The Aesthetic Unit Principle of Facial Aging

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IMPORTANCE In youth, facial aesthetic units flow together without perceptible division. The face appears as a single dynamic structure with a smooth contour and very little if any shadowing between different anatomical regions. As one ages, facial aesthetic units slowly become distinct. This process may be a consequence of differences in skin thickness, composition of subcutaneous tissue, contour of the facial skeleton, and location of facial ligaments. Although the impact of aesthetic unit separation is clinically apparent, its fundamental role in perceived facial aging has not yet been defined empirically.

OBJECTIVES To evaluate and define the effect of aesthetic unit separation on facial aging and to empirically validate the rationale for the blending of aesthetic units as a principle for facial rejuvenation.

DESIGN, SETTING, AND PARTICIPANTS We prepared the photographs of 7 women for experimental evaluation of the presence or absence of facial aesthetic unit separation. Photographic stimuli were then presented to 24 naive observers in a blinded paired comparison. For each stimulus pair, observers were asked to select the facial photograph that they considered to be more youthful in appearance. Each stimulus was compared with all others.

MAIN OUTCOMES AND MEASURES We calculated a preference score for the total number of times any photograph was chosen to be more youthful compared with all others. Paired t tests were used to compare the preference scores between the facial stimuli with and without aesthetic unit separation.

RESULTS We generated 4032 responses for analysis. Photographs without facial aesthetic unit separation were consistently judged to be more youthful than their aged original or modified counterparts, with mean preference scores of 0.66 and 0.33, respectively (P = .047). When we selected the paired stimulus that directly compared one photograph with aesthetic unit separation with another with blended aesthetic units (2015 pairs), observers indicated that the photograph with the blended aesthetic unit was younger 95% of the time. Within-rater reliability was found to be very good (r = 0.88).

CONCLUSIONS AND RELEVANCE Our data support the hypothesis that facial aesthetic unit separation influences perceived facial youthfulness among photographs of women. The presence of facial aesthetic unit separation results in a less youthful appearance. Based on these empirical data, the concept of facial aesthetic unit separation appears to play a significant role in perceived facial aging.

LEVEL OF EVIDENCE NA.
In youth, the face appears as a single dynamic structure that is characterized by the appearance of smooth facial contours and very little shadowing between facial features. Facial aging results in surface and subsurface structural changes, including skin thickness, composition of subcutaneous tissue, contour of the facial skeleton, and location and integrity of retaining ligaments. These factors contribute to greater variability of bony landmarks, formation of lines and wrinkles, variable skin pigmentation, and discontinuity of the facial region, which have been termed facial aesthetic units. Therefore, facial aging results in changes within and between distinct facial aesthetic units, which collectively contribute to the overall facial appearance. The goals of facial rejuvenation are multiple, depending on the unique changes of each individual patient. These changes may include creation of more homogeneous skin tones and texture and facial symmetry. In addition, one of the distilled underlying goals of facial rejuvenation procedures is the creation of smooth contours between anatomical regions of the face by blending the transition of facial aesthetic units, so that the face appears harmonious and youthful. Although facial aesthetic unit separation results in a more aged appearance, objective analysis of the effect of this separation on facial aging and its psychophysical detectability has not been described. Thus, the primary goal of this investigation was to demonstrate and define the construct and impact of aesthetic unit separation and to assess the perceptual effect of this separation on facial aging. In doing so, we desire to validate empirically the blending of facial aesthetic units as a core principle for facial rejuvenation. In turn, this principle can facilitate our discussion with patients and assist in their understanding of the goals of facial rejuvenation and treatment planning.

