Population-Based Assessment of Currently Proposed Ideals of Nasal Tip Projection and Rotation in Young Women

Omar Ahmed, MD; Amrita Dhinsa; Natalie Popenko, BS; Kathryn Osann, PhD, MPH; Roger L. Crumley, MD, MBA; Brian J. Wong, MD, PhD

**IMPORTANCE** There is no universally accepted quantitative metric that defines the ideal nasal tip rotation and projection.

**OBJECTIVE** To identify the ideal nasal tip projection (NTP) and rotation by using 3 classic NTP methods (Crumley 1, Crumley 2, and Goode).

**DESIGN, SETTING, AND PARTICIPANTS** Lateral facial portraits of normal-appearing white women aged 18 to 25 years were selected from a previously validated and attractiveness-scored database of images. Each image was digitally modified to fit the NTP ideals outlined by the Crumley 1, Crumley 2, and Goode methods with columellar facial angles (rotation metric) of 96°, 101°, 106°, 111°, and 116° (15 modified images per portrait). These variants were incorporated into electronic surveys that were distributed to traditional focus-group and online social-network participants. Analysis was performed using paired comparison analysis, a consumer preference research analytic. The traditional focus-group participants were undergraduate students at the University of California, Irvine, whose online social-network contacts were also used.

**MAIN OUTCOMES AND MEASURES** Mean ranks.

**RESULTS** There were no significant differences in preference between the traditional focus-group (n = 106) and online participants (n = 3872) (P > .05). The most preferred rotation variant for all 3 NTP methods was 106° (Crumley 1: mean rank, 2.11 [95% CI, 2.07-2.16]; Crumley 2: mean rank, 2.07 [95% CI, 2.02-2.12]; and Goode: mean rank, 2.05 [95% CI, 1.99-2.11]; P < .001). Crumley 1 was considered to be the most attractive NTP method (mean rank, 1.84 [95% CI, 1.82-1.85]; P < .001) overall and was the most preferred NTP method for faces of above-average attractiveness (mean rank, 1.78 [95% CI, 1.76-1.80]; P < .001). No significantly preferred NTP method was found for faces of average attractiveness (P > .05). The most aesthetic combination of tip rotation and projection was a columellar facial angle of 106° with the Crumley 1 tip projection.

**CONCLUSIONS AND RELEVANCE** To our knowledge, this is the first population-based study to attempt to simultaneously determine the ideal NTP and rotation. Each classic NTP method uses measurements dependent on both projection and rotation; thus, ideal rotation for each NTP method must be determined before comparison of the ideals. A rotation of 106° (columellar facial angle) was found to be the most aesthetic. The Crumley 1 method was determined to be the most attractive nasal tip variant overall.

**LEVEL OF EVIDENCE** NA.
Rhinoplasty is among the most technically challenging of aesthetic surgical procedures, requiring meticulous preoperative planning and facial analysis. Nasal attractiveness is evaluated in terms of geometry and architecture but is also dependent to some degree on cultural context and generational standards for beauty. Attempts to objectively capture ideal nasal tip projection (NTP) have been elusive and ongoing for decades without any clear aesthetic standard identified.

Quantifying aesthetic factors for NTP started with Baum's method of assessment, which entails a vertical line made from the nasion intersecting a perpendicular horizontal line emanating from the tip-defining point. These 2 lines join at the alar crease, creating a 2:1 ratio of the vertical line to the horizontal line. In 1984, Powell and Humphreys described a method using Baum's landmarks of the nasion and nasal tip, but they extended the vertical line from the nasion to the vertex of the nasolabial angle to create a 2.8:1 ratio of the vertical line to the horizontal line. The simplest method was developed by Simons in 1982, who proposed that the nose's basal length should be equal to the length of the upper lip. Unfortunately, this method has received criticism because the proposed 1:1 ideal seems to underestimate the length from the subnasal to the nasal tip. Goode developed what is currently the most commonly applied and known method, which uses a triangle with the nasion and tip-defining point as landmarks that join at a 90° angle at the alar crease. In 1988, Crumley and Lanser proposed 2 additional methods (Crumley 1 and Crumley 2) to account for shortcomings that they perceived in the previously established techniques. The methods of Crumley and Lanser were unique because they incorporated the upper lip and chin, structures that affect the appearance of the nasal profile, thereby not limiting assessment to nasal substructures. Peer-reviewed, evidenced-based literature on the subject of nasal aesthetics is sparse. As such, although the use of ratios may not always translate into a clinically useful guideline for every patient, they may serve as a valuable clinical heuristic and starting point for analysis and currently represent the objective approach to gauge nasal attractiveness.

