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Tolerance of deviations in eye and mouth position

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Structured Abstract
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Objective – To develop and refine a technique for measuring the tolerance for deviations in facial appearance.
Design – A psychophysical method was administered using photocopies of altered facial photographs to measure tolerances for deviations in eye position and mouth angulation and judges' reaction time.
Methods – Stimulus photos were displayed as Kodachrome slides to 76 individuals grouped by their familiarity with craniofacial anomalies, i.e. dental professionals, orthodontic and craniofacial patients, also a group of normal patients.
Results – (1) Tolerance for deviation of facial appearance varies inversely with the magnitude of the physical deviations from normal; (2) tolerance varies directly as a function of assumed familiarity with deviation; (3) response and reaction time varied inversely with the tolerance for facial deviation.
Conclusion – Significant differences in tolerance and reaction time were found among the groups and depended on whether an isolated feature was judged or if the feature was judged in the context of the whole face.

Key words: asymmetries; craniofacial abnormalities; facial appearance; perception

Introduction

The purpose of this study is to estimate a range of acceptable appearances for selected facial features, particularly for craniofacial abnormalities in which features deviate from socially accepted/culturally defined norms. Individuals all have unique variations in facial features and asymmetries which may go unnoticed because the deviation is below the perceptual recognition thresholds of the self or significant others, e.g. 3–4 mm from vertical midline or 3–4 mm from horizontal (1–3), or have been minimized through the use of illusory techniques such as using cosmetics,

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growing facial hair, changing hairstyle, or minimizing by orthodontic or surgical treatment. Similarly, dental variations affect judgments of dental esthetics (4).

Unfortunately, a significant number of individuals have major facial deformities and anomalies which cannot be concealed or changed by surgical interventions. As has been noted (5), there is in fact a hierarchy among components of the total body in judging attractiveness, with the face being the most important. The mouth and eyes in turn seem to influence facial attractiveness most strongly. It is widely recognized that such judgments are not necessarily in the eyes of the beholder (5–11). Rather, features or proportions reflecting symmetry, youthfulness, averageness of facial features or, conversely, exaggeration of selected features are found attractive across several cultures (11–18). Attractive people also appear to be superior in abilities essential for survival and prosperity in an adverse society (18). For evolutionary psychobiologists, symmetry and other aspects of facial beauty may serve as cues of reproductive and survival capacity for mate selection (6,17,19).

Although patients with facial deformities may be of normal intelligence and have few other physical disabilities, aversive behavior toward them greatly hinders their social development. Studies of children's attractiveness ratings, differential treatment by teachers, and social preference (20,21) document the serious handicap that facial disfigurement can create particularly in generating negative social reactions in the form of nicknames and teasing (22).

Many studies confirm that the social difficulties surrounding those with facial anomalies do not stem solely from a simple negative reaction to facial defects. Since the phrenology days of Lombroso, Gall, and Spurzheim (23), society has imposed physiognomic judgments, associating character flaws with facial defects (24,25).

Except for a few instances (5,26,27), research on the physical bases of these preferences has tended to be qualitative and categorical (28). Little information actually exists on the precise anatomical characteristics or anthropometric measures which distinguish perception of acceptable from non-acceptable appearance among different professional and lay judges. Lucker (26) attempted to determine quantitative differences in acceptable or unacceptable facial appearance by using many conventional anteroposterior measurements of the soft tissue profile to establish norms. Giddon et al. (29) compared objective and subjective measures of facial profiles to determine how accurately subjects could simulate their own profiles. In a subsequent study, Hershon and Giddon (30) related the discrepancy between the perception of one's own profile and their actual profile to a measure of self-concept.

The improvements in plastic and reconstructive surgery and technology over the past 20 years have made it possible to bring previously untreatable facial deformities and anomalies closer to socially acceptable standards of appearance. The practical clinical question becomes how close to an idealized perception of appearance do health care providers actually have to come to maximize treatment outcome, including patient satisfaction, psychosocial well-being, and quality of life relative to cost (31). The present experiment, therefore, was designed to quantify in precise physical units the anthropometric range of acceptability of the perceived appearance in selected facial features.

Method

Rationale

In general, tolerance for deviation from normal is inversely related to the magnitude of the physical abnormality. Based on clinical experience and previous studies of patients with craniofacial deviations (32), it was hypothesized that familiarity with craniofacial deformities would result in an increased tolerance of deviation from normal. The following specific variables were manipulated in the face: the interocular distance to simulate hypotelorism and hypertelorism and the cant of the mouth and chin to simulate hemifacial microsomia.

