Emotional expression on a profile: Feature height, mouth angle, and tilt

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Profiles may vary in expression with changes in the height of the profile's features, the mouth's angle at the profile contour, and head tilt. In three experiments, we varied these factors. Features low on the profile, with mouths at an obtuse angle to the profile line and head tilted 15° forehead-forward, appear especially sad. High features with acute mouth angles suit forward, upright, and backward head tilts. Feature height, mouth angle, and head tilt on a profile are physical variables that can specify postures such as downcast heads and turned-down mouths, and thereby psychological factors. We point out alternative accounts of the height and tilt effects.

Emotion is a psychological matter made known through expressive physical features as arbitrary as a white flag and as species-specific as a smile (Darwin, 1872). Faces are especially significant for showing emotions, and their physical features have been widely researched (Duclos et al., 1989; Tracy & Robins, 2004). Testing drawings with elliptical faces, Todorovic (2008) and Chan et al. (2007) found that higher features were judged happier than lower features (see Figure 1). Height may also affect expression of profiles of faces (see Figure 2). Feature height on a face per se has no obvious theoretical link with emotion. Perhaps the effect could be mediated by inferred head tilt or inferred mouth angle. Profiles could be used to test such expressive variables and their interactions. Here, we find that low

features, with mouths at an obtuse angle to the profile line and a head tilted forehead-forward, appear especially sad. Also, we show that several head tilts—forward, upright, and back—fit happier or neutral expressions. We inquire about the psychological significance of these physical variables.

We observed the effect that feature height on a face influences its emotional expression. It is unlikely that this effect was due to feature height per se, because there is no theoretical reason for this to be the case. Alternatively, the effect might be mediated by mouth angle or inferred head tilt.

In Figure 3, height is related to mouth angle. Lowering the features on the profile changes the mouth angle from 76° to 92° to 125° with respect to the tangent at the profile (measuring the upper angle at the intersection with the profile). The mouth angles are not symmetrical with respect to 90° because the eyes and nose occupy space between the mouth and the top of the ellipse. On rectangles (see Figure 4), the mouth angle remains 90° as the features change height.

The physical variables manipulated here are straightforward, but they could have several psychological implications. At the outset, let us consider one set of variables that we will test and find wanting—perception and projection. We will later discuss others, such as head tilt and mouth angle, more positively. As a face, an ellipse may appear more 3-D than a rectangle, with implications for 2-D features in Figure 2 (Lyons et al., 2000). Curves fit an egg-like head—an ellipsoid—projected from a point source, and straight lines fit a flatter form such as a brick. That is, in linear perspective, a 3-D distal ellipsoid projects a 2-D ellipse (see Figure 5). Above the equator, horizontal lines of latitude on the ellipsoid project lines concave downward on the ellipse. They are concave upward below the equator. Straight lines above the 2-D ellipse's equator would be projections from lines concave upward, like

Figure 1. Front-facing elliptical faces used by Chan et al. (2007), following Todorovic (2008).

Figure 2. Elliptical face profiles used in Experiment 1.

Figure 3. Elliptical faces with labels for the mouth, the face contour, and the upper angle between the mouth and face contour.

a smile, on the ellipsoid. Below the equator, they would be projections from lines concave downward, like a sad mouth. Lines on flat distal forms project true forms in the rectangle—straight distal lines project as straight lines. The rectangle's straight vertical sides fit the straight sides of a cylinder, but its straight horizontals suggest a brick rather than a cylinder's convex, curved top and bottom.

Does height's expressiveness rely on 2-D curves suggesting ellipsoids? Alternatively, features low and high on

Figure 4. Rectangular face profiles used in Experiments 1 and 2.

ellipses may imply expressive postures such as a downcast or erect head, and rectangles a fixed upright posture. In either case, rectangles would not change expression with feature height. Another possibility is that just as a smile is species-specific, features high on a head are positive and low features are negative per se. In this case, the rectangles would differ in expression.

In Experiment 1, expressive effects of feature height (high, middle, and low) and the shape of the face (ellipses and rectangles) were tested. In addition, participants were asked which appeared more 3-D, the ellipse or the rectangle.

EXPERIMENT 1

Method

Participants. As in all experiments here, the participants (here, $N = 24$, mean age = 19 years, $SD = 1.43$; 19 females, 17 with corrected-to-normal vision) were enrolled in an introductory psychology course at the University of Toronto Scarborough, received course credit for their participation, and were naive about the purpose of the experiment.

