Relationship between sensory memory and speech motor learning

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Introduction

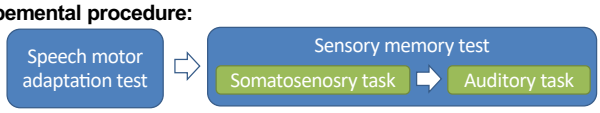
- Learning to acquire new motor skills requires the retention of sensory information about prior movements.
- In work on reinforcement learning, individual differences in sensory memory capacity were found to be correlated with the overall magnitude of learning (Sidarta et al. 2018), which raises the possibility that better retention of information may also contribute to better performance in error-based learning.
- In the case of speech, audition and somatosensation are the main sensory sources of information for learning.
- Both kinds of memory could possibly be related to the capacity for motor learning and adaptation.

To test this possibility, **we here examined whether individual differences in auditory and somatosensory memory capacity can predict speech motor adaptation.**

Method

Participants: 21 French native speakers (nine women, ages 18-35 yr)

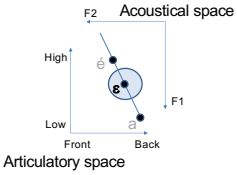
Expemental procedure:



Data analysis:

Pearson product moment correlation coefficient were compared between adaptation and memory scores.

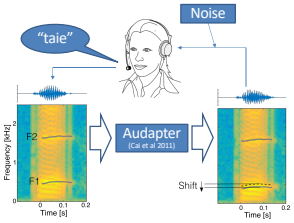
- Adaptation score: Change in normaized F1
- Memory score: the sensitivity index,
  d' = Z(hit rate) – Z(false alarm rate)



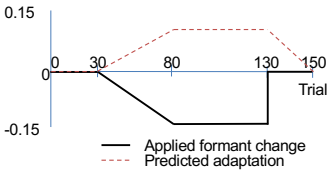
Target speech utterances

Speech motor adaptation test:

- Repeat /tɛ/ ("taie": pillow cover in English) in 150 times.
- F1 of the produced sound was changed over the course of trials.



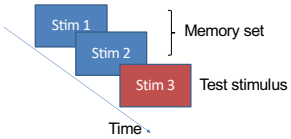
Altered auditory feedback system



Formant changes over the course of training

Sensory memory test:

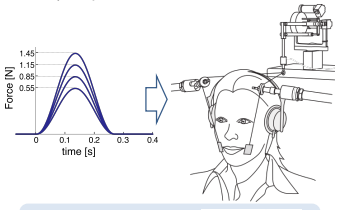
- To judge whether a test stimulus was presented in memory set.
  Memory set: two of four stimulus variants.
  Test stimulus: one of four stimulus variants.
- All possible combinations (48) were tested in random order and repeated 4 times each (192 trials).
- Somatosensory test and auditory test were carried out seperately.



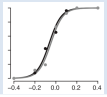
Stimulus sequece of one trial

Somatosensory stimuli

Four different amplitudes (0.3 N difference each) of upward facial skin stretch.

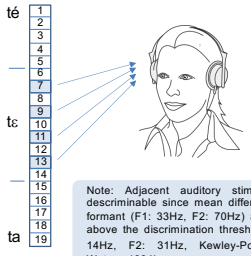


Note: A 0.3 N of force diffrence is discriminable based on a previous finding in which 0.2 N differences produced a 90% discrimination rate (Ito and Ostry 2012).



Auditory stimuli

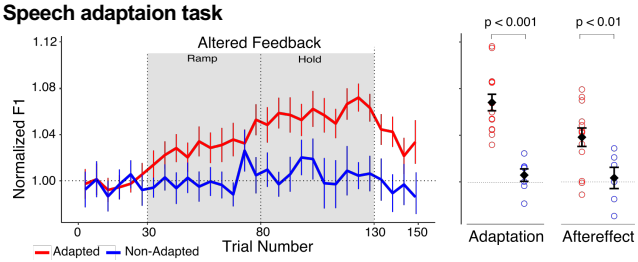
Four variants of the /tɛ/ sound on a synthesized continuum between /té/ and /ta/ (Nos 7, 9, 11 and 13).



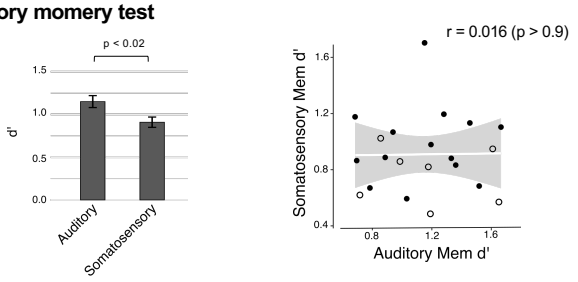
Note: Adjacent auditory stimuli are descriminable since mean differnces in formant (F1: 33Hz, F2: 70Hz) are well above the discrimination threshold (F1: 14Hz, F2: 31Hz, Kewley-Port and Watson 1994).

Results

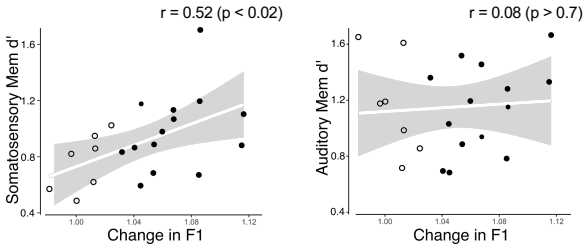
Speech adaptaion task



Sensory momery test



Correlation analysis



Control test

- A separate ABX test showed that the correct performance rate for adjacent stimulus pairs was above chance (0.75 ± 0.019 s.e., n = 15).

  ⇨ The current auditory stimuli is discriminable.

- The auditory memory test on its own showed that the observed d' (1.20 ± 0.12 s.e, n =10) was not different from the one in the main test (1.15 ± 0.07 s.e, t(15.3) = 0.37, p > 0.7) .

  ⇨ The order of perceptual testing does not affect to a measure of auditory memory performance.

Summary

- The magnitude of adaptation to altered auditory feedback varied substantially as in Lametti et al. (2012).
- Subjects' auditory sensory memory was better than their somatic sensory memory in the current test.
- Sensory memory scores were uncorrelated.
- Measures of speech motor adaptation were correlated with somatosensory memory performance, but not with auditory memory performance.

Even though the nature of the task is primarily auditory, motor learning itself may be substantially reliant on somatosensory inputs and memory processing.

Acknowledgement

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