Stimulus preparation

Standardized full frontal black and white photo of a normal 8-year-old boy and a 10-year-old girl were acquired. From these photos the eyes were cut out as a block, separated by a vertical midline cut and then systematically increased or decreased along the horizontal axis to simulate variations of hypertelorism to hypotelorism. The eyes were then taped in place and the intercanthal distance was measured using a millimeter ruler. The ratio of eye deviation was determined by dividing the distance between the eyes by the average exocanthion–endocanthion distance of the respective face. Similarly, the angulation of the mouth was varied from 90° to simulate hemifacial microsomia. These composites were photocopied, touched up to eliminate any dark or stray lines that might confuse the judge, then reproduced as Kodachrome (Kodak, Rochester, NY, USA) slides (Figs 1–4). Approximately 30 preliminary trials were obtained to establish the range of stimulus variations of the eyes and mouth which would yield a psychophysical function from 0.0 to 100% acceptability.

Respondent judges

The stimulus photos were displayed as Kodachrome slides to the 76 individuals, primarily Caucasian, who were classified into four judge groups for comparison: dental professionals (dentists, assistants and dental students) 'DP,' adolescent orthodontic patients and their parents 'O,' adolescent craniofacial patients and their parents 'CF,' normal patients (age 7 or older who presented for routine dental evaluation with no prior history of orthodontic treatment) and their parents 'N.'

