Mechanosensory Modulation of Trigeminofacial Pathways During Speech

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Abstract:

The human orofacial sensorium is richly endowed with low-threshold SA mechanoreceptors that respond vigorously to self-generated movements and externally applied loads. The effects of oral mechanosensory flow on the recruitment of motor units and resultant force during speech is undefined. Mechanically evoked activity in the orbicularis oris superior and inferior muscles was studied in young human adults (N=9) during active lip force recruitment (pursing the lips) associated with repeated productions of the speech gesture "*ah-wa*." This controlled motor task involved recruitment of perioral motor units through a force compression operating range of zero to 0.60 Newtons. A 6-point array skin contactor coupled to a servo controlled linear motor operating under position feedback was used to deliver precise mechanical inputs to select quadrants of the lip vermilion in order 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 response was observed in the electromyograms sampled from the upper and lower quadrants of the orbicularis oris muscle under these conditions. 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 trigeminal-facial pathways during nonspeech task dynamics using similar stimuli rarely evokes R2.

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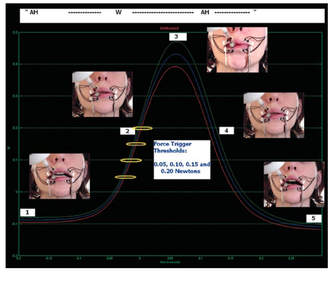
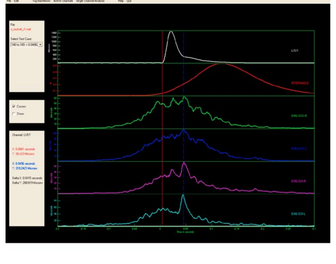
Methods:

A servo controlled linear motor operating in position feedback was used to present mechanical inputs to the lip vermilion (1300 microns displacement, 6 ms rise/fall) triggered to discrete force threshold points associated with lip rounding during production of the speech phrase "***ah-wa***." Mechanically evoked EMG responses were sampled from bilateral sites overlying the orbicularis oris superior m. (upper lip) and the orbicularis oris inferior m. (lower lip) using custom-designed, low profile 4 millimeter diameter Ag/AgCl hydrogel surface electrodes. A special low-mass force transducer was placed between the corners of the mouth and used by the subject for real-time monitoring of force dynamics associated with the speech task. Each of the 9 normal female subjects (ages 20-24 years) produced a series of "***ah-wa***" gestures in a randomized block design (~30 reps/force threshold), plus two control conditions. A waveform discriminator was programmed to trigger the servo linear motor in randomized blocks of 30 trials among the four threshold conditions including 0.05, 0.10, 0.15, and 0.20 Newtons during the recruitment phase of lip compression associated with active contraction of the orbicularis oris muscles during lip rounding for the /**w**/ in "ah-**w**a."