In the present study, we chose to examine the Crumley 1, Crumley 2, and Goode methods as they are rigorously defined, reproducible, and widely cited. In a previous study, facial attractiveness was shown to decrease as ratios deviated from the ideals proposed by these methods, whereas the inverse was true for the ideals proposed by Baum, Powell and Humphreys, and Simons. Furthermore, the most attractive faces had average NTP ratios similar to the ideal ratios proposed by Goode and Crumley and Lanser, and the most unattractive faces had NTP ratios closer to the Baum and Powell and Humphreys ideal ratios.

Many studies have examined the major proposed methods (Baum, Powell and Humphreys, Goode, Simons, and Crumley and Lanser) for assessing NTP; however, none has explicitly recognized that rotation and projection are mathematically dependent on one another. This makes comparing NTP ideals challenging, because a particular nose could be modified to fit many different combinations of rotation and projection while adhering to the same numerical NTP ratio. Thus, it is important to first identify either the most aesthetic rotation for a given NTP ideal or the most aesthetic NTP for a given rotation variant before attempting to compare NTP ideals or rotation variants, respectively. In addition, some studies that have attempted to identify ideal rotation have used the traditional nasolabial angle metric, a method prone to the highly variable anatomy of the upper lip (ie, premaxillary fullness or deficiency, protuberant incisors, tension nose).

To our knowledge, the present study is the first to identify both an ideal NTP and nasal tip rotation using a population-based method that involves online social-network volunteers, a method validated in previous work. In the present study we also used a novel method for assessing facial attractiveness that is an established business and marketing analytic (paired comparison analysis). This method allows the researcher to convert subjective pairwise comparisons into relative quality scores or preference ranks.

The objectives of this study were 2-fold: (1) determine the ideal rotation for each of 3 NTP methods (Crumley, Crumley 2, and Goode) and (2) use this information to make optimized comparisons of the 3 NTP ideals to determine which is the most aesthetic. Because the perception of beauty is multifactorial, being affected by culture, sex, and age, our objectives were carried out using digital portraits of young (aged 18-25 years) white women, with raters drawn from a similar age cohort. This population is the most heavily studied in the rhinoplasty literature.

### Methods

#### Image Database and Selection

The facial images used in this study were synthetic derivations of actual digital photographs from a database of 300 white female volunteers aged 18 to 25 years without any overt craniofacial abnormalities. The women were recruited at our institution, and the photographs were used with the approval of the institutional review board at the University of California, Irvine. Informed consent was not obtained because actual images were not used and there was no financial compensation. This database of images has been used in previous studies. The synthetic images are 50:50 composites, each derived from 2 actual lateral facial photographs. Using actual patient photographs would have required extensive written informed consent, likely deterring accrual of the sample.

To standardize features of the facial profile other than NTP and rotation, we used the following literature-proposed aesthetic norms as inclusion criteria: nasomental angle between 120° and 132°, nasion position between the supratarsal fold and upper eyelash line, distance from the long axis of the nostril to the alar and columellar rims between 1 and 2 mm, and an approximately 1:2 ratio of the upper lip to the lower lip and chin. From the database of 300 synthetic images, 6 images were selected. Three were previously rated as being above average in terms of attractiveness (mean score, >1 SD from the mean attractiveness score of the entire database), and 3 that were designated as average in terms of attractiveness (mean score, ±1 SD from the mean attractiveness score of the entire database). Images were dichotomized by attractiveness to investigate the effect of attractiveness on NTP and rotation preference.
Survey Design
Two main survey instruments were developed, with the second survey’s design contingent on the results of the first. Surveys were designed (Qualtrics, version 37,892; Qualtrics Laboratories Inc) incorporating the principles of paired comparison analysis.13 This method of analysis allows for conversion of the results of subjective pairwise comparisons into relative quality scores or preference ranks for each option. The conversion is accomplished by using a series of side-by-side comparisons of all unique pairing combinations for a set of choices and then calculating a quality score for each item based on the comparison results. The number of unique pairs is found using the formula $k(k - 1)/2$, with $k$ indicating the number of objects to be compared.19 Rankings are assigned to items based on tabulating the number of times a particular item or variant is selected over other items within a comparison set. In the present study, variants were ranked 1 to 5, with 1 representing the variant selected most often over the others. In the event of ties, the mean of the ranks among the options was determined.

