A computer method "point-pair system" for measuring movement in facial expression based on video from a natural/clinical context

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Introduction

There are "paper and pencil" facial coding systems in expression research; the FACS, facial action coding system [1], is perhaps the one most widely used. In neonatal pain research, the NFCS, neonatal facial coding system [2], which is derived from the FACS and specific to areas of neonatal pain expression, is frequently used in this field of research. The measurement level derived with this tool is categorical. We attempted to increase the measurement level to ratio with the following "point-pair" methodology.

Point-Pairs

We assigned pairs of points between commonly implicated areas of movement in pain expression; for example, *point-pair 1* lies between the medial borders of the eyebrows; to track horizontal brow movement or equivalent to *brow bulge* in the NFCS vernacular. We devised a total of 7 point-pairs to track movement in the mouth, cheek and eye areas. Whereas previous attempts to track facial action have used video, those attempts assume a stationary head [3], something that was not possible since we were recording infants receiving a painful stimulus (a heel stick), and they almost universally rotated their head in reaction. Also, because these recordings occurred in a naturalistic environment (a newborn nursery), it was not feasible to have additional equipment to facilitate the measurement of video with moving targets. This method assumes that faces are always facing the camera. In order to achieve this, the video was converted to still images (jpegs) using Rad Video Tools (Rad Game Tools, Kirkland, WA). The still pictures were reviewed and two pictures were selected: one depicting a "neutral" face (Figure 1), sometime close to and before receiving the painful stimulus; and another picture depicting a "reaction" face (Figure 2), sometime close to and after receiving the painful stimulus. Thus, because of methodological/practical reasons, we replaced the machine assignment associated with automatic systems, with a manual assignment that tried to maximize the position and expression of the face between the neutral and reaction pictures.

Point-Pair Calculation

The goal was to measure movement, in pixels, in particular facial areas implicated in neonatal pain expression by tracking change between point-pairs. To preclude issues of image size and differences in infant anthropometrics, we chose *percent of facial width* as the standardized unit of measurement. Each child's face-width was measured twice at both baseline and reaction, and the average was used to scale all subsequent point-pair pixel measures. Baseline and reaction images maintained similar scales. Measuring and averaging over both images allowed for a second view and more accurate estimation of facial width. We begin by calculating the Euclidean distance between a pair of points. The final point-point pair output, expressed as a percent of face-width, was the computed distance between the two test points divided by the scale and multiplied by 100:

$$P_i = \frac{100 * dist(X_{i1}, X_{i2})}{dist(S_1, S_2)}$$

Or,

$$P_i = \frac{100 * \sqrt{(x_{i1} - x_{i2})^2 + (y_{i1} - y_{i2})^2}}{\sqrt{(x_{S1} - x_{S2})^2 + (y_{S1} - y_{S2})^2}}$$

Where S are the scale points derived from measuring facial width. Point-pairs were calculated for both baseline and reaction images. Point-pair change, net movement between images, was calculated as:

$$\Delta P_i = P_i^R - P_i^B$$

Where P_i^R is the point-pair value for the reaction image, and P_i^B is the point-pair value for the baseline.

The above calculations were done in Matlab (MathWorks Inc., Natick, MA).

Discussion

The manual assignment of points undoubtedly introduces a level of subjectiveness and some degree of error to the measurement. It should be mentioned that in the earlier phases of this research, we tried an affine transformation to account

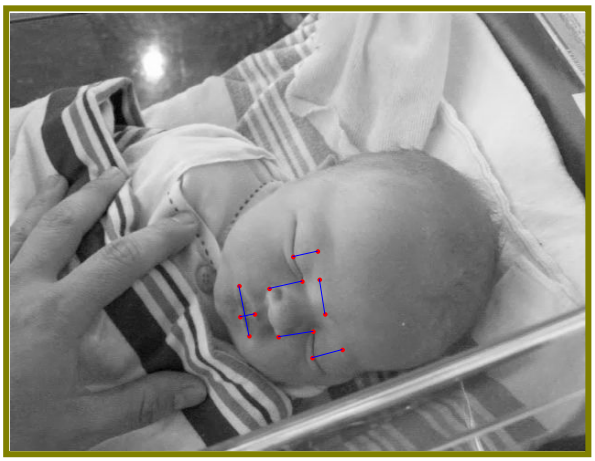

Figure 1. *Neutral face.*

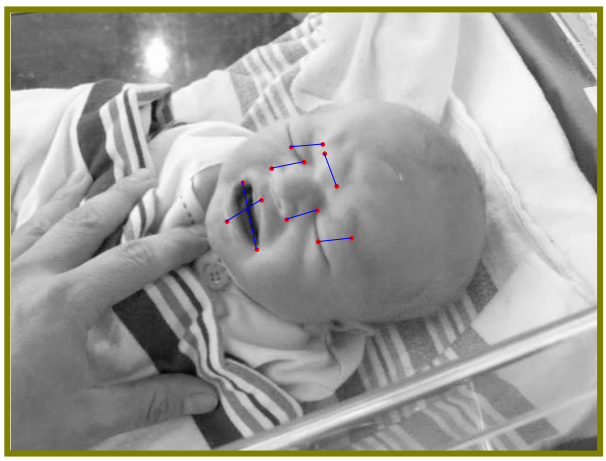

Figure 2. *Reaction face.*

for minor changes in head movement; however, these affine transformations were prone to considerable error due to the lack of a good number of rigid points on the face, and again, to considerable head movement. Clearly methodological issues of measuring expression on a moving face remain to be tackled. Our point-pair system demonstrates the ability to advance the measurement of the facial display of pain from a categorical level to a ratio level, thereby making possible statistical comparisons heretofore not afforded with current methodology.

References

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