Methods

To objectively determine the perceptual effect of facial aesthetic units on aging, we evaluated results of a blinded, paired comparison of systematically modified facial stimuli. When presented with pairs of facial photographs, naive observers were asked to select the photograph that they judged to be more youthful using a forced-choice paradigm. In performing this task, observers were presented with a series of 2 randomly selected facial photographs that had been modified systematically to demonstrate the presence or the absence of facial aesthetic unit separation. We hypothesized that photographs with blended aesthetic unit separation would be rated as more youthful compared with photographs with more strongly defined borders of aesthetic unit separation. The institutional review board (Health Sciences Research Ethics Board of Western University, London, Ontario, Canada) approved this investigation (HSREB No. 16448E). Written informed consent was obtained from participants depicted in the photographs before the study. Written consent was also formally obtained from each participant observer.

Acquisition of Stimulus Photographs

Standard digital photographs of 9 female volunteer participants aged 28 to 57 years were taken by a professional photographer at the Audiovisual Department of St Joseph's Hospital, London, Ontario, under identical conditions; photographs included standard front, lateral, and oblique views of the face. The photographer was unaware of the goals of this investigation. Participants in the facial photography were recruited from individuals who presented to a tertiary care facial plastic and reconstructive surgery clinic. Participation was strictly voluntary.

As a proof of principle project, we selected 1 aesthetic unit for initial evaluation, the periorbital unit of the upper face. Frontal view photographs were selected for use in this investigation, because we believed that they best represented the facial unit of interest in its entirety. Initially, photographs were systematically cropped in an identical manner to emphasize the aesthetic area of interest. More specifically, the facial photographs were cropped superiorly at the level of the suprabrow (to exclude forehead wrinkles and hair), inferiorly just above the nasal supratip, and laterally to just the anteromedial region of the temporal hairline (to exclude hair); examples are shown in Figure 1 and Figure 2.

Once all photographs were cropped, they were then modified to add or remove skin and soft tissue characteristics that separated the aesthetic units. Youthful faces with limited aesthetic unit separation were digitally aged through the addition of lines and contours for aesthetic unit separation (Figure 1). Aged faces were digitally enhanced through the blending of aesthetic units (Figure 2). This process involved modification of the junction lines between the facial aesthetic units and changing the appearance of skin such as rhytids within the facial aesthetic unit. Although other methods of separating aesthetic units within the face exist, which can include change of facial skin color, volume, or bony structures, we focused on the coarse lines between aesthetic units and fine lines within them. This process created the perception of separation or blending of the facial aesthetic units. All photographic manipulations and cropping were performed using commercially available software (Adobe Photoshop CS3; Adobe Systems).

Technical addition of facial aesthetic unit separation was performed by first selecting a template facial photograph of an aged participant (Figure 2A). The evident and clearly demarcated skin creases and fine lines that divided the periorbital aesthetic unit were copied, resized, color matched, and placed on the youthful faces (Figure 1B). Similarly, in facial photographs of aged participants who already exhibited the presence of aesthetic unit separation, removal of the separation was performed by identifying and extracting pixels from the surrounding skin to blend over the demarcation of the facial aesthetic unit until it was no longer visually present (Figure 2B). Aside from the digital manipulation noted herein, we performed no further modifications to the photographs. The abovementioned process created a set of 2 photographs for each face consisting of the original and the digitally manipulated photographs. All photographs with aesthetic unit separation (original or artificially modified aged photographs) were labeled group A, and those photographs with blended aesthetic units (original or artificially modified) were labeled group B.

Based on consensus of the research team, 2 of the 9 photographs were excluded owing to inadequate realism or
conflicting facial features (distracting facial asymmetry including, eg, 1 heterochromia iridis, hair strands over 1 eye). This process yielded a total of 14 photographs, including 7 original and 7 modified. Three of the 7 photographs were modified to add facial aesthetic unit separation, and the remaining 4 were modified to remove facial aesthetic unit separation.

Participant Observers
Twenty-four naive young adults aged 20 to 29 (mean age, 24.9) years, including 16 women and 8 men, served as judges for this project. All judges were fluent English speakers in an effort to ensure that they fully understood the requirements of the experimental task. Naive observers were recruited as volunteers from the undergraduate and graduate student population at Western University. None of the participants had any formal academic exposure to facial aesthetics, dermatology, facial plastic and reconstructive surgery, or the concept of facial aesthetic units. We had no additional exclusion criteria, given the nature of the experimental task.

