to perfect symmetry. Accordingly, the stimuli we used provide a reasonable representation of the range of asymmetry encountered in clinical practice, and our data give further insight to the nature of face symmetry judgment both by clinicians and laypersons.

The relative skill of all participants in our study has implications for patient communication. Providers should be aware that faces are unique visual stimuli[45] and that judging symmetry in faces is a perceptual process distinct from other tasks to evaluate dentofacial esthetics. While orthodontists are experts at face symmetry assessment, patients are likely to posses some inherent skill as well. Similarly, orthodontists are only better at judging face symmetry than general dentists in difficult cases. In our study, this difference became evident when the dissimilarity between stimuli was only a 25% change in overall face symmetry (see Figure 3.2). Orthodontists may use this evidence as a framework for understanding the perceptual abilities of both patients and colleagues with whom they communicate.

Orthodontists may also use our evidence as a basis for understanding their own abilities. Confidence ratings for symmetry tasks followed performance for this group (see Figure 3.3 A, C). That is to say that orthodontists rated themselves most confident in the tasks for which they were most accurate and least confident in the tasks where they performed the worst. An ability to accurately evaluate one's own performance is an indicator of expertise [35] and consistent with this tenet, general dentists, non-professionals, and TSA officers failed to show the same pattern. Our evidence suggests that an orthodontist's self-assessment of performance is more likely to be consistent with their actual accuracy than untrained laypersons or general dentists making the same judgment. This finding may facilitate the reconciliation of differences in face symmetry perception between patient and provider.

3.5 CONCLUSIONS

Orthodontists demonstrate robust expertise in assessing face symmetry when compared to laypersons, and expertise in only the most difficult judgments compared to general dentists.

Both orthodontists and general dentists show a significant advantage judging face symmetry with upright compared to inverted faces.

When photographic patient records are being compared over time, our data suggests that orthodontists will incorrectly identify symmetry in less than 15% of these situations.

3.6 TABLES AND FIGURES

Table 3.1

Accuracy (%correct), Response Time (sec.), and Confidence Scores for Symmetry Tasks

	Orthodontists (n=31)	**General Dentists** (n=12)	**Non-Professionals** (n=23)	**TSA Officers** (n=10)
Accuracy *mean (std. dev.)*				
All Faces	85.5 (3.8)	82.4 (5.0)	79.7 (6.7)	79.1 (6.0)
Upright Faces	87.0 (4.1)	84.8 (6.8)	80.8 (7.9)	79.8 (6.7)
Inverted Faces	84.0 (4.7)	80.0 (4.8)	78.6 (7.1)	78.4 (6.2)
Dots	63.8 (10.3)	61.6 (6.1)	65.8 (10.8)	63.9 (9.1)
Response Time *mean (std. dev.)*				
All Faces	7.5 (3.0)	8.5 (7.7)	3.3 (1.5)	7.7 (3.9)
Upright Faces	7.6 (3.3)	8.3 (6.6)	3.2 (1.6)	7.7 (4.4)
Inverted Faces	7.4 (4.2)	8.8 (9.3)	3.3 (1.5)	7.6 (4.0)
Dots	0.9 (0.40)	0.8 (0.2)	0.6 (0.3)	0.9 (0.5)
Confidence *% repsonses indicating confidence* [a]				
Upright Faces	100	91.7	91.3	70
Inverted Faces	61.3	75	52.1	50
Dots	41.9	66.7	52.1	70

[a] Royal College of Physicians Confidence Rating Scale - 4: Fully confident in most cases 3: Confident in some cases 2: Satisfactory but lacking confidence 1: Not confident (responses of 3 or 4 indicate confidence)

