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Preferred track: Speech Motor Control

Title: Specificity of speech sensori-motor learning

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Brief Biographical Sketch

First Name	Last Name	Bio
Amélie	Rochet-Capellan	Post-doctoral Fellow at McGill University, Canada. Received Ph.D. from Grenoble University, France. Ph.D. thesis focused on the link between language universals and the motor constraints of speech production. Current research focuses on speech sensori-motor learning and its consequences for speech perception.
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Preferred format: Oral presentation.

Key words: Auditory-motor adaptation, Acoustical perturbation, Specificity of motor learning.

Audiovisual requirements: None.

ABSTRACT

Specificity of speech sensori-motor learning

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The present study examines the specificity of sensori-motor learning in speech production by assessing speakers' abilities to correct for opposing acoustical changes to the first formant (F1) of the vowel in CVC words. The training utterances were composed either of different vowels in the same consonantal context (experiment 1: "had" shifted up; "head" shifted down or unshifted); or the same vowel in different consonantal contexts (experiment 2: "head" shifted up; "bed" shifted down and "ted" unshifted). The results show that, in the same training phase, the speakers compensate for the two opposite acoustical shifts independently by reliably modifying F1 in a direction opposite to the shift and F2 *minus* F1 in the same direction as the shift. This adaptation does not transfer to the unshifted word. These results support the hypothesis that sensori-motor learning in speech is local or instance-based. They also show that this specificity is applied to complete production units (in this case words) rather than the individually shifted sounds (in this case vowels).

PROPOSAL SUMMARY

Specificity of speech sensori-motor learning

Introduction: During the acquisition of speech, children learn a relationship between motor commands and sensory feedback that enables then to achieve speech targets. However, the anatomy of perceptual-motor system changes continuously over the course of development, and accordingly sensori-motor representations have to be re-mapped or updated in order to achieve desired movements and sounds. This sensori-motor plasticity is also evident in adult speech. For example, during CVC production, speakers compensate for real-time perturbation of vowel formants in auditory feedback (Houde & Jordan 1998, 2002; Purcell & Munhall 2006 a, b; Villacorta et al. 2007). Here, we focus on the specificity of this sensori-motor remapping. In a first experiment, we tested whether the subjects could independently learn more than one sensori-motor transformation by shifting the first formant (F1) of two different vowels in opposite directions over the course of the same training session (/æ/ "had" and /ɛ/ in "head"). In a second experiment, we tested whether the adaptation is specific to each utterance by assessing the extent to which subjects could simultaneously learn opposite perturbations of a same sound unit (the vowel /ɛ/) embedded in different phonetics contexts (the words "head" and "bed").

Methods: Thirty-six native speakers of English with no reported impairment of hearing or speech were trained to produce CVC words while their auditory feedback (F1) was shifted in real-time, by about +24% for the upward shift and about -15% for the downward shift. Subjects read test words in random order from a computer monitor. In the first experiment, for all 24 subjects, F1 in "had" utterances was shifted down while F1 in "head" utterances was shifted up for half of the subjects and unshifted for the other half (control group). In Experiment 2 (12 new subjects), F1 was shifted down for "head", shifted-up for "bed" and unshifted for a control-word "ted". Adaptation to the shift was evaluated by measuring the acoustical changes from before to after adaptation in F1, F2 and F2 *minus* F1 frequencies.

Results: In the first experiment, the subjects compensated for both the downward shift of F1 in "had" and for the upward shift of F1 in "head", while "head" utterances with normal feedback remained unchanged. The adaptation for "had" involved a reliable 6% increase in F1 that compensated for about 37% of the applied shift. The increase in F1 was associated with a non-significant decrease in F2, which resulted in an overall decrease in F2 *minus* F1 of about 8%. For "head" utterances, the subjects compensated for about 47% of the upward shift by significantly decreasing F1 by about 9%. There was also a non-significant increase of F2 and a clear change in F2 *minus* F1, which increased by about 7%. Finally, none of the three measures displayed a significant change in the production of /head/ when the feedback of this word was unshifted.

In the second experiment, the subjects simultaneously compensated for an upward shift of F1 in "head" and a downward shift of F1 in "bed". This adaptation did not affect the production of "ted" which involved normal feedback. The acoustical analysis showed that the subjects compensated for about 37% of the downward shift for "head" by increasing F1 by about 7%. At the same time, they compensated for about 32% of the upward shift for "bed" by decreasing F1 by about 6%. F2 change was not reliable for either utterance. F2 *minus* F1 significantly increased

by 6% for "bed" and decreased by 7% for "head". None of the three measures displayed any significant change during repetitions of "ted".

Discussion: The results of the first experiment show that speakers are able to adapt to opposite shifts of F1 in "head" and "had" independently. Moreover, there is no transfer of the adaptation from "had"-shifted to "head"-unshifted. The second experiment shows that both the ability to adapt to the two opposite shifts and the absence of transfer to the unshifted utterance is not due to the fact that the two vowels were different. Indeed, speakers were able to adapt to opposite shifts in "head" and "bed" utterances while maintaining the vowel in "ted" utterances. Taken together, these results are consistent with the idea that the mapping between the motor command and the sensory feedback in speech learning is specific to complete production units (in this case words) rather than to the individual sounds (in this case phonemes).

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