

## Notes and Comment

### **Pouting and smiling distort the tactile perception of facial stimuli**

STUART M. ANSTIS

*York University, Downsview, Ontario, Canada*

and

LOU TASSINARY

*Dartmouth College, Hanover, New Hampshire*

Many sensory surfaces are decidedly nonuniform in resolving power. For instance, visual acuity in the retina falls off progressively with eccentricity, or distance from the fovea centralis. On the skin of the arm, the fingertips play a role analogous to the fovea. Their high acuity can enable a person to discriminate two tactile points that are separated by only 2 mm. Two-point localization thresholds rise progressively along the arm, from 7 mm on the palm to 10 mm at the shoulder, like a cutaneous retina (Weinstein, 1968). On the facial skin, the two-point threshold is only 2 mm on the nose and lips and rises progressively to 3.5 mm on the forehead. Targets initially perceived by low-acuity peripheral areas are reflexively brought to high-acuity regions for detailed examination. A fixation reflex turns the fovea towards visual targets detected by the retinal periphery. A tactile placing response brings a kitten's paws on to a solid surface which brushes its front legs (Grillner, 1975). A baby brings any new object to its lips for examination (Sameroff, 1973).

This arrangement of a steerable surface with tapered acuity cleverly reconciles the conflicting requirements of range (or field of view) and resolution within the available neural bandwidth. It is reminiscent of a low-powered finder telescope which can search a large region of the sky, coupled to a steerable high-powered telescope which can be turned toward promising targets.

The high-acuity centers—fovea, fingertips, lips—have much larger areas of sensory cortex than do the low-acuity surrounding regions, such that, within each modality, each receptive field is assigned a roughly constant amount of cortex (Penfield & Jasper, 1954). The receptive surfaces are steered

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by muscle groups which also command unusually large areas of motor cortex. As a result, one tends to expect unusually precise psychophysical judgments when using these areas, but we report a surprising exception.

The world does not seem to jump about when one moves one's eyes, because the visual system can readily distinguish retinal image motion caused by moving objects from those caused by eye movements (Mackay, 1973). Similarly, if one strokes a cat, one can tell whether it is one's hand or the cat that moves, because motor output and tactile feedback are accurately monitored and compared. Gibson (1962) discusses this issue. One might expect the same close sensorimotor coordination for the lips, which are used for tactile exploration by the infant and for ingestion and speech by the adult. For instance, we have reported that the position of the mouth parts is precalibrated for pitch in whistling or singing, although modifiable by auditory feedback (Cavanagh & Anstis, 1979). However, the tongue makes pronounced errors of overestimation in judging the size of small holes (Anstis, 1964; Anstis & Loizos, 1966). And we now report an illusion showing surprisingly loose coupling between motor positioning of the lips and the resulting tactile feedback. The brain does not fully compensate for the position of the lips in judging the position of stimuli which touch the lips.

Subjects were successively touched on the lips with two pairs of stimuli which differed in separation, and were asked to judge whether the stimuli of the first or the second pair were farther apart. The stimuli were pairs of horizontally separated vertical edges of acetate film, glued into wooden holders at distances of 1 to 4 cm in steps of 0.5 cm. Using a double-staircase procedure, the subjects were asked to smile broadly (pout) on the odd-(even-) numbered trials for the first, standard stimulus and to pout (smile broadly) during the second, variable stimulus. This manipulation served to narrow (smile) or lengthen (pout) the distance between stimuli as defined over the skin surface.

The results for all eight subjects are plotted in Figure 1. Open symbols show the matches selected when the standard stimulus (on the abscissa) touched pouting lips and the matching stimulus selected (on the ordinate) touched smiling lips. In every case, the spatial separation of pout stimuli was overestimated. In the opposite condition (filled symbols), all smile stimuli were underestimated. Large symbols indicate positions on the graph occupied by more than one datum point. The line that gave the