Figure 3.1A

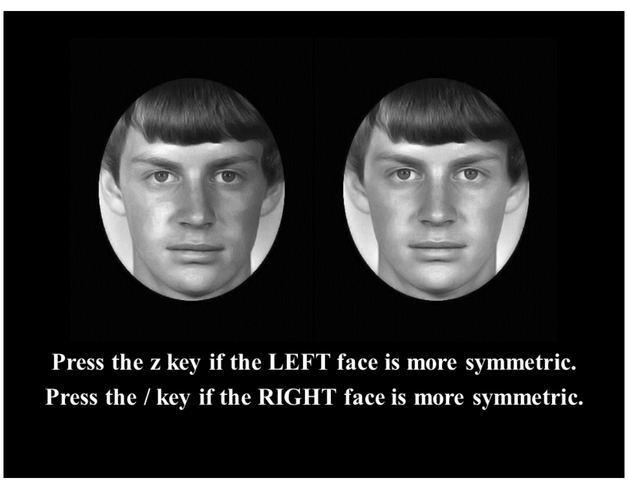
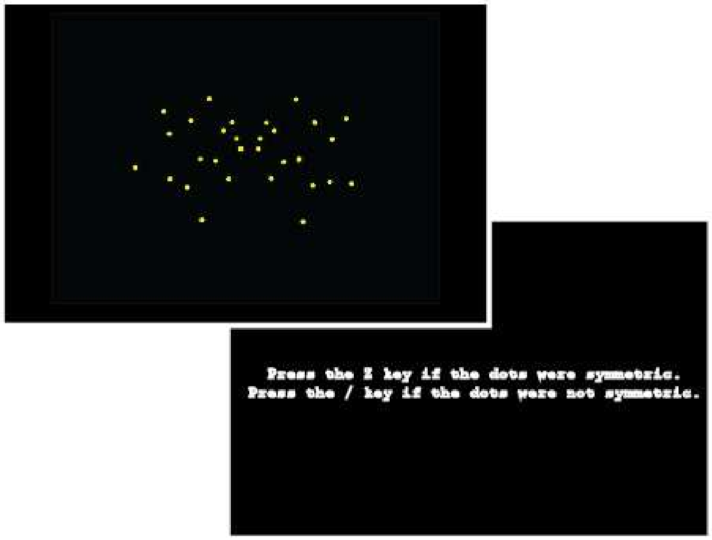
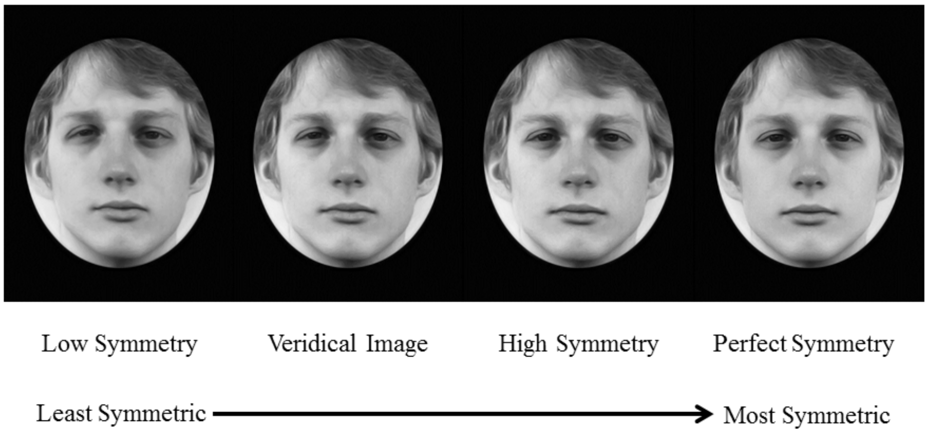