Each of the 6 facial portraits used in the present study was morphed to fit the 3 NTP methods examined here across 5 rotation (columellar facial angle [CFA]) variants, resulting in a total of 15 unique images per face. Using paired comparison analysis, the 5 rotation variants for each NTP method for each face provided a total of 10 unique pairing combinations (Figure 1A) resulting in a total of 30 unique side-by-side comparisons for each face and a total of 180 side-by-side comparisons for all 6 faces. This is an impractically large data set for any single participant to evaluate given attention span limitations and practical time constraints; hence, a statistical sampling method was used, as described below.

The first survey (phase 1) aimed to identify the most preferred rotation variant for each NTP method. This survey was composed of 14 unique, randomly assigned subsurveys. Each subsurvey included 20 or 30 side-by-side comparisons (2 or 3 sets of 10 side-by-side comparisons) rather than the daunting 180 side-by-side comparisons that would otherwise be required to acquire data for all 6 faces. Subsurveys were created to reduce the number of image pairs that each participant would have to evaluate, shorten the survey time, and thus improve the quality of the data and accrual of the participants. With the exception of 2 subsurveys, each contained 2 sets of 10 side-by-side comparisons, with each set consisting only of rotation variants for the same NTP method and for the same face. Of the 14 subsurveys, 3 had 10 side-by-side comparisons shared by other subsurvey versions to assess interrater reliability, and 2 subsurveys had 30 side-by-side comparisons using sets from all 3 NTP methods for the same face. The remaining 9 surveys had 20 side-by-side comparisons, with each set of 10 comparisons belonging to different faces. The different subsurvey versions are depicted in Figure 2A.

The second survey (phase 2) compared only the most attractive rotation variants identified in the phase 1 survey for each NTP method with other NTP methods for a given face (Figure 2B). With 3 unique pairing combinations for each face, only 18 side-by-side comparisons were needed to acquire data for all 6 faces. As such, only 1 survey version was necessary. For all surveys, side-by-side comparisons were presented to the participant (Figure 1B).

For all surveys, both traditional focus-group and online participants were used. We requested that any participants taking the survey be between the ages of 18 and 25 years. Traditional focus-group participants were undergraduate students recruited at our institution and were given credit toward classes for their participation. Surveys were administered in a supervised untimed setting. After completion of the survey, participants were instructed to invite their contacts on the social-network website Facebook (Facebook Inc) to also complete the survey using a standardized invitation. Duplicate survey responses that were sent from the same internet protocol address and incomplete surveys were eliminated by the survey program.

For each survey, the following demographic data were collected: age, sex, race/ethnicity (African American, Asian/Pacific Islander, Arabic/Middle Eastern, white, Hispanic, or Native American), and participant type (traditional focus group or online social network).

Nasal Tip Morphing
Nasal tip morphing was performed using the free transform feature in Adobe Photoshop CS5 (Adobe Systems Inc), and facial measurements were made using VistaMetric, version 1.38 (Skillcrest LLC). Tip rotation was assessed with CFA, a proposed rotation metric that uses an objective vertical reference line rather than the highly variable slope of the upper lip used by the traditional nasolabial angle metric.7

Tip rotation was manipulated to fit the 3 NTP methods examined according to their individual specifications (Figure 3). To ensure that nasal features other than rotation and projection remained static between morphs with use of an objective system, the following features were maintained between morphs: supratip angle (±2°), distance from the long axis of the nostril to the alar and columellar rims, and location of the nasion and subnasale.

Statistical Analysis
Data analysis was performed using PASW Statistics, release version 20.0 (SPSS Inc). Rank data collected from both surveys required use of the nonparametric Friedman test to examine for significant differences. Confidence intervals for mean rank data were also calculated. The $\chi^2$ and Mann-Whitney tests were used to examine demographic data.

Data from 1 of 6 faces were excluded because they differed greatly from those of the other faces. This was likely the result of ethnic-appearing features of the face that were not typical of white women, whereas all other faces used in the study lacked such features.