Stimuli. Six face stimuli were presented on paper. The ellipses were 4 cm in height and 2.4 cm in width, shaped as in Figure 2. The rectangles were 4.4 cm in height and 2.4 cm in width, shaped as in Figure 4. The facial features were short, straight horizontal lines for the mouth (6 mm long), the nose (2 mm), and the left eye (4 mm) on the left side of the ellipse and rectangle. The nose was on the outside of both shapes, with the other two features on the inside; high, middle, and low on the ellipses and rectangles. The distance between the top of the ellipse and the high mouth was 1.5 cm; between the

Figure 5. An ellipsoid is projected on a 2-D flat surface as an ellipse. The observer's vantage point is at the equator of both figures. Horizontal lines above and below the equator would project as curves (concave down and up, respectively). At the same locations, straight lines on the 2-D ellipse would be projections of curves (concave up and down, respectively) on the ellipsoid.

Figure 6. Median expression ratings for rectangles and ellipses with features at the low, middle, and high positions in Experiment 1. The error bars indicate the first and third quartiles.

top of the ellipse and the middle mouth, 2.5 cm; and between the top of the ellipse and the low mouth, 3.7 cm. The mouth angles to the contour's tangent were 76°, 92°, and 125°. For the rectangle, the corresponding distances were 1.1, 2.4, and 3.9 cm, and all the mouth angles were 90°.

Procedure. Participants, tested individually, were shown two faces, one ellipse and one rectangle, on each page, with three pages total. The ellipse and rectangle on each page had features at the same facial height (high, middle, or low). On pages 1 and 3, either the ellipse or the rectangle was at the top, with the opposite shape at the top on page 2. There were 12 orders total, and 2 participants were exposed to each order, with a total of 24 participants. Participants judged expressions on a scale from 1 to 7 (1, *very sad*; 2, *sad*; 3, *slightly sad*; 4, *neutral*; 5, *slightly happy*; 6, *happy*; and 7, *very happy*). The rating scales were presented as horizontal lines to the right of each stimulus, and judgments were made by checking a number.

Results

On a Friedman test for height, averaging across shape (ellipse and rectangle), the main effect was significant ($\chi^2 = 39.9, p < .001$). Wilcoxon signed ranks tests found

differences between all heights (high vs. middle, $Z = -2.68, p = .007$; high vs. low, $Z = -4.21, p < .001$; low vs. middle, $Z = -4.22, p < .001$). Another Wilcoxon signed ranks test, averaging across height, found a main effect for shape ($Z = -3.28, p = .001$). A Friedman test for the shape $\times$ height interaction found it significant ($\chi^2 = 34.16, p < .001$; see Figure 6). Furthermore, all participants judged the ellipses more 3-D than rectangles ($p < .001$, binomial). The mean rating for the difference in apparent depth was considerable: 3.3 on a 5-point scale ($SD = 1.23$).

Discussion

Low features elicited sad ratings: Rectangles had a median rating of 3 (*slightly sad*), and ellipses rated 1 (*very sad*). Rectangles were judged less 3-D than ellipses, which could explain the relatively small range of ratings for the rectangles on the projection hypothesis. Or, it may be primarily mouth angle that drives the range of expression in the ellipse. A change of 33°, from 125° to 92°, may be related to an increase in median rating of 3, and the further change of only 16°, to 76°, may be related to a correspondingly small rating increase of 1. The noticeably obtuse mouth angle received very sad ratings.

Unlike rectangles and ellipses, triangular and trapezoidal stimuli allow height and mouth angle to be varied separately. In these figures, would mouth angle and height act additively—wide-ranging when consistent and neutral when inconsistent? Or would one dominate? Would straight-sided figures continue to produce ratings close to neutral, because curves suggest projection from 3-D convex surfaces?

EXPERIMENT 2

Experiment 2 used triangles, trapezoids, and rectangles to vary mouth angle and feature height independently. Apex-up triangles in Figure 7 have acute mouth angles (70°), and apex-down triangles have obtuse mouth angles (110°). Opposite each apex is a horizontal line, completing the image of a face. Trapezoids based on similar horizontal lines have mouth angles of 85° (narrow top) and 95°

Figure 7. Faces used in Experiment 2, with mouth angles 70° to 110°.

