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High-Resolution Facial Electromyography in Freely Behaving Humans

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Abstract : Human facial expressions carry important psychological and neurological information. Facial expressions involve the co-activation of diverse muscles. They depend strongly on personal affective interpretation and on social context and vary between spontaneous and voluntary activations. Smiling, as a special case, is among the most complex facial emotional expressions, involving no fewer than 7 different unilateral muscles. Despite their ubiquitous nature, smiles remain an elusive and debated topic. Smiles are associated with happiness and greeting on one hand and anger or disgust-masking on the other. Accordingly, while high-resolution recording of muscle activation patterns, in a non-interfering setting, offers exciting opportunities, it remains an unmet challenge, as contemporary surface facial electromyography (EMG) methodologies are cumbersome, restricted to the laboratory settings, and are limited in time and resolution. Here we present a wearable and non-invasive method for objective mapping of facial muscle activation and demonstrate its application in a natural setting. The technology is based on a recently developed dry and soft electrode array, specially designed for surface facial EMG technique. Eighteen healthy volunteers (31.58 ± 3.41 years, 13 females), participated in the study. Surface EMG arrays were adhered to participant left and right cheeks. Participants were instructed to imitate three facial expressions: closing the eyes, wrinkling the nose and smiling voluntary and to watch a funny video while their EMG signal is recorded. We focused on muscles associated with 'enjoyment', 'social' and 'masked' smiles; three categories with distinct social meanings. We developed a customized independent component analysis algorithm to construct the desired facial musculature mapping. First, identification of the Orbicularis oculi and the Levator labii superioris muscles was demonstrated from voluntary expressions. Second, recordings of voluntary and spontaneous smiles were used to locate the Zygomaticus major muscle activated in Duchenne and non-Duchenne smiles. Finally, recording with a wireless device in an unmodified natural work setting revealed expressions of neutral, positive and negative emotions in face-to-face interaction. The algorithm outlined here identifies the activation sources in a subject-specific manner, insensitive to electrode placement and anatomical diversity. Our high-resolution and cross-talk free mapping performances, along with excellent user convenience, open new opportunities for affective processing and objective evaluation of facial expressivity, objective psychological and neurological assessment as well as gaming, virtual reality, bio-feedback and brain-machine interface applications.

Keywords : affective expressions, affective processing, facial EMG, high-resolution electromyography, independent component analysis, wireless electrodes
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