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Stability in postural tongue control: response to transient mechanical perturbations.

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Introduction

Tongue has properties as a muscular hydrostat that are unique in the human body. It is also a fundamental organ in a variety of basic biological functions for humans, such as breathing, swallowing and speaking. However, the neurophysiological mechanisms enabling its fine motor control have not been yet thoroughly investigated. While the involvement of reflex mechanisms has been largely documented for quick compensations in postural control of limbs and body as a low-level of control function, the functional role or even the existence of autogenous reflex has not been yet clearly established for the tongue. This study aimed at **investigating tongue reflex characteristisc by examining responses to transient mechanical perturbations in postural tongue control.**

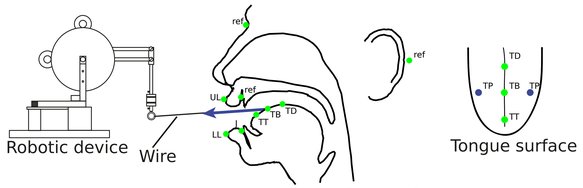
Method

Participants: 8 native speakers of French.

Task: Combination of the following vowels and manners.

(1) Vowel: /i/, /e/ and /ɛ/.

(2) Manner: Voicing, Whispering and Posturing

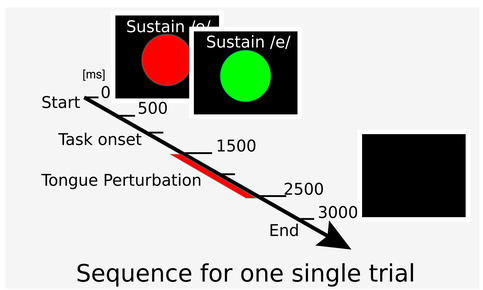


Experimental setup

Tongue perturbation: 1 N of step-wise force in forward direction was applied in the trials selected randomly.

Electromagnetic articulograph (Wave NDI inc.)

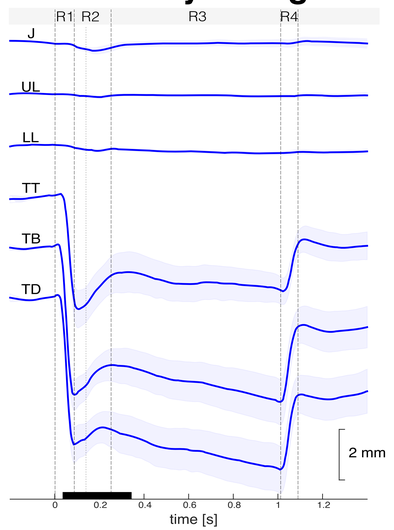
Jaw (**J**), upper and lower lip (**UL** and **LL**), and tongue tip (**TT**), blade (**TB**) and dorsum (**TD**) were recorded at 400 Hz. Nasion, upper incisor and left and right mastoid were for references of head movement correction. Speech sounds were recorded at 44.1kHz.