Results
Phase 1 Survey: Determining Ideal Rotation for Each NTP Method
Surveys were completed fully by 2156 study participants. Table 1 describes the sex, race/ethnicity, and age of the participants.

Rank data for all faces were consolidated to determine which rotation variant was most aesthetic for each NTP method (Table 2). For all 3 NTP methods, the CFA 106 variant was the
Facial attractiveness significantly affected the degree to which the CFA 106 variant was preferred; however, it had no effect on which rotation variant was the most preferred (Table 2). Across all 3 NTP methods, the CFA 106 variant was significantly more preferred in faces of above-average attractiveness.

Differences in participant demographics (age, race, and sex) had no significant effect on which rotation variant was most preferred; however, one significant effect was noted on the degree of preference of the CFA 106 variant. This was found in the Crumley 1 method, for which the CFA 106 variant was significantly more preferred by participants aged 18 to 25 years compared with those older than 25 years ($P = .001$).

Analysis by racial profile across all 3 NTP methods yielded some instances in which overlapping CIs with the most-preferred CFA 106 variant and the next most-preferred variant were present. In 2 instances the CFA 101 variant was more preferred than the CFA 106 variant; however, the CIs were overlapping (Table 2).

**Phase 2 Survey: Optimized Comparison of NTP Methods**

Surveys were completed fully by 1822 study participants. Similar to the sample in the first survey, most participants were...
female (66.0%), the largest race represented was Asian/Pacific Islander (49.3%), and the median age was 20 years. The only significant difference in demographics between the participants in the 2 surveys was race distribution (P < .001); sex, age, and participant type were similar (Table 1).

Rank data for all faces were consolidated to determine which rotation-optimized NTP ideal was considered the most aesthetic (Table 3). A comparison of only the most aesthetic rotation variants for each NTP method demonstrated that the Crumley 1 ideal was significantly most preferred (P < .001), with
Table 1. Demographics of Survey Participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Survey, No. (%)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>2156</td>
<td>1822</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>727 (33.7)</td>
<td>619 (34.0)</td>
</tr>
<tr>
<td>Female</td>
<td>1429 (66.3)</td>
<td>1201 (66.0)</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>46 (2.1)</td>
<td>30 (1.6)</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>1060 (49.2)</td>
<td>899 (49.3)</td>
</tr>
<tr>
<td>Arabic/Middle Eastern</td>
<td>60 (2.8)</td>
<td>67 (3.7)</td>
</tr>
<tr>
<td>White</td>
<td>452 (21.0)</td>
<td>525 (28.8)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>521 (24.2)</td>
<td>292 (16.0)</td>
</tr>
<tr>
<td>Native American</td>
<td>17 (0.8)</td>
<td>9 (0.5)</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-25</td>
<td>2105 (97.6)</td>
<td>1773 (97.3)</td>
</tr>
<tr>
<td>≥25</td>
<td>51 (2.4)</td>
<td>49 (2.7)</td>
</tr>
<tr>
<td>Participant type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online social network</td>
<td>2100 (97.4)</td>
<td>1772 (97.3)</td>
</tr>
<tr>
<td>Traditional focus group</td>
<td>56 (2.6)</td>
<td>50 (2.7)</td>
</tr>
</tbody>
</table>

* The χ² test was used to calculate P values. Incomplete surveys excluded. Data from 1 of 6 faces (face 5 in Figure 2) were excluded.

Table 2. Phase 1 Survey: Mean Ranks of Rotation Variants Across NTP Methods

<table>
<thead>
<tr>
<th>NTP Method</th>
<th>CFA 96</th>
<th>CFA 101</th>
<th>CFA 106</th>
<th>CFA 111</th>
<th>CFA 116</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crumley 1</td>
<td>3.72 (3.67-3.78)</td>
<td>2.46 (2.40-2.51)</td>
<td>2.11 (2.07-2.16)</td>
<td>2.59 (2.54-2.64)</td>
<td>4.12 (4.05-4.18)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Crumley 2</td>
<td>3.62 (3.55-3.70)</td>
<td>2.26 (2.19-2.33)</td>
<td>2.07 (2.02-2.12)</td>
<td>2.86 (2.79-2.93)</td>
<td>4.19 (4.11-4.26)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Goode</td>
<td>4.23 (4.17-4.29)</td>
<td>2.54 (2.47-2.61)</td>
<td>2.05 (1.99-2.11)</td>
<td>2.46 (2.40-2.53)</td>
<td>3.71 (3.62-3.80)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Most Preferred Rotation Variant, CFA 106