(wide top). If height effects depend on projection from 2-D figures with curved sides, Experiment 2's stimuli would be neutral in expression. Alternatively, expression might depend on mouth angle and height.

Method

Participants. Twelve undergraduates (mean age = 19 years, $SD = 1.8$; 11 females, 6 with corrected-to-normal vision) were tested.

Stimuli. All 10 stimuli (see Figure 7) were 5 cm in height. Intermediate features were not used since expressive effects likely appear most clearly in comparisons of high and low features, and the ratings for centered features were intermediate for both shapes in Experiment 1. The distance between the high mouth on the apex-up triangle and the apex tip was 1.5 cm; it was 2.9 cm for low features. Avoiding crowding at the apex, the corresponding distances for the apex-down triangle were 0.9 and 2.9 cm. The stimuli were presented to participants in random orders with the proviso that a stimulus with features located high was always followed by one with features low. Other details were as in Experiment 1.

Procedure. One stimulus was presented per page. Also, participants first underwent a familiarization trial in which they viewed all the stimuli without recording a response and then they reexamined the stimuli to judge the expression on each face. This was to boost sensitivity, dilute order effects, and to encourage participants to see each stimulus as a face.

Results

On a nonparametric Friedman test for height, averaging across angles (70° to 110°), the main effect was significant ($\chi^2 = 5.333$, $p = .021$). Also, a nonparametric Wilcoxon signed ranks test for height, averaging across angles, found a main effect ($Z = -2.049$, $p = .04$). A Wilcoxon signed ranks test of the shape $\times$ height interaction found it significant ($Z = -3.07$, $p = .002$; see Figure 8).

On a Friedman test, averaging across height, the main effect for angle was significant ($\chi^2 = 18.48$, $p = .001$), the most acute mouth angles being judged happier and the most obtuse sadder than intermediates. To identify the source of this significant effect, we conducted 10 additional Wilcoxon signed ranks tests. One test was significant after Holm correction for multiple testing (70° vs. 110° , $Z = -2.938$, $p = .003$). Six other tests showed trends in keeping with this significant value (70° vs. 85° , $Z = -1.975$, $p = .048$; 70° vs. 90° , $Z = -2.157$, $p = .031$; 70° vs. 95° , $Z = -0.203$, $p = .028$; 110° vs. 85° , $Z = -2.679$, $p = .007$; 110° vs. 90° , $Z = -2.691$, $p = .007$; 110° vs. 95° , $Z = -2.043$, $p = .041$), though they were not significant by the Holm criterion. With this as a caution, we will treat the uncorrected values as likely to be reliable.

Of note, both the low-featured 70° and 110° stimuli stood out. Paired-sample t tests found significant pairwise comparisons for the 70° mouth angle with low features versus all other angles with low features ($p < .001$), as well as the 110° mouth angle with low features versus all other profiles ($p < .001$). However, we found no significant pairwise comparisons between the high-featured profiles.

In sum, if features are at the bottom, there is a large range of ratings from *happy* (the median for acute mouth angles is 5.5, meaning an equal number of ratings 5 and below and 6 and above) to *sad* (obtuse mouth angles rated 1). High features are rated *slightly happy* or *neutral*.

Figure 8. Median expression ratings for faces with mouth angles varying from 70° to 110° and features positioned high and low in Experiment 2. The error bars indicate the first and third quartiles.

Discussion

The rectangle's median judgment (4) was consistent with Experiment 1's results (3–4). In addition, the straight-sided figures offered wide-ranging expressions (range 3.5), so we can safely conclude that 2-D curves suggesting projections from curved surfaces are not crucial. The projection hypothesis we entertained used linear perspective and a point source, but the hypothesis could be broadened to include parallel projection, with triangles as projections of cones, trapezoids projections of truncated cones, and rectangles projections of cylinders. The conclusion in either case is that projection cannot explain the considerable range of the low-featured compared with the high-featured faces since they share the same forms. One possible factor is that low-featured faces show primarily a face and a head, and high-featured faces the body carrying the head. Predominance of the face and head could emphasize expression. Furthermore, large, low mouth angles were judged especially sad but angle and height are not additive since the largest and smallest ratings are given to the low-featured faces. Could head posture be at work, with distinctive effects for low features? We test this in Experiment 3.