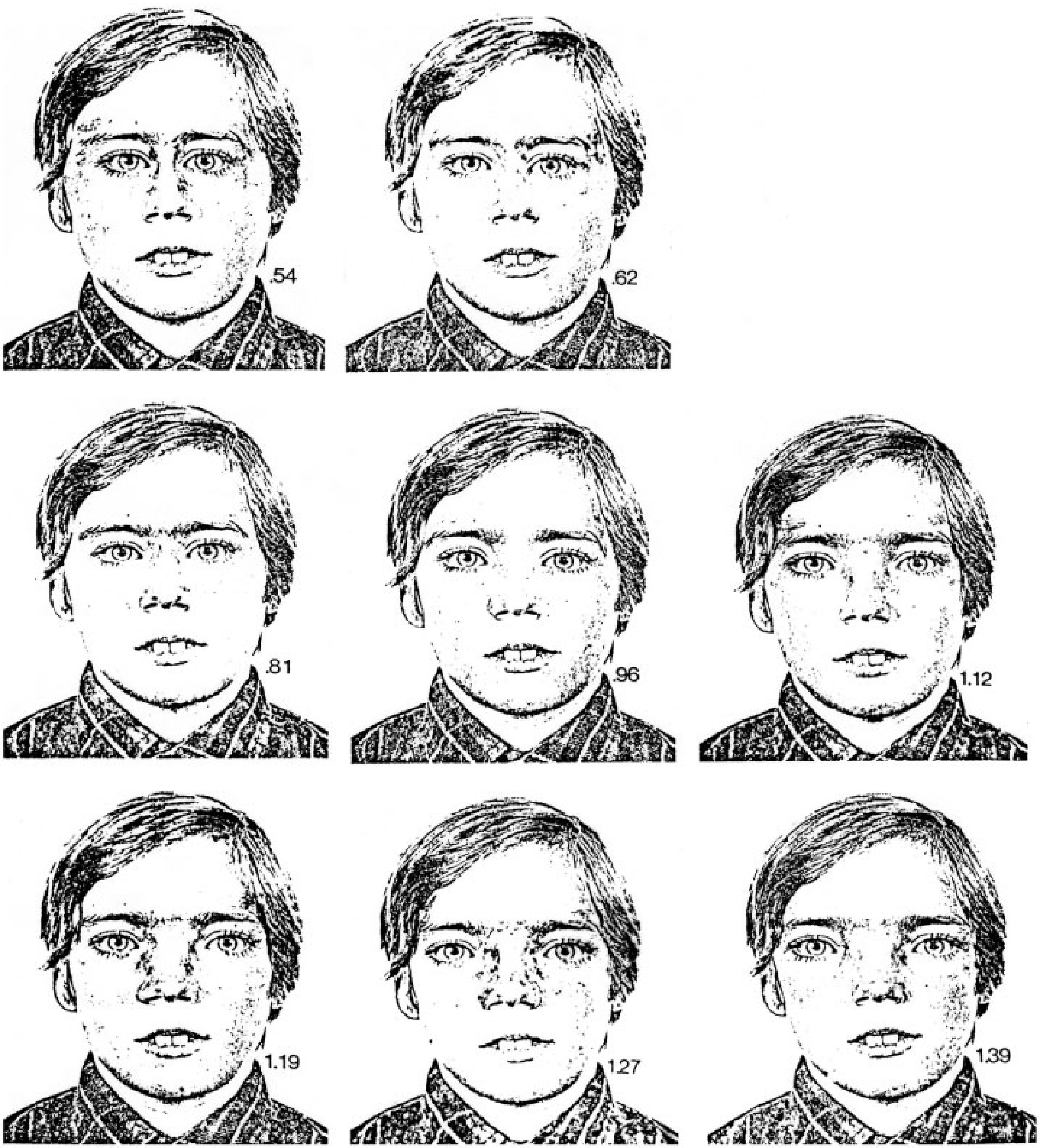

Fig. 1. Stimulus photos of boy with altered intercanthal distance.

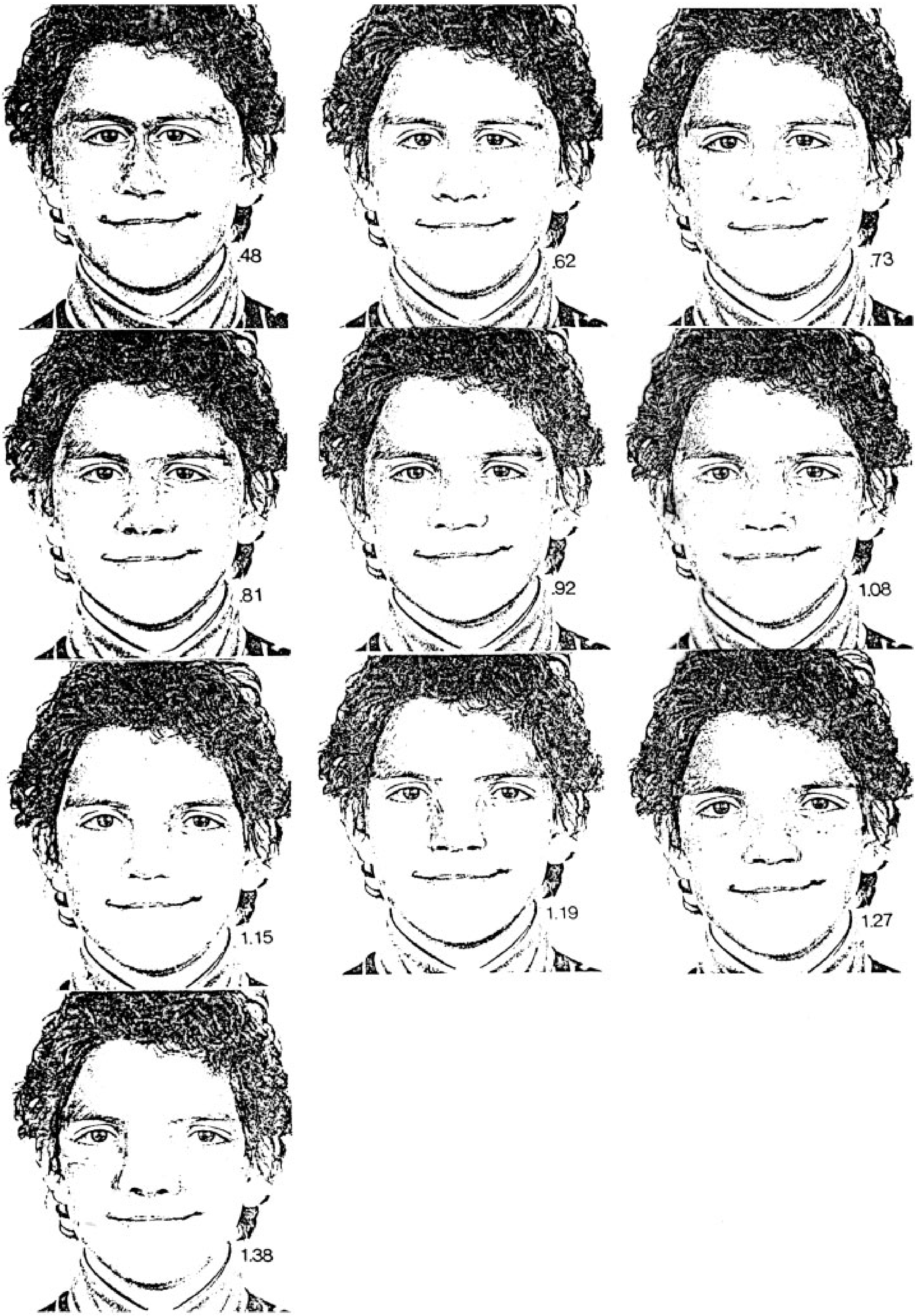

Fig. 2. Stimulus photos of girl with altered intercanthal distance.