<table>
<thead>
<tr>
<th>NTP Method</th>
<th>Crumley 1</th>
<th>P Value</th>
<th>Crumley 2</th>
<th>P Value</th>
<th>Goode</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above average</td>
<td>2.02 (1.97-2.08)</td>
<td>&lt;.001</td>
<td>1.99 (1.92-2.06)</td>
<td>&lt;.001</td>
<td>1.99 (1.91-2.07)</td>
<td>.20</td>
</tr>
<tr>
<td>Average</td>
<td>2.28 (2.20-2.36)</td>
<td>.22</td>
<td>2.15 (2.06-2.25)</td>
<td>.06</td>
<td>2.11 (2.00-2.22)</td>
<td>.31</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2.15 (2.07-2.22)</td>
<td>.53</td>
<td>2.15 (2.06-2.25)</td>
<td>.47</td>
<td>2.10 (1.97-2.25)</td>
<td>.34</td>
</tr>
<tr>
<td>Female</td>
<td>2.09 (2.04-2.15)</td>
<td>.01</td>
<td>2.03 (1.96-2.09)</td>
<td>.75</td>
<td>1.89 (1.61-2.19)</td>
<td>.38</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>2.12 (1.77-2.46)</td>
<td>.05</td>
<td>2.09 (1.74-2.43)</td>
<td>.05</td>
<td>2.00 (1.48-2.52)</td>
<td>.05</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>2.12 (2.05-2.18)</td>
<td>.05</td>
<td>2.12 (2.04-2.20)</td>
<td>.05</td>
<td>2.07 (1.98-2.15)</td>
<td>.05</td>
</tr>
<tr>
<td>Arabic/Middle Eastern</td>
<td>2.10 (1.86-2.35)</td>
<td>.05</td>
<td>1.80 (1.48-2.12)</td>
<td>.05</td>
<td>1.88 (1.60-2.15)</td>
<td>.05</td>
</tr>
<tr>
<td>White</td>
<td>2.03 (1.93-2.11)</td>
<td>.05</td>
<td>1.99 (1.89-2.09)</td>
<td>.05</td>
<td>1.94 (1.83-2.10)</td>
<td>.05</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2.17 (2.07-2.26)</td>
<td>.05</td>
<td>2.07 (1.97-2.18)</td>
<td>.05</td>
<td>2.14 (2.02-2.25)</td>
<td>.05</td>
</tr>
<tr>
<td>Native American</td>
<td>2.04 (1.61-2.47)</td>
<td>.05</td>
<td>2.00 (1.19-2.81)</td>
<td>.05</td>
<td>2.10 (0.68-3.52)</td>
<td>.05</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-25</td>
<td>2.10 (2.06-2.15)</td>
<td>.01</td>
<td>2.07 (2.02-2.13)</td>
<td>.75</td>
<td>2.05 (2.00-2.21)</td>
<td>.38</td>
</tr>
<tr>
<td>≥25</td>
<td>2.59 (2.32-2.86)</td>
<td>.01</td>
<td>1.97 (1.61-2.34)</td>
<td>.01</td>
<td>1.89 (1.50-2.27)</td>
<td>.01</td>
</tr>
</tbody>
</table>

Abbreviations: CFA, columellar facial angle; NTP, nasal tip projection.

* The Friedmann test was used to calculate the P value of the difference between rotation variants; the Mann-Whitney test was used for analysis of attractiveness, sex, and age categories; and the Kruskal-Wallis H test was used for analysis of race. Data from incomplete surveys were excluded. Data from 1 of 6 faces were excluded (face 5 in Figure 2). The rank of 1 indicates most attractive and 5 indicates least attractive.

a mean of 1.84 (95% CI, 1.82-1.85). The Goode ideal had the second lowest mean rank at 1.99 (1.97-2.01), and the Crumley 2 ideal had the highest mean rank at 2.17 (2.16-2.19).