Figure 3.1B



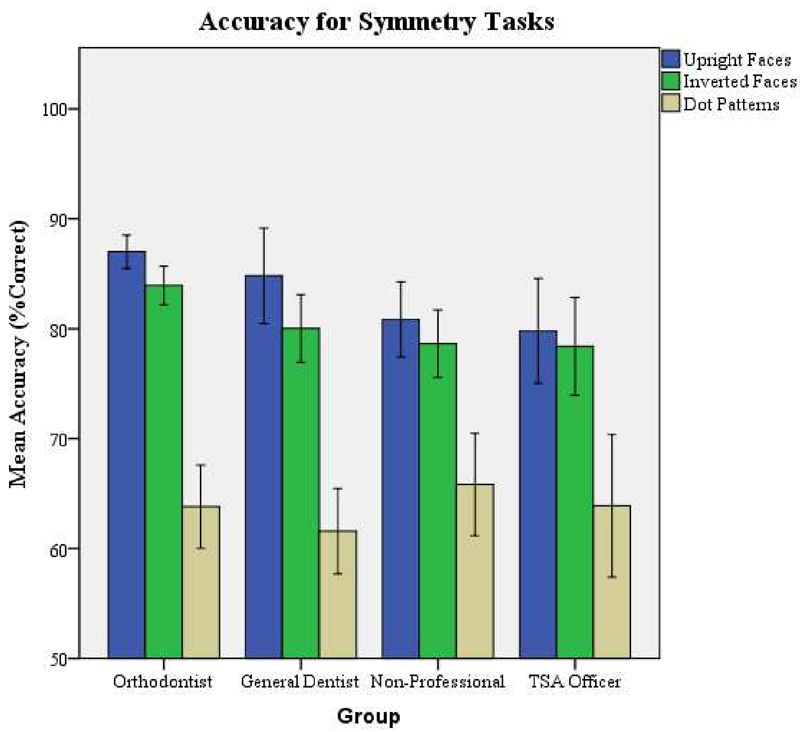
Example stimuli and instructions presented to participants for (A) Tasks 1 and 2 and (B) Task 3. The face stimuli of Tasks 1 and 2 were presented with no time constraints, whereas the dot patterns used in Task 3 were presented for 2000ms (followed by the instructions screen that remained until response).

Figure 3.2



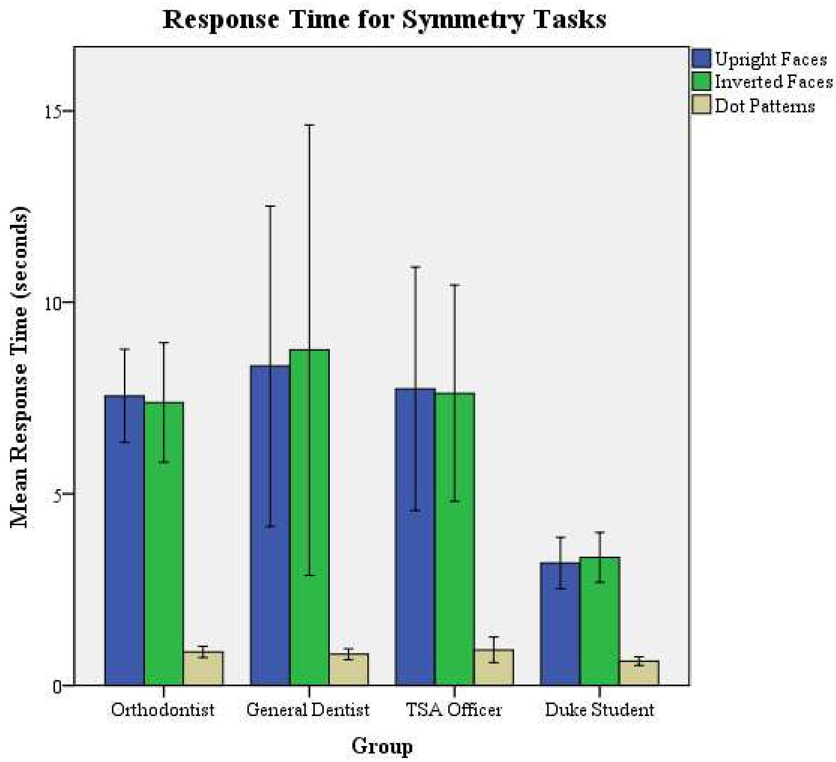
Example of face stimuli showing four morphed versions of one individual's face: the actual face (veridical), a version 50% less symmetric (low symmetry), a version 50% more symmetric (high symmetry), and a version with perfect symmetry. Note that the hairstyle for each version of the face is the identical, veridical hairstyle.