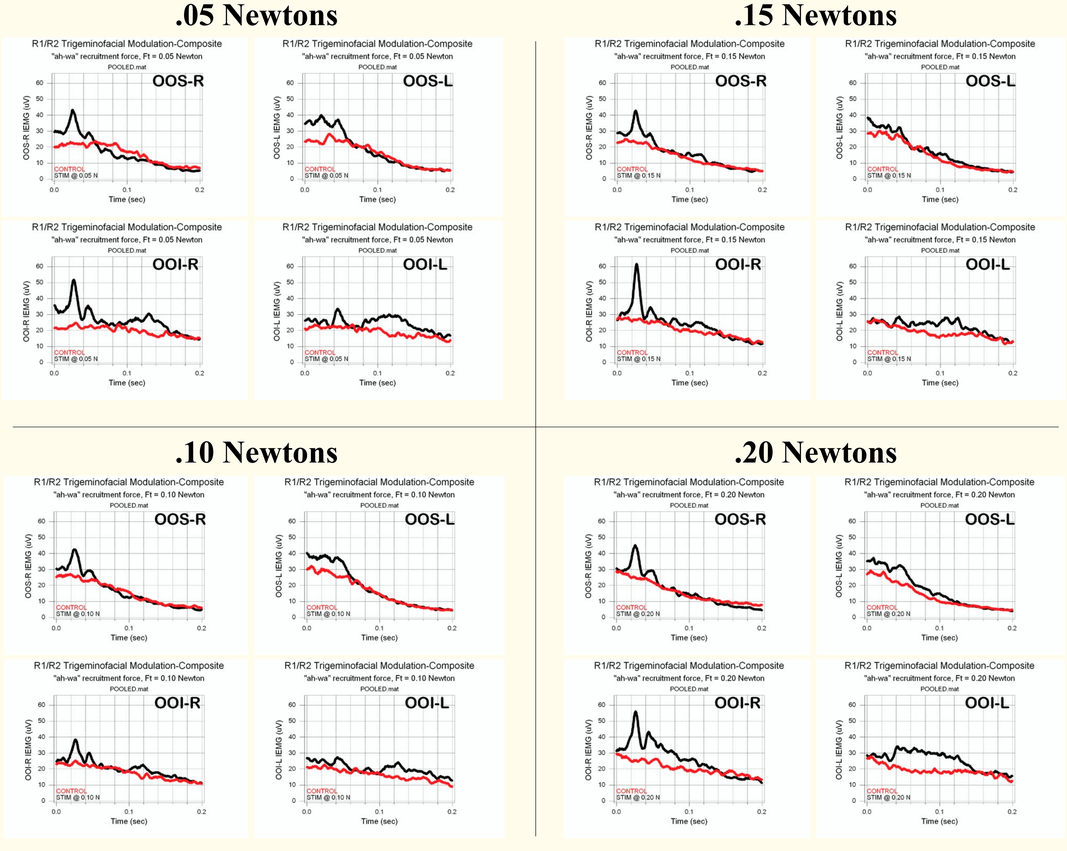
Perturbation Paradigm During Speech "ah-wa"



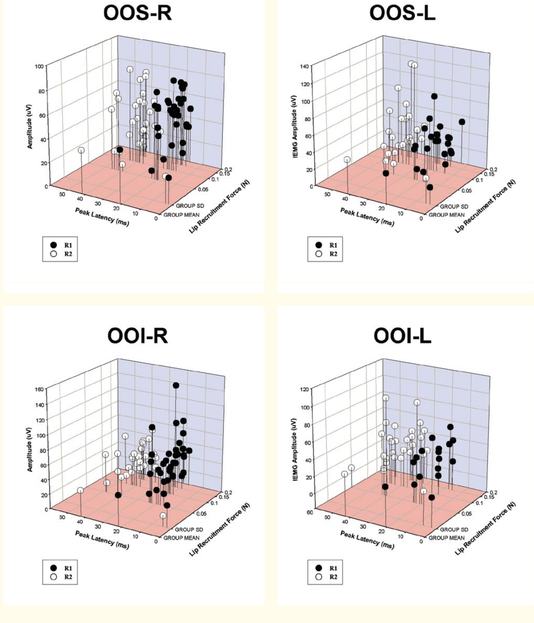
Mechanical Inputs to Lower Lip (right side) Drive R1 and R2 Among Perioral Muscle Sites



Composite Mechanically Evoked Trigemino-Facial Responses as a Function of Lip Force



Distribution of Individual R1 & R2 Peak Latency and Amplitude



Pooled R1 & R2 Trigemino-Facial Response Profile N=9 adults								
Muscle	**Latency (ms)**				**Amplitude (uV)**			
	RI		**R2**		**RI**		**R2**	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
OOS-R	**20.80**	**1.99**	**41.74**	**3.59**	**44.70**	**21.92**	**36.89**	**22.59**
OOS-L	**20.36**	**3.39**	**41.48**	**5.56**	**35.99**	**19.84**	**40.91**	**29.38**
OOI-R	**21.79**	**2.32**	**42.37**	**4.32**	**41.73**	**29.80**	**35.57**	**14.98**
OOI-L	**20.69**	**2.61**	**42.77**	**6.80**	**28.04**	**16.42**	**31.61**	**21.63**

Conclusions:

The early (R1 – brainstem) and late (R2 - suprabulbar) components of the trigemino-facial response were consistently evoked during force recruitment associated with lip rounding in all test subjects during the speech task "ah-wa."

R1 and R2 were frequently observed at the homonymous muscle stimulation site (OOI-Right), with the R2 response observed contralateral to the mechanical input.

Sensorimotor integration in the lower face is influenced by the task dynamics (speech vs. nonspeech motor control).