EXPERIMENT 3

Profiles in the obtuse mouth angle figures in Experiment 2 lean as if the head is downcast. The profiles with acute mouth angles are upward oriented, as if the head is elevated and assured. Ellipses in Experiment 1 all have vertical axes, but features high and low on them may imply a head tilted up and down, respectively, so implicit postural variables could contribute to their expression. Making the implied posture explicit, Experiment 3 used ellipses with head forehead forward (-15°), upright, and forehead back ($+15^\circ$).

In Experiments 1 and 2, the mouth line is horizontal, but keeping it horizontal in Experiment 3 would confound

increasing mouth angles with increasing tilt. The mouth line must tilt with the head. This means that features presented low (mouth angle 125°) and high (mouth angle 76°) in the ellipse confound feature height and mouth angle, as in Experiment 1. However, the purpose of the experiment is to determine the effect of tilt. Hence our question can be, for a given arrangement of features: Is an upright head happier than one tilted forward? Is a head tilted back happier still? The experiment can determine the effect of tilt for two arrangements of features: high features with an acute mouth angle (high and acute), and low features with an obtuse mouth angle (low and obtuse).

Method

Participants. Twenty undergraduates (mean age = 20.5 years, $SD = 2.7$; 14 females, 13 with corrected-to-normal vision) were tested.

Stimuli. All six ellipses (see Figure 9) were Experiment 1's figures, with features high and low, in three tilts: -15° , 0° , and $+15^\circ$.

Procedure. One stimulus was presented per page, for rating as before. The stimuli were presented to participants in random orders with the proviso that a stimulus with features located high was always followed by one with features low and that no two stimuli with the same head tilt were presented in succession. Other details were as in Experiment 1.

Results

Low and obtuse features were ranked especially sad, with -15° head tilt saddest. A nonparametric Wilcoxon signed ranks test for feature arrangement (height/mouth angle), averaging across tilt (-15° , 0° , and $+15^\circ$), found low and obtuse sadder ($Z = -3.83$, $p < .001$). A Friedman test, averaging across feature arrangement, found the main effect for tilt significant ($\chi^2 = 8.71$, $p = .013$), but on a Wilcoxon signed ranks test, averaging across height, tilt was significant only for $+15^\circ$ (median 5) versus -15° (median 3), and 0° (also median 3) ($Z = -2.79$, $p = .05$, and $Z = -2.09$, $p = .37$, respectively). A Friedman test for the height $\times$ tilt interaction was significant ($\chi^2 = 12.79$, $p = .002$). The -15° tilt with features low and obtuse was ranked notably sadder than its high and

Figure 9. Figures used in Experiment 3, heads tilted forehead forward (-15°), upright (0°), and back ($+15^\circ$).

Figure 10. Median expression ratings for heads tilted forward, upright, and back and features positioned high and low in Experiment 3. The error bars indicate the first and third quartiles.

acute counterpart (median rating of 1, four rating steps from features high and acute, the largest range of the tilt pairs; see Figure 10).

Discussion

Head tilt had only modest effects. Within each of the two arrangements of features, the range of ratings as tilt varied was one step. Since explicit postures had modest effects, it is unlikely that Experiment 1's height effects are due to implied posture, and the two experiments are commensurate since both upright ellipses were rated within one rating step of Experiment 1's ratings. The low and obtuse forward-tilted profile was indeed sad (median 1). A bowed head may increase the sadness indicated by other features. It could directly express sadness or it may in addition suggest submission or concern about showing the emotion. In contrast, tilts forward and back made no difference to the happier features (medians 5 in both cases). Head down may reinforce sadness, but be neutral with regard to happiness. With an acute mouth angle suggesting a positive or neutral emotion, a forehead-forward head can be dominant, looking down at other people. The same head tilted back can seem proud, and held upright, neutral. All three tilts are consistent with an acute mouth angle and an expression that is not sad.

GENERAL DISCUSSION

Physical heights, angles, and tilts need to be interpreted and, in principle, inducing psychology from geometry—working backward from proximal to distal stimuli—is not straightforward. Many roads can lead to Rome. The facts to be explained are that low features allow wide-ranging expressions, mouth angle matters, and only some tilts are distinctive.