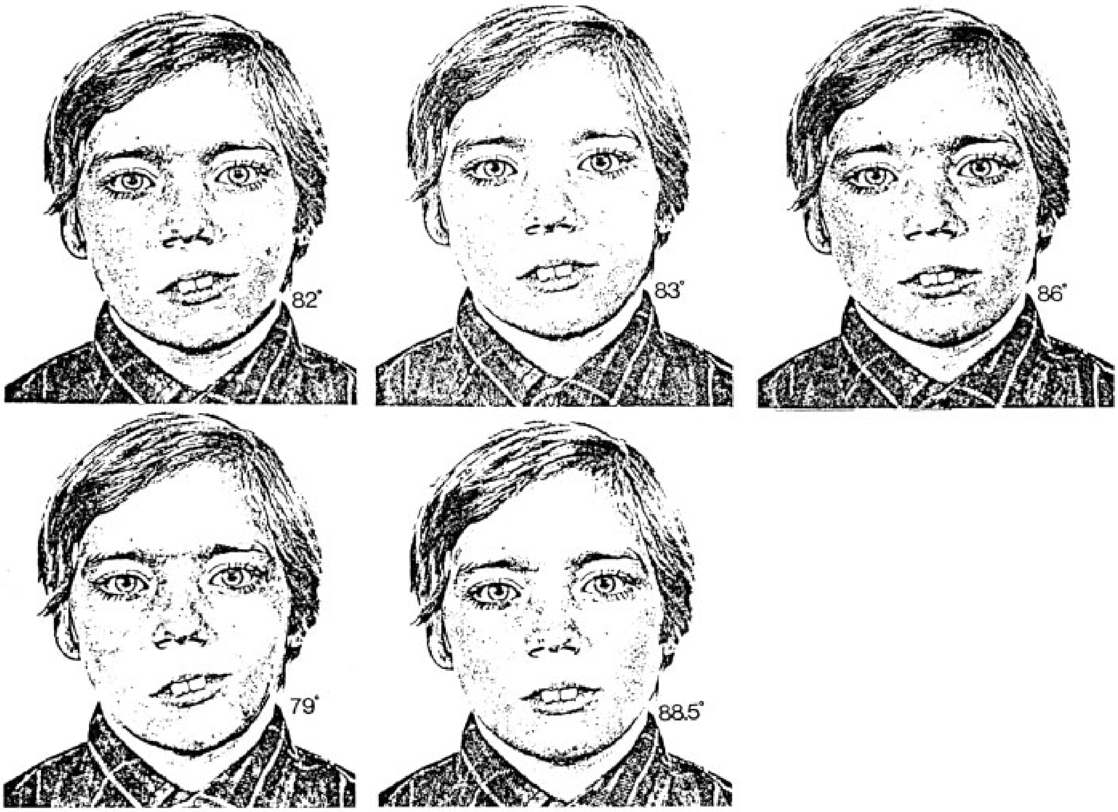

Fig. 3. Stimulus photos of boy with altered cant of mouth.

Procedure

Each judge responded to a total of 48 stimulus slides displayed in the same random sequence. Using the male and female faces, 19 slides showed variations of the eyes (E) only (10 female, nine male). Another 19 slides showed variations of the eyes embedded in the whole face WFE (10 female, nine male). Ten slides showed variations of the mouth embedded in the whole face WFM (five female, five male). The altered mouth stimuli were only displayed within the context of the full face. The slides were shown in random order, with all WFE slides being shown before the E slides. Odd numbers slides were reversed. Every subject viewed the slides in the same sequence.

The judges were instructed to focus only on the mouth and the eyes, and to ignore the eyebrows, nose, teeth, etc. They were told that there were no right or wrong answers, only to indicate whether the photo was okay or not okay, as an indicator of acceptability or non-acceptability. The terms 'okay/acceptable' and 'not okay/non-acceptable' were chosen as the outcome measure because there is little doubt about their meaning as a dichotomy for separating all positive words such as beautiful, attractive, etc. from all negative words such as ugly or unattractive (33). The judges' response time and verbal response to the stimuli were also recorded by the observer.