Analysis of any effect of participant demographics and facial attractiveness on NTP preference or degree of preference for each NTP ideal revealed that facial attractiveness had a sig-
significant effect on the degree of preference for each NTP ideal and the NTP ideal most preferred (Table 3). In faces of above-average attractiveness, Crumley 1 was significantly most preferred with a mean rank of 1.78 (95% CI, 1.76-1.80). In faces of average attractiveness, no single NTP ideal was preferred; the Crumley 1 and Goode ideals had closely overlapping CIs. Furthermore, within each NTP ideal, the degree of preference was significantly different based on attractiveness (P < .001).

Sex had an insignificant effect on the NTP ideal identified to be most aesthetic but an effect approaching significance on the degree of preference for each NTP ideal. Race/ethnicity had no significant effect on NTP ideal identified to be most aesthetic; however, in terms of degree of preference, sex/ethnicity had an effect approaching significance on the NTP ideal most preferred. Sex and age categories; and the Kruskal-Wallis H test was used for analysis of race. Data from incomplete surveys were excluded. Data from 1 of 6 faces were excluded (face 5 in Figure 2). The rank of 1 indicates most attractive and 5 indicates least attractive.

### Discussion

Throughout history, artists and scholars have been engrossed in the pursuit of capturing what constitutes beauty. Dating back to ancient Egypt, artists idealized facial proportions in their works. The Greeks formalized aesthetics into a discipline of study, embodied by artists such as sculptor Polycleitus who defined beauty as the harmony found when the parts of the body relate to one another in perfect proportion and balance. Renaissance artists such as Leonardo da Vinci furthered the study of aesthetics by proposing the classical canons, such as dividing the lateral facial profile into equal thirds. Throughout history, artists and scholars have been engrossed in the pursuit of capturing what constitutes beauty. Dating back to ancient Egypt, artists idealized facial proportions in their works. The Greeks formalized aesthetics into a discipline of study, embodied by artists such as sculptor Polycleitus who defined beauty as the harmony found when the parts of the body relate to one another in perfect proportion and balance. Renaissance artists such as Leonardo da Vinci furthered the study of aesthetics by proposing the classical canons, such as dividing the lateral facial profile into equal thirds. Although neoclassical canons that address nasal projection and rotation were not proposed, the past few decades have given way to 6 major proposed ideals that outline rotation and projection (Goode, Crumley 1, Crumley 2, Baum, Powell, and Simons).

In the present study, we chose to compare the ideals outlined by Goode and Crumley by applying a population-based method using traditional focus-group and online social-network participants. Considering that the ratio calculation of each NTP method examined here is mathematically affected

### Analysis of Study Validity Measures

Preferencedatafromsubsurveysthatsharedcomparisonsetswithother subsurveysshowednoappreciabledifference(P > .05). Preference data for one face obtained from the same rater did not differ significantly from data for the same face aggregated from different raters (P > .05).
by both rotation and projection, we first sought to identify the
most aesthetic rotation for each method to make optimized
comparisons of these methods’ ideals.

For each of the 3 methods, we identified 106° degrees as the
ideal rotation (using the CFA metric). This suggests that
ideal rotation may be aesthetically independent of projec-
tion, even though mathematically the 2 measurements
are linked. The rotation of 106° is consistent with the study of Biller
and Kim17 that identified 104° and 108° as being the most fa-
vored CFA angles for women. Rotation-optimized compari-
son of the NTP ideals demonstrated that the Crumley 1 was
most aesthetic, followed by Goode and then Crumley 2. In ad-
tion, in faces of above-average attractiveness, rotation-optim-
ized comparison demonstrated that Crumley 1 was the
most strongly preferred NTP ideal; however, in faces of aver-
age attractiveness, no single ideal was most preferred. This
may suggest that, in faces of average attractiveness, aesthetic
changes made to the nasal tip may be undermined by other less-
than-ideal aesthetic features of the face and nose.

To our knowledge, this is the first study to compare NTP ide-
als from a population-based perspective, with data derived from
nearly 4000 completed surveys. This level of statistical power
is possible from the use of social-network groups (or virtual fo-
cus groups), a sampling method validated by Popenko et al.10
To our knowledge, this is also the first study to acknowledge ro-
tation as having a mathematical effect on NTP ratio calcula-
tions. Although the study by Devcic et al6 used population-
based methods to indirectly ascertain relationships between the
methods examined here, it did not control for features other than
the nasal profile when comparing attractiveness between faces.
In addition, Devcic et al did not take into account rotation and
used lateral facial portraits that likely did not contain the most
aesthetic combination of rotation and projection for a given
ideal. To truly compare NTP ideals to determine which is most
aesthetic, one must first optimize each ideal’s rotation and projec-
tion for a given face before comparison.

