Relationship between sensory memory and speech motor learning

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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.

We carried out a speech motor adaptation task along with somatosensory and auditory memory tasks using a within-subject design. As stimuli for three tasks, we focused on a group of vowels e-ɛ-a, which are acoustical and articulatory neighbors. In the speech motor learning task, the speech utterance /tɛ/ was used. In the auditory memory task, the stimuli were discriminable variants of the vowel /ɛ/ which were drawn from a synthesized speech sound continuum te-tɛ-ta. In the somatosensory memory task, small orofacial skin stretch was applied in an upward direction (Ito and Ostry 2012). This direction was chosen based on the fact that the vowels è-e-a are distinguishable on the basis of their vertical articulatory position and movement. As the model of speech motor learning, we studied the adaptation that occurs when subjects' auditory feedback is altered in real-time during speech production. An acoustical-effects software (Cai et al. 2011) was used to shift portions of the frequency spectrum of the signal from the microphone and played it back to subjects through headphones in real-time. The shift was gradually applied over repetitions of speech utterance /tɛ/. Sensory memory performance was tested in somatosensory and auditory tasks separately. The procedure in both sensory tasks was similar, that is, subjects were required to identify whether a test stimulus had been presented previously as part of a memory set of stimuli. We prepared four different sensory stimuli as memory and test items. On each trial, two of the stimuli were used to form the memory set and one of the original four was used as the test stimulus. All possible combinations with four stimuli were tested in random order.

The results of the motor learning task showed that two-thirds of the subjects tested adapted to the altered auditory feedback manipulation. In the sensory memory tests, a sensitivity index, d' was computed. It was found that auditory memory performance was better than somatosensory memory performance in the current test. Despite better performance in the auditory memory task, we found that measures of speech motor adaptation were correlated with somatosensory memory performance, but not with auditory memory performance. The results suggest that even though the nature of the task is primarily auditory, motor learning itself may be more reliant on somatosensory inputs and memory processing.

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