Statistical analysis

The primary data are the observed proportions of acceptable responses for each slide, within each group of subjects, and a given mode of presentation WFE, E and WFM. These sample proportions are used to estimate the corresponding true proportions of acceptable responses. A typical hypothesis in the present study is a homogeneity hypothesis (H) comparing the proportions among the four groups for each slide presentation.

Given the experimental results, the posterior probability (p) of the homogeneity hypothesis $p(H)$, was obtained from the Bayes factor (the ratio of average likelihoods for the hypothesis and its alternative) and the prior odds on H (34–37). In the present analyses, the prior odds were set to 1, thus indicating a 50:50 prior belief that all groups are the same. The values of $p(H)$ range from 0 to 1, with values close to 0 indicating

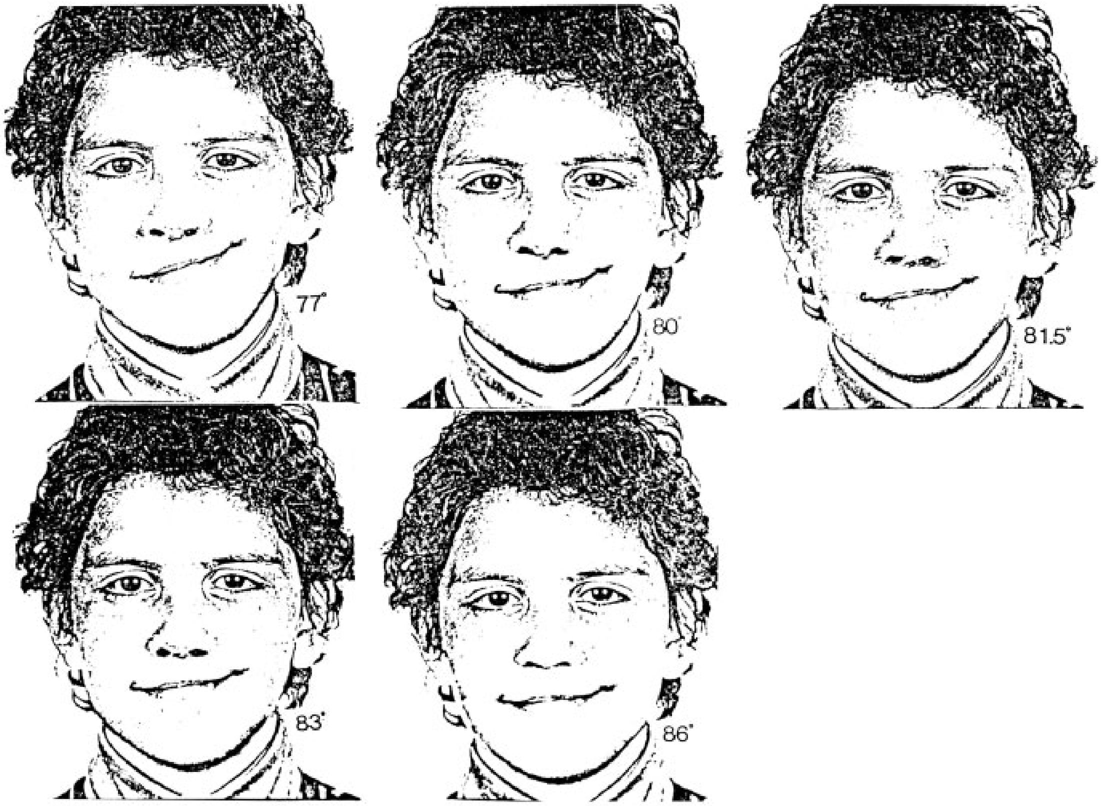

Fig. 4. Stimulus photos of girl with altered cant of mouth.

strong evidence against the hypothesis and those close to 1 indicating strong evidence for the hypothesis. There is no evidence to support or reject H when $p(H)$ is close to 0.5.

In the present study, when $p(H) > 0.8$, the proportions were judged to be homogeneous. When $0.20 \leq p(H) \leq 0.80$ there is no evidence to support or to reject the groups as homogeneous. Similarly, if $p(H) < 0.20$, the proportions are judged to be heterogeneous. The Bayes factor is particularly appropriate when one or more proportions may be very close to the extremes of the [0, 1] interval, and when the sample size is reduced.