Rating of Photographs
While seated comfortably at a desktop computer (Studio XPS 8100; Dell, Inc) and high-definition computer monitor (LG 1401; LG Electronics), participants were asked to anonymously review a randomized series of photographs, presented 2 at a time as a paired comparison research task. Photographs were reviewed in a quiet perceptual laboratory free of ambient noise and other distractions. The participant observers were permitted to move through the pairs of photographs at their own pace. The order of presentation for the photographic pairs was randomized for each participant rater. Photographs were presented as pairs in a side-by-side format via the use of commercially available presentation software (Powerpoint; Microsoft Corporation). All photographic pairs were presented in combinations of A vs B and B vs A. This counterbalancing of all potential photographic pairs was intended to eliminate any potential response bias related to a given observer’s random selection of the first (A) or second (B) photograph in any given pairing. This process resulted in a total of 168 pairings of photographs, which were then randomized to 4 sets of 42 pairings each. The observers provided judgments in a single rating session lasting approximately 45 minutes. The complete database consisted of 4032 responses (168 photographic pairs by 24 raters). In addition, to ensure that the ratings of our judges were consistent and reliable over the course of the experimental procedure, all participants also provided a second rating of 34 randomly selected photographic pairs (20.2%) that were duplicates from the original pool; these additional reliability samples were introduced at random throughout the perceptual experiment. The observers were not made aware of this duplication.

Figure 1. Facial Photographs Before and After Digital Aging

A, Photograph without aesthetic unit separation (group B). B, Photograph with separation of the facial aesthetic unit (group A).

Figure 2. Facial Photograph Before and After Digital Modification to Reduce Aging

A, Photograph with aesthetic unit separation (group A). B, Photograph without aesthetic unit separation (group B).
able software (SPSS, version 17.0; SPSS Inc.). We hypothesized that detectability of facial aesthetic unit separation is a psychophysical cue in the perception of facial youth.

Within-rater consistency was evaluated via point-by-point agreement scores for each observer. These scores were calculated based on a comparison between the initial and subsequent presentation of identical photographic pairs and, hence, the consistency of the observer’s selections. This measure involved a simple determination of whether a second judgment of the same stimulus pair matched that obtained at the first presentation. Thus, an absolute reliability score for identical judgments by any given rater could be determined for the set of 34 comparisons.

### Results

The total number of times each facial photograph was selected as being more youthful is shown in Figure 3. All participants were consistently found to judge faces without facial aesthetic unit separation to be more youthful than their aged counterpart. In addition, for each facial stimulus, the preference score was calculated (the number of times a facial stimulus was selected to be more youthful divided by the total number of comparisons). For example, facial photograph 1 in group B was chosen 641 times to be more youthful in any given pair (Figure 3). Thus, the preference score is calculated as $641/672 = 0.95$. For all 7 facial photographs, the preference score was higher for the photograph without aesthetic unit separation (Table). Both versions of the same face differed only in terms of a single manipulated aspect of the facial aesthetic unit (i.e., the presence or absence of unit separation). The mean preference score for group A (photographic stimuli with aesthetic unit separation) was 0.33; for group B (photographic stimuli without aesthetic unit separation), 0.66 ($P < .047$). These data suggest that the presence of facial aesthetic unit separation provides a salient, detectable point of reference for the perception of aging. In further evaluating our data, when we selected the paired stimulus that only directly compared a photograph from group A with one from group B (2015 pairs), observers indicated that the photograph without separation of the aesthetic unit was younger 95% of the time. Finally, within-rater reliability was found to be very good ($r = 0.88$, $P = 0.88$).