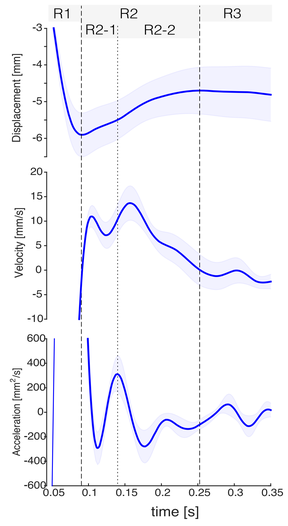


Sequence for one single trial

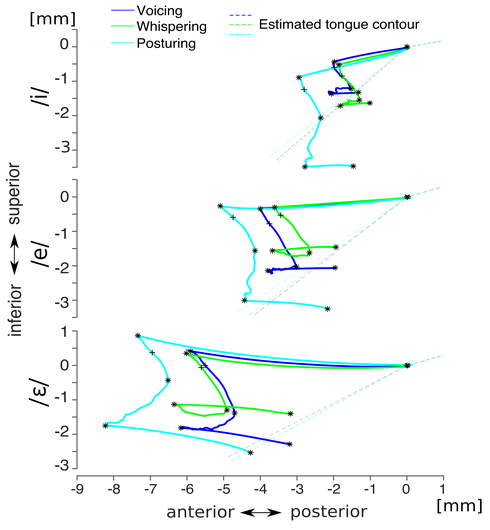
Results

Articulatory changes



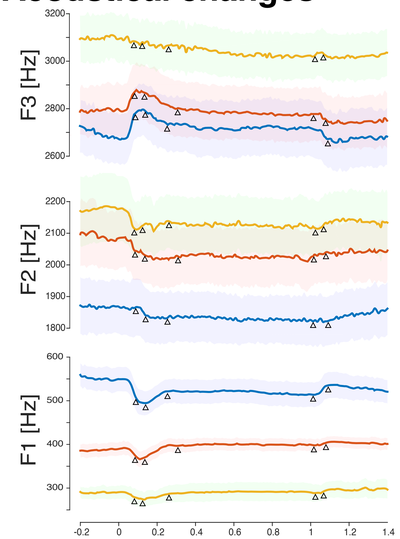


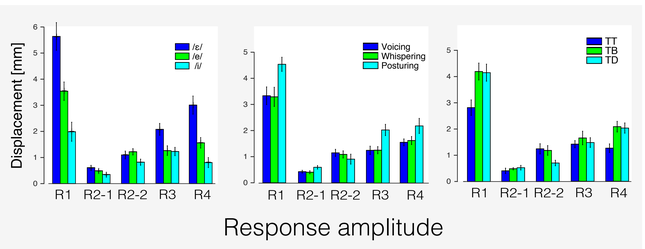
Horizontal displacements



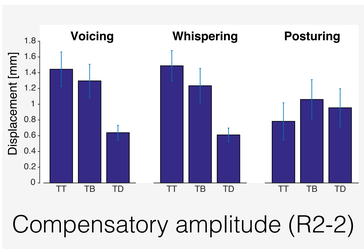
Displacement of TB in sagittal plane

Acoustical changes





Response amplitude



Compensatory amplitude (R2-2)

(1) Compensatory response was induced not in the direction to return the original location, but in the direction to recover the original tongue contour.

(2) The amplitude of the compensatory responses (R2-2) in each tongue location were modulated depending on speaking manners [$F_{(4,182)} = 8.33$, $p < .001$].

(3) Initial displacement changes due to the tongue perturbation (R1) was varied depending on the vowel tasks [$F_{(2,182)} = 13.45$, $p < .0001$] and the speaking manners [$F_{(2,182)} = 4.82$, $p < .01$], but no reliable interaction between them [$F_{(4,182)} = 1.73$, $p > .15$]. This tendency was also found in R2-1 and R4.

Discussion

- The current response can be generated by reflex mechanism, but not by voluntary reaction because the latency of response [around 140 ms to the movement onset] is faster than the latency for voluntary reaction [150±13 ms in jaw (Ottenhoff et al., 1992), 315.7±98.4ms for lip (Ito et al., 2005) and 154 ms in finger (Cole and Abbs, 1987) to the onset of muscle activition increase].

- The acoustical change due to the tongue perturbation was also compensated quickly in conjunction with the articulatory compensation. This may be driven not by auditory-basis, but by somatosensory-basis mechanism since the compensation was induced even in whispering condition and the current auditory compensation was occurred faster and greater than the ones induced by auditory perturbation (Larson et al., 2000; Purcell and Munhall, 2006).

Summary

(1) We demonstrated a quick compensatory response of the tongue, which may be driven by reflex mechanism, that was modulated in task-dependnent manner.

(2) The tongue may be controlled not by a specific target at each individual sites, but by an abstract target, such as a tongue contour in the posture control for vowel production.

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