Mechanosensory Modulation of Trigeminofacial Pathways During Speech

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Abstract:
The human orofacial sensorium is richly endowed with low-threshold A-delta mechanoreceptors that respond vigorously to self-generated movements and externally applied loads. The effects of such mechanoreceptors upon the motor units of the facial musculature are not well understood. The present study examines the modulation of trigemino-facial reflexive responses during the production of speech gestures and the accompanying lip forces. The trigemino-facial response (TFR) was elicited by delivering a mechanical perturbation to the lips in a randomized block design using a force compression operating range of zero to 0.60 Newtons. A 154.16-micron mechanical stimulus, which is known to modulate perioral muscle activation, was used to trigger the TFR in experimental subjects. The effects of force threshold and task dynamics (speech vs. nonspeech motor control) were evaluated to characterize reflex specificity, gain, and modulation as a function of force threshold and task dynamics. Significant modulation of the early (R1 — peak latency 18-23 ms) and late components (R2 — peak latency 30-60 ms) of the perioral TFR were repeatedly observed at bilateral sites overlying the orbicularis oris superior muscle in the superior m. (upper lip) and the orbicularis oris inferior m. (lower lip) during speech task dynamics using similar threshold criteria. R1 and R2 were frequently observed at the homonymous muscle stimulation site (OOI-Right), with the R2 response observed contralateral to the mechanical input. The consistent appearance of R2 during this speech task, which is presumed to involve suprabulbar pathways, represents a new and significant finding. Modulation of the trigemino-facial pathways during nonspeech task dynamics using similar threshold criteria evokes R1, similar stimuli rarely evokes R2.

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Methods:
A custom-controlled linear motor operating in position feedback was used to present mechanical inputs to the lip muscles. A 154.16-micron mechanical perturbation (0.20 Newtons during lip rounding for the speech gesture “ah-wa”) associated with active contraction of the orbicularis oris muscles was used to trigger the TFR in experimental subjects. A waveform discriminator was programmed in a randomized block design (~30 reps/force threshold), plus two subjects (ages 20-24 years) produced a series of speech gestures associated with the speech task. Each of the 9 normal female subjects (age 20-24 years) conducted a series of speech gestures in a randomized-block design ± 10 macrosecond flexibility, plus two control conditions. A waveform discriminator was programmed to trigger the servo linear motor in randomized force off 0.20 Newtons for the four-thousand conditions in both R1 and R2 (OOS-Right), R1 and R2 were frequently observed at the homonymous muscle stimulation site (OOI-Right), with the R2 response observed contralateral to the mechanical input. Significant modulation in the force task is influenced by the task dynamics (speech vs. nonspeech control).