Results

Figures 5 and 6 illustrate the estimated proportions of acceptable responses as a function of the ratio of eye deviation, for conditions WFE and E, respectively. Figure 7 illustrates the estimated proportions of acceptable responses as a function of the angulation of the mouth for the WFM condition. Each figure illustrates the responses within the groups DP, N, O and CF separately. The values (ratio, angulation) represent a series of stimuli of varying magnitudes (38).

The slopes of the lines of best fit are used to illustrate, descriptively, the psychophysical model of minimal change (39,40) in which the greater the slope the more acute the discrimination among the stimuli. Also included in these figures are the boundaries (vertical lines) within which the proportions of acceptable responses are 50% or more.

Statistical analysis of the slopes and ratios

When the eyes were varied in the context of the full face (WFE, Fig. 5), the observed proportions of acceptable responses at the unaltered ratio (0.92) for the female face were 0.63 for the DP group (n = 19), 0.82 for the N group (n = 22), 0.87 for the O group (n = 15) and 1.00 for the CF group (n = 20). Because the posterior probability of the corresponding homogeneity hypothesis is $p(H) = 0.38$, given the present data, there is no evidence to support or to reject the homogeneity hypothesis at the unaltered position. The same conclusion holds for the ratios, 1.15, 1.19 and 1.27. However, at the majority of the stimuli corresponding to

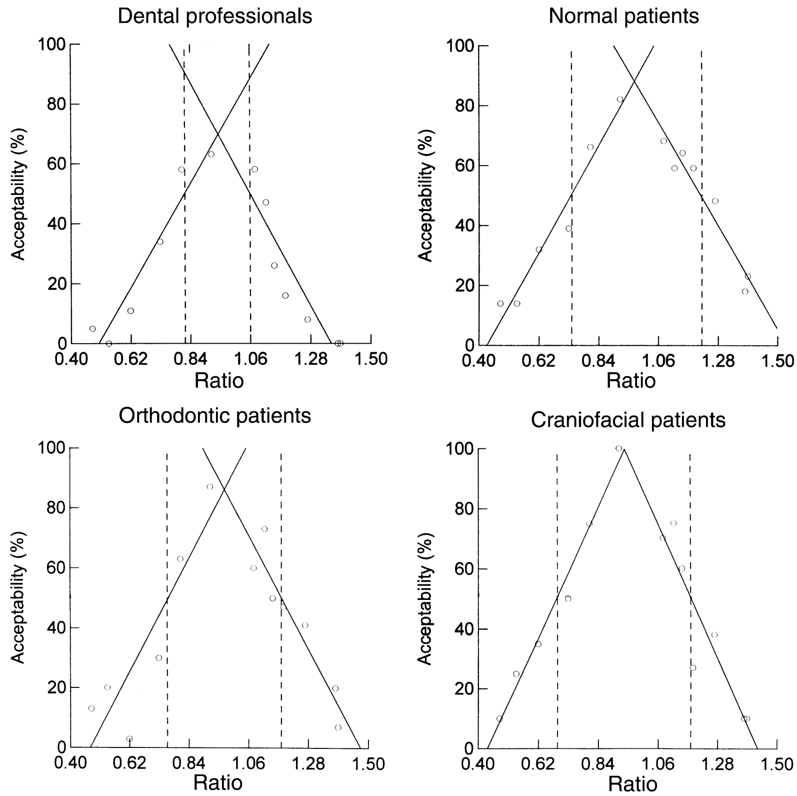

Fig. 5. Percentage of acceptability of the perceived appearance for different ratios of the childrens' eye deviations and groups of subjects when eyes were shown embedded in the whole face (WFE).

ratios that deviate from the unaltered one, namely 0.48, 0.54, 0.62, 0.73, 0.81, 1.08, 1.12, 1.38 and 1.39, it was found that $p(H) > 0.80$, thus suggesting that all four groups have the same rate of acceptable responses for these ratios. The correlations associated with the slopes estimated from the DP, N, O and CF groups were, respectively, 0.964, 0.978, 0.896, 0.990 (increasing trend) and −0.918, −0.965, −0.942, −0.923 (decreasing trend). The statistical comparison of these slopes, however, did not show a significance difference at the 0.05 level, thus indicating that the groups have an equally discriminating perception. A distinctly narrower 50% acceptability ratio range of 0.24 (indicated by the distance between the vertical dashed lines) exists for DP relative to the other groups (respectively, 0.48, 0.52 and 0.56).

