The Roots of Facial Expressions: Pragmatic and Semantic Facial Expressions Comprise Biologically-Rooted Facial Movements

Jonas Nölle*[1], Yichen Wu[1], Pablo Arias Sarah[1,2], Chaona Chen[1], Oliver G.B. Garrod[1], Philippe G. Schyns, and Rachael E. Jack[1]

*Corresponding Author: jonas.noelle@glasgow.ac.uk
[1]School of Psychology & Neuroscience, University of Glasgow, UK
[2]Department of Cognitive Science, Lund University, Sweden

Facial expressions are crucial for effective human and primate social communication (Bliss-Moreau & Moadab, 2017). What motivates the mapping of specific face movements on social signals, and how did they become integrated with speech? Current evidence suggests that facial expressions of *emotion* evolved from physiologically-relevant facial cues. For example, FEAR facial expressions typically involve widened eyes that increase the visual field. Conversely, DISGUST facial expressions typically involve contracted eyes and nostrils that reduce sensory input, protecting the expresser (Darwin, 1872; Susskind et al., 2008).

In line with these existing theories, we hypothesized that *social* facial expressions, such as THINKING, INTERESTED, BORED and CONFUSED and those accompanying speech, would also comprise mappings between contrasting expansion and contraction facial movements and broad social information (e.g., affective, pragmatic, semantic). To test this, we first analyzed two complementary sets of facial expression models derived from Western European and East Asian culture participants using a highly-powered perception-based data-driven method: the six basic emotions (HAPPY, SURPRISE, FEAR, DISGUST, ANGER and SAD, N=30 per culture, 31 females, M_{age}=22 years; Jack et al., 2012) and four key social messages (THINKING, INTERESTED, BORED and CONFUSED, N=20 per culture, 20 females, M_{age}=22 years, Chen et al., 2020). Using non-parametric permutation testing (p<0.05), we found that, in each culture, both sets of facial expressions systematically comprise expansion and contraction facial movements (e.g., wide opened eyes, wrinkled nose, respectively) that map onto broad affective information (see Fig. 1A). Specifically, *expansion* facial movements are primarily associated with high arousal, regardless of positive/negative valence, while *contraction* facial movements are primarily associated with negative valence, regardless of high/low arousal.

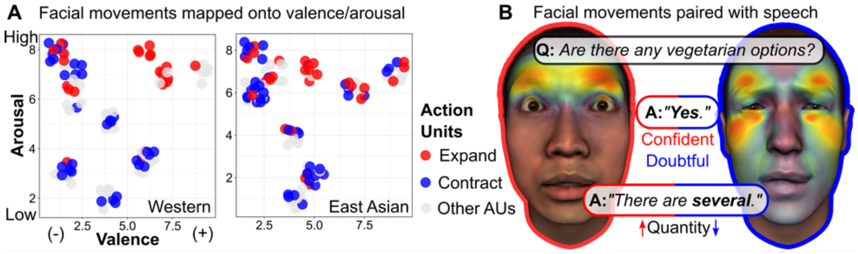

Figure 1. A: Mapping between expansion and contraction facial movements and valence and arousal, for each culture. Color-coded points denote expansion/contraction facial movements (see legend to right). In both cultures, expansion facial movements are primarily associated with high arousal, regardless of positive/negative valence (e.g., HAPPY, FEAR). Contraction facial movements are primarily associated with negative valence, regardless of high/low arousal (e.g., DISGUST, SAD, BORED, CONFUSED). **B:** Expansion and contraction facial movements also influence the interpretation of spoken words. Left: Expansion facial movements convey speaker CONFIDENCE when answering questions ("*yes*") and LARGER quantities when speakers use vague quantifiers ("*several*"). Right: Contraction facial movements convey DOUBT and SMALLER quantities.

Next, we examined whether expansion and contraction facial movements modify the perception of otherwise neutral speech. In two experiments (Nölle et al., 2022), participants in each culture (Western European English speakers, East Asian Mandarin speakers) rated speakers displaying expansion or contraction facial movements. In the first experiment, participants rated the confidence of a speaker answering *yes/no* to a question. Results showed that participants in both cultures rated speakers displaying *expansion* facial movements as more CONFIDENT, and those displaying *contraction* facial movements as more DOUBTFUL (Fig. 1B). In the second experiment, participants estimated the quantity the speaker referred to using a vague quantifier (e.g., *several*). Results showed that participants in both cultures associated *expansion* facial movements with HIGHER quantities and *contraction* facial movements with LOWER quantities (Fig. 1B).

In sum, we found that social facial expressions comprise opposing expansion and contraction facial movements that map onto broad affective, semantic and pragmatic information. Our results support the hypothesis that physiologically-rooted facial movements underpin a broad spectrum of facial expressions—a pattern consistent across two distinct cultures with known differences in facial expression perception (Jack, 2013). This suggests that such facial movements may have guided the development of semantic and pragmatic facial signals that support spoken language in multimodal communication. Future research should examine whether similar mappings exist amongst other cultures, sign languages, and species for homologous and non-homologous expressions.

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