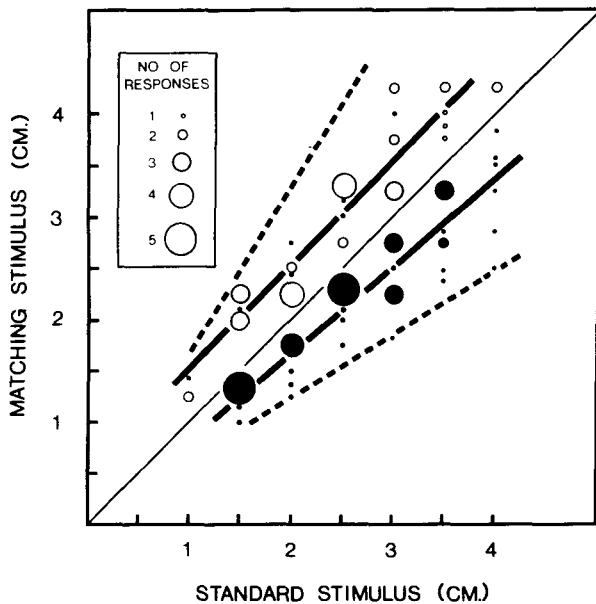


Figure 1. Size judgments for stimuli pressed on the smiling or pouting lips. Results for eight subjects. Large symbols indicate several datum points falling on same position on graph. Open symbols indicate that stimuli pressed on pouting lips were overestimated compared with comparison stimuli pressed on smiling lips. Filled symbols show the converse case. Accurate spatial judgments of stimuli, showing perfect size constancy, would lie along diagonal. Judgments based on skin sensations disregarding lip positions, showing zero size constancy, would lie along dashed lines. Actual results were intermediate, showing only partial compensation for lip positions.

best fit by least squares for the entire set of open symbols was

$$y = 1.03x + .47, r = 0.951$$

and for the pout estimates (filled symbols) was

$$y = .84x - 0.03, r = 0.925.$$

These are shown as solid lines in Figure 1.

The width of smiling lips was  $71 \pm 5$  mm, and of pouting lips was  $44 \pm 4$  mm. The separations on the skin calculated from these lip positions are shown in Figure 1 as dashed lines with slopes of 1.6 ( $= 71/44$ ) and 0.6. Results lying along these lines would imply that the subjects responded entirely to intrinsic skin distance and took no compensatory account of skin deformation in making their judgments. Results lying along the positive diagonal would imply perfect "object constancy," with judgments unaffected by smiling or pouting; this would require accurate allowance for the changes on the skin produced by lip movements. The actual results lie about half-way between these possibilities, implying only partial and incomplete compensation.

We also measured a related phenomenon known

as the "twisted lip illusion." The subject was asked to grimace by moving his or her upper lip to the right and the lower lip to the left. During this grimace, a vertical edge touched to the two lips appeared tilted, with its top displaced to the left. The extent of this illusion was nulled by touching the upper and lower lip with a pair of hairs 2 cm apart and allowing the subjects to rotate the hairs in a swivel bearing until the orientation of the stimulus felt vertical. The mean setting was  $19.1 \pm 8.1$  deg from the vertical (mean and SD of four subjects), in the same direction as the lips were skewed.

There are at least three major hypotheses about the nature of tactile space, two of which we believe the present data do not support. First, there is the hypothesis that tactile space is organized in metric extrinsic coordinates. This hypothesis is directly related to the "object constancy" prediction in our first experiment, which was not borne out by the data. The second hypothesis is that tactile space is functionally organized; that is, it is organized to reflect the action requirements of the system. Those objects which require more lip movement to encompass them would be "bigger" than those which require less lip movement. This interpretation is consistent with subjects' overestimating stimuli on pouted lips and underestimating stimuli on smiling lips, but is at a loss to explain the twisted-lip illusion. In addition, based on informal observations, we strongly suspect that the phenomenon of our first experiment is not dependent on muscle activity; distortion of the skin, regardless of how it is brought about, is all that is necessary. If true, this suggests that the tie between the phenomenon and the motor system is somewhat weak.

The third hypothesis is that distance and orientation on the skin are defined in intrinsic coordinates; that is, distance is defined by the amount of skin intervening between two points, regardless of the shape of the skin, and orientation is defined by the "resting" anatomical position. This interpretation is entirely consistent with the results of both of our experiments and, in addition, suggests why the face might be particularly amenable to the demonstration of tactile illusions. The face is one of the few areas of the body where muscle tissue inserts directly into the skin and, in a few places, originates there as well (Figge & Sobotta, 1974). Thus, unlike the skin covering the limb musculature, which passively follows limb movement, the facial skin is actively stretched and compressed across the craniofacial skeleton. This hypothesis predicts that the illusion will probably be found on the skin in other parts of the body; if not, there may be something special about facial sensations, a claim that others have made for different reasons (Tomkins, 1979; Darian-Smith, 1966).

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