For the eyes presented in isolation (E, Fig. 6), the observed proportions of acceptable responses at the unaltered ratios (0.92) for the female face were 1.00 for the DP group ($n = 19$), 0.77 for the N group ($n = 22$), 0.93 for the O group ($n = 15$) and 0.80 for the CF group ($n = 20$). For the male face (unaltered ratio 0.96) the observed proportions were 0.95, 0.91, 1.00 and 0.80, respectively. The posterior probability $p(H)$ of the homogeneity hypothesis at the unaltered ratios were 0.86 for the female face and 0.96 for the male face, thus supporting the homogeneity hypothesis among the four groups. The same conclusion holds for the ratios: 0.48, 0.62, 0.73, 0.81, 0.92, 0.96, 1.08, 1.12, 1.19 and 1.38. However at the stimulus corresponding to the ratios 0.54 and 1.15, the posterior probability was found to be <0.20, thus rejecting the hypothesis of homogeneity among the four groups at these two ratios. There was no evidence to support or to reject the homogeneity hypothesis at ratios 1.27 and 1.39, where $0.20 < p(H) < 0.80$. The correlations associated with the slopes estimated from DP, N, O and CF groups were, respectively: 0.975, 0.868, 0.975, 0.964 (increasing trend) and −0.976, −0.928, −0.990, −0.984 (decreasing trend). Similarly with the WFE condition, the statistical comparison of these slopes did not show a significance difference at the 0.05 level, thus indicating that the groups have an equally discriminating perception. The 50% acceptability ratio ranges (respectively, 0.46, 0.60, 0.54 and 0.50) were very similar among the four groups.

For the angulation of the mouth within the full face (WFM, Fig. 7), the results were similar to those obtained from the eyes embedded in the full face (WFE). In general, all four groups showed a homogen-

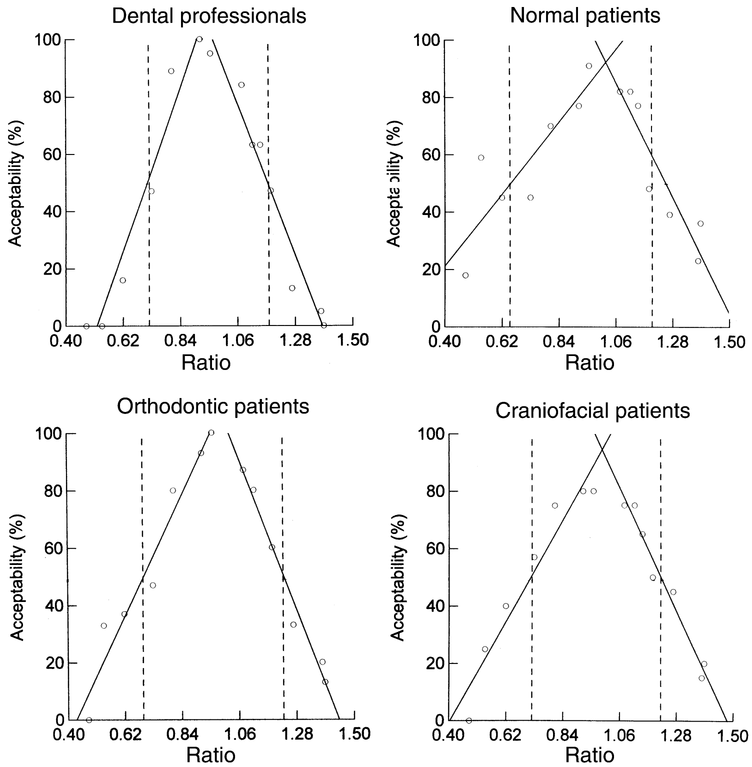

Fig. 6. Percentage of acceptability of the perceived appearance for different ratios of eye deviations and groups of subjects when the childrens' eyes were shown isolated from the whole face (E).

eous rate of acceptable responses, with $p(H) > 0.80$, across all angular mouth positions. As shown in Fig. 7, the CF group had a somewhat more acute slope than the other three groups, thus supporting a statistically significant greater sensitivity to the changes of the mouth in the full face than the other three groups DP, N and O. The slopes of these three groups were very similar one to each other. The DP group showed the least slope, indicating less ability to discriminate among changes in mouth orientation. The correlations associated with the slopes estimated from DP, N, O and CF groups were, respectively 0.880, 0.863, 0.926, and 0.880 and were statistically equivalent at the 0.05 level.