Our study used paired comparison analysis, which is a
novel method of assessing facial attractiveness. This method
was particularly appropriate for the present study because it
addresses the problem of asking participants to examine subtle
differences between nasal variants. When faced with the task
of selecting a most preferred nasal variant among many similar-
appearing options, chance judgments are probable. How-
ever, if a participant is simply asked to select one variant over
one other, in a series-wise fashion, relationships between all
options can be deduced and chance judgments are reduced.

As with all studies, ours was not without limitations. Many
of the canons used to define aesthetics for white faces are not
necessarily applicable to faces of other races or ethnicities.20-25
In addition, it is well known that the aesthetic nasal tip is dif-
f erent between males and females. As such, we limited our
analysis to white female faces of a similar age cohort; thus, the
conclusions derived from the results of this study may not ap-
ply to individuals whose origins are outside of Europe or those
who are males. Our study was also limited by the fact that the
surveyed population, predominantly Asian/Pacific Islander
participants aged 18 to 25 years, is not reflective of the gen-
eral population. However, this is not an immigrant population
and reflects the ethnic makeup of the entire University of Cal-
fornia system.

Although the use of literature-proposed aesthetic norms
as exclusion criteria for the images used in this study may limit
the applicability of the findings in this study, they were cru-
ical to the study design to control for aberrant features other
than the nasal profile between faces. This objective system al-
lowed us to attribute differences in the aesthetic ratings be-
tween faces solely to changes in the nasal profile.

Finally, it should be noted that the Crumley 1 method was
found to be most aesthetic regardless of attractiveness (al-
though when dichotomized, the finding was significant only
for attractive faces) and rotation (as rotation appears to be aes-
thetically independent of projection). Because rotation and
projection are aesthetically independent, the following find-
ings do not necessarily have to exist in combination to be sig-
nificant: the ideal rotation is 106° (CFA) and the ideal projec-
tion follows the method outlined by Crumley 1.

Conclusions

In the present study, the Crumley 1 method was determined to
be the most attractive nasal tip variant overall. Nasal tip rota-
tion of 106° using the CFA metric was the preferred rotation for
all the NTP methods examined. The ideal rotation and projec-
tion identified here do not have to exist in combination to have
significant effects. The data support the hypothesis that these
facets are aesthetically independent and, as such, are separate
significant findings. When considering only faces of above-
average attractiveness, the nasal tip adhering to the Crumley 1
ratio with a rotation of 106° is the most aesthetic. In faces of av-
erage attractiveness, no single NTP ratio is preferred; however,
a rotation of 106° is significantly preferred. In determining these
findings, the present study demonstrated the powerful useful-
ness of virtual focus groups. Further research is needed to de-
termine whether a more ideal projection exists beyond the stan-
dards defined by current NTP methods.

ARTICLE INFORMATION

Accepted for Publication: February 27, 2014.
Published Online: June 26, 2014.

Author Contributions: Drs Ahmed and Wong had
full access to all the data in the study and take
responsibility for the integrity of the data and the
accuracy of the data analysis.
Study concept and design: Ahmed, Popenko,
Crumley, Wong.
Acquisition, analysis, or interpretation of data:
Ahmed, Dhinsa, Osann, Wong.
Drafting of the manuscript: Ahmed, Popenko,
Wong.
Critical revision of the manuscript for important
intellectual content: All authors.
Statistical analysis: Ahmed, Osann.
Administrative, technical, or material support:
Ahmed, Wong.

Study supervision: Ahmed, Crumley, Wong.
Conflict of Interest Disclosures: None reported.
Previous Presentation: This study was presented
as an oral presentation at the American Academy of
Facial Plastic and Reconstructive Surgery Spring
Scientific Meeting in conjunction with Combined
Otolaryngological Spring Meetings; April 13, 2013;
Orlando, Florida.

Copyright 2014 American Medical Association. All rights reserved.
REFERENCES