### Table. Absolute Preference Score for Each Facial Photograph

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<thead>
<tr>
<th>Facial Stimuli No.</th>
<th>Score by Group ( \times 100 )</th>
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<tbody>
<tr>
<td>A</td>
<td>B</td>
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<tr>
<td>1</td>
<td>0.51</td>
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<tr>
<td>2</td>
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<td>6</td>
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<tr>
<td>7</td>
<td>0.22</td>
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<tr>
<td>Mean preference score</td>
<td>0.33</td>
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* Group A were photographs with aesthetic unit separation; group B, without aesthetic unit separation.
further substantiating the consistency of judgments and the overall results obtained.

Discussion

The principle of facial aesthetic units stems directly from established reconstructive concepts. González-Ulloa first described regional aesthetic units of the face and emphasized that, in facial reconstruction, facial units should be restored as a complete region as opposed to a patchwork fashion. Later, Thompson and Menick incorporated visual principles of facial aesthetic units and emphasized how the separation of facial units plays a significant role in the perception of facial aging.

To date, 2 previous investigations have evaluated facial rejuvenation procedures and their effect on the apparent age of patients. These studies were the first objective efforts to empirically determine the effect of facial rejuvenation procedures on perceived facial age. Their results objectively validate 2 important constructs. First, facial age can be characterized objectively. Second, rejuvenation procedures influence perceived facial age. The present investigation adds to this body of literature because it introduces the concept of facial aesthetic unit separation as an underlying construct driving the objective perception of facial aging. Thus, a natural progression and clinically validated concept emerges: efforts focused on the blending of facial aesthetic units directly target the fundamental source of apparent facial age.

The results of the present investigation support the hypothesis that the separation of aesthetic units has a direct effect on the perception of facial age. Using a rigorous paired comparison paradigm, our data empirically validate the hypothesis that observers were sensitive to systematic changes in the separation of facial aesthetic units. For all 7 photographic participants undergoing assessment herein, images without aesthetic unit separation were perceived to be more youthful. Further, the present data indicate that variations in facial aesthetic unit separation represent a clear and consistently detectable phenomenon to untrained, naive observers.

Although the present study achieved valid and consistent results, some limitations do exist. First, the photographs used were computer-processed and -modified images. Although the original images were standardized photographs obtained for aesthetic analysis, they may not translate directly to the 3-dimensional physical changes that occur in the aging face. Furthermore, the photographs do not capture subtle facial dynamics that can be perceived in a direct face-to-face interaction. Finally and most important, we chose to focus on the periocular region. Although one cannot discount the effect of global facial appearance and interpersonal interaction on observed age, this investigation serves as an exemplary proof-of-concept endeavor. As such, a balance was reached between achieving external validity and empirically valid results. To this end, evaluations of additional facial aesthetic units and global facial analysis are currently under way. These investigators will strive to integrate individuals of various ethnicities in studies similar to the present work to ensure pragmatic results that can be applied broadly.

The results of this investigation provide a springboard for future research efforts and clinical interventions. With the role of facial aesthetic unit separation in apparent facial age established, validated aesthetic and rejuvenation outcome measures can now be defined. Given the paucity of validated outcome measures in the aesthetic/rejuvenation literature, the development of scales using aesthetic unit separation for the basis of rejuvenation outcome evaluation provides a tangible hinge on which to base patient goals and clinical decision making. Thus, the present work sets the foundation for the evidence-based advancement of the aesthetic literature.

Conclusions

The youthful face demonstrates consistency of texture and harmony of contours. Older faces demonstrate compartmentalization of distinct facial aesthetic units. Through rigorous psychophysical methods, this investigation has objectively defined the effect of aesthetic unit separation on observer judgments of facial age. These findings confirm clinical practices and guide future research. Finally, these data substantiate the principal that separation of facial aesthetic units is fundamental to the perception of facial aging with direct relevance to the principles of facial rejuvenation.

ARTICLE INFORMATION

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Author Contributions: Dr Moore had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Tan, Brandt, Doyle, Moore. Acquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: Tan, Brandt, Doyle, Moore. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: Tan, Brandt, Doyle. Administrative, technical, or material support: Tan, Yeung, Moore. Study supervision: Brandt, Doyle, Moore.

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REFERENCES