Reaction time

The WFE slides at the ratio position 0.48 (far from the unaltered position) shows a mean response time of 2.50 s and at the ratio position 0.73 (close to the unaltered position) shows a mean response time of 5.12 s. At the ratio 0.92 (unaltered face), the mean reaction time (3.56 s) in the professional group is larger than the other three groups. The WFM slides with angulations of 77° and 80° show a mean response time of only 2.30 s, while slides with angulation of 81.5° and 86° show a mean response time of 4.40 s. In these cases, it was observed that when the WFM angulations are close to the unaltered position, the reaction time becomes longer.

Discussion

A psychophysical technique was developed to quantify differences in tolerance for deviation in facial features. Different groups of judges classified on the basis of familiarity with facial deformities were found to have differing tolerances for deviations in facial features. By virtue of their education, the DPs may have learned to focus their attention on specific details such as a particular tooth within a 'normal' appearing face; for example, the orthodontic patients and/or parents may have focused on specific aspects of a malocclusion. These results concur with Faure *et al.* (41) who found that enlargement of inter-ocular distance has a negative effect on facial esthetics.

The CF group, however, had much more experience with deviation within the entire face and may not have been as preoccupied with fine details or isolated features. Another possibility is that judging the eyes outside the context of the face may be a more emotionally neutral task than evaluating the entire face.

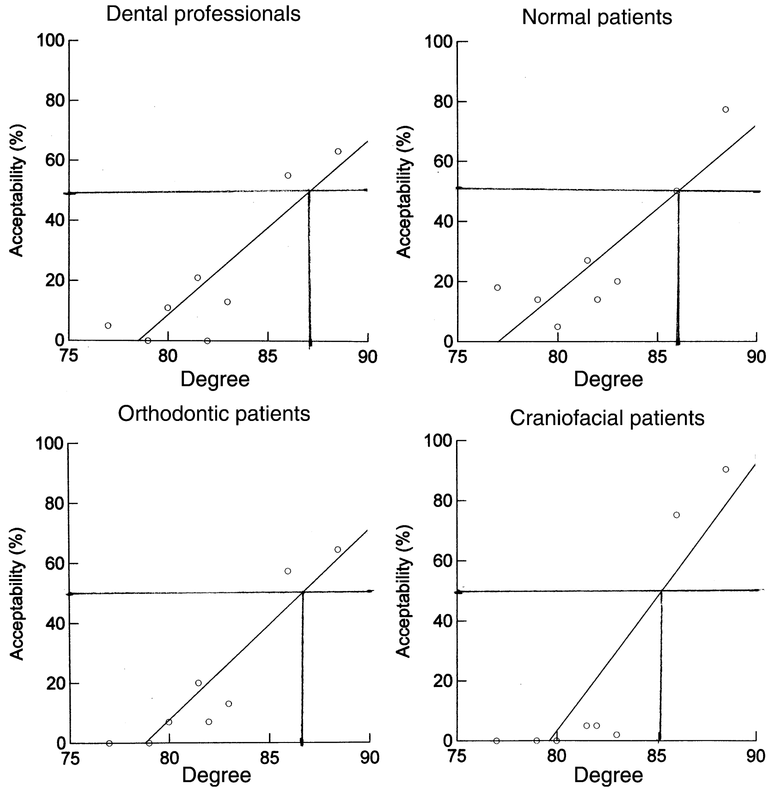

Fig. 7. Percentage of acceptability of the perceived appearance for different degrees of mouth angulation and groups of subjects when the mouth was shown embedded in the whole face (WFM).

Other explanations for observed differences may be due to unintended or uncontrolled imperfections in the facial stimulus photos; for example, hair, or perceived facial expression of emotion. Differences in age, sex, or psychosocial or economic status between the groups of judges may also have influenced the results. Other factors may also have contributed to delays in making judgments; for example, conflicts with social norms against negatively judging variations of facial features.

Although reaction or response time is a reflection of difficulty in reaching a decision, it may also be an indication of judges' conflict between preference and desire to conform to a social standard (42,43). On the other hand, a lower mean response time of the groups, for example, may be more a reflection of hasty decision making on the part of the any of the groups.

Conclusions

1. While the four groups of judges equally discriminated the distance between the eyes when viewed in the context of the full face, dental professionals had a narrow range of acceptability than the other groups.
2. When eyes were viewed in isolation, all groups were equally discriminating and had equivalent ranges of acceptability.
3. When the angulation of the mouth was judged within the full face, the craniofacial group demonstrated greater sensitivity to changes of the mouth than the other three groups.
4. Reaction time increased for distortions close to the unaltered position.

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