The clearest finding here is one with several possible interpretations. Particularly sad ratings and happy ratings are given to low features. In Experiment 1, ellipses with low features and a mouth angle of 125° had the lowest possible median rating (1). In Experiment 2, triangles with low fea-

tures and a mouth angle of 110° had a median rating of 2. In Experiment 3, an ellipse with a tilt of -15° and a mouth angle of 125° had the lowest median (1). The same mouth angle but with the two other tilts garnered median ratings of 2. High features are relatively happy in Experiment 1, but only median 5 for ellipses and 4 (*neutral*) for rectangles. In Experiment 2, high features are given a smaller range (1.5) than low features (3.5), with low features appearing at the happy and sad ends of the scale. In Experiment 3, high features were rated only 4 or 5.

Physically, the asymmetry of high and low features may be partly due to the room at the bottom of a profile to move the mouth to an extreme. At the top of a profile, other features fill the space between the mouth and the top of the head. Psychologically, the emphasis on the face in low-featured stimuli, rather than a head plus its supporting body, could enhance expressiveness. Projection and posture insofar as it is indicated by the tilt of the ellipse are not crucial, since projection cannot explain differences in ratings for similar forms in Experiment 2, and posture had only modest effects in Experiment 3. Social factors are worth considering, as in expressions such as "Yesterday I was up, but I'm feeling quite low today" (Lakoff & Johnson, 1980; Winner, 1982). Social factors could be tested in experiments with speakers of a language that does not have these idioms.

Mouth angle, implicated in the ellipses of Experiments 1 and 3, has clear effects at the 70° and 110° extremes in Experiment 2. In the intermediate 85° to 95° range in Experiment 2, it is neutral, and normal faces likely have a range of mouth angles reflecting neutral moods. The mouth line was horizontal in Experiments 1 and 2. Fuller effects can be anticipated for departures from horizontal. Mouth angle seems our most unambiguous, direct variable. Corners of mouths curl up in smiles and turn down in pouts.

Head tilt had modest effects across the 30° range tested, but Experiment 3 revealed the interesting possibility that a downcast head tilt is distinctive for sad features, but several head tilts are consistent with happier or more neutral features. Like height and like shape in Experiment 2, tilt has physical limits. Increasing the height of the features at the top of an ellipse creates crowding problems and suggests heads and bodies rather than just heads and faces, and another limit is set by the need for a chin below the mouth line. Exaggerating the sloping sides of triangles to increase mouth angle would create flat-headed figures that were not particularly facelike. Tilting a head too far may make it look asleep. Furthermore, comparing the effects of each variable creates apples versus oranges problems. Of more interest may be interactions, such as the distinctiveness of forward head tilt for sad features.

Since working backward from proximal to distal stimuli often involves several options, we used the phrase "posture insofar as it is indicated by the tilt of the ellipse." The proximal stimulus is often different from the distal stimulus, so manipulating head tilt by manipulating ellipse tilt does not necessarily affect the inferred head tilt. Head tilt might be inferred from the geometrical relations between mouth and face profile, for example. Indeed, many features could indicate head tilt and mood—for example, explicit eye postures showing that we have leveled our gaze

at the audience, possibly assertively, or we are looking down our noses at them, perhaps as if superior, or we are looking up at them, maybe as if submissively. Therefore, inferred head tilt should not be excluded as an explanatory variable for the inferred emotional expression of a face. The role of head tilt is an open issue.

In Experiment 2, in addition to height, mouth angle, and tilt, the baseline could matter—figures with large bases might be taken by observers as offering physical stability, and hence confidence (Kennedy, 1982). Evidently, geometrical variables indicate expression by specifying psychologically relevant factors, but the factors to be disentangled are many.

Inversion of photographs of faces hinders perception of expression, and Chan et al. (2007) found the same hindrance for the Figure 1 ellipses. The reader may want to invert the figures here. The expressive differences vanish. Hence, the expressive differences here are allied with standard face perception effects.

In conclusion, as in the Todorovic (2008) effect with face-frontal stimuli, expression in simple profiles based on ellipses, triangles, and quadrilaterals varies intriguingly with height of facial features, posture, and mouth angle. Low facial features, forehead-forward and with obtuse mouth angles, are found to be especially sad. The height effects could be due to curving mouths, a distinctive head posture, and social connections with "low."

AUTHOR NOTE

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