Figure 3.3A



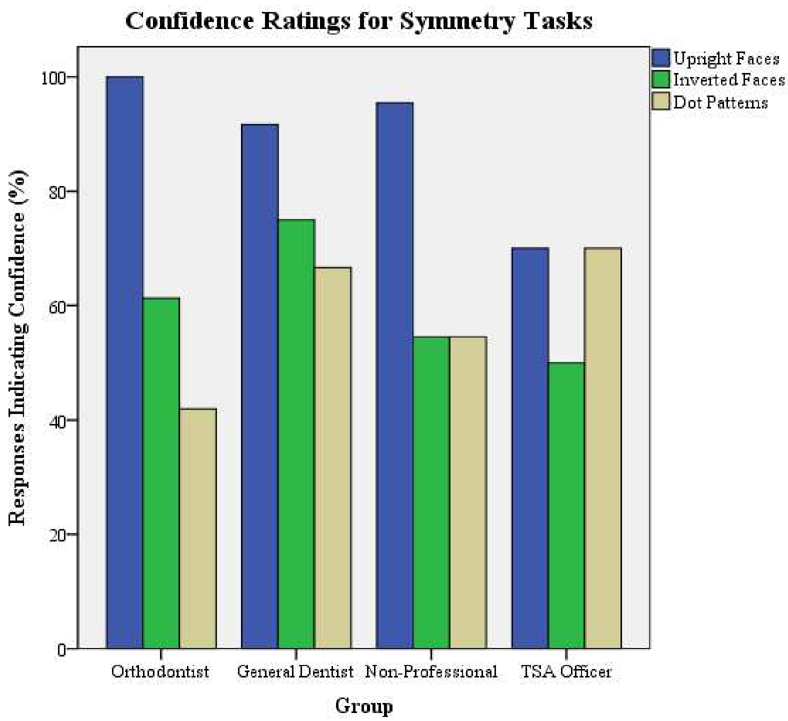
Mean accuracy scores for each symmetry task (% correct) by group. Error bars represent 95% confidence intervals.

Figure 3.3B



Mean response time for each symmetry task (seconds) by group. Error bars represent 95% confidence intervals. Note that only dot pattern tasks had a restricted presentation time of 2000ms.

Figure 3.3C



Proportion of responses indicating confidence for each symmetry task by group. Royal College of Physicians Confidence Rating Scale – Responses indicating confidence: 4) Fully confident in most cases 3) Confident in some cases; Responses not indicating confidence: 2) Satisfactory but lacking confidence 1) Not confident

4. CONCLUSION

Longitudinal data following individuals from pre-dentistry, through dental school, residency, and clinical practice is required to make definitive statements regarding the relative contributions of training, experience, and potential inherent ability to the acquisition of clinical skills. Until that data is available, clinical dental education, whether pre- or post-doctoral, should be targeted to provide more than simple repeated experiences. When considering the acquisition of a diagnostic skill, such as face symmetry assessment, the effect of testing by providing critical feedback during training may enhance learning in a meaningful way. Accurate self-assessment is one facet expertise and may be an important end-point for the evaluation of clinical skill acquisition. Incorporating these principles into clinical curricula and methodology will enhance dental education.

Orthodontists demonstrate robust expertise in assessing face symmetry when compared to laypersons, and expertise in only the most difficult judgments compared to general dentists. Both orthodontists and general dentists show a significant advantage judging face symmetry with upright compared to inverted faces. When photographic patient records are being compared over time, our data suggests that orthodontists will incorrectly identify symmetry in less than 15% of these situations.

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