SUPPLEMENTAL DATA

Participants

Thirty-six healthy adults, native French speakers, participated in the study: 20 in Experiment 1 (tongue motor training; 8 females; mean age ± SD, 29 ± 2 years) and 16 in Experiment 2 (lip motor training; 6 females; mean age ± SD, 32 ± 3 years). All participants were right-handed (according to a 10-item version of the Edinburgh Handedness Inventory; Oldfield, 1971), had normal or corrected-to-normal vision and reported no history of speaking, hearing or motor disorders. All were naive as to the purpose of the experiment.

Stimuli

The set of stimuli consisted of 40 individual syllables: 10 /pa/, 10 /ta/, 10 /pa/ embedded in white noise (/pa/$_{noise}$) and 10 /ta/ embedded in white noise (/ta/$_{noise}$). Multiple utterances of /pa/ and /ta/ syllables were first individually recorded by ten native male French speakers in a sound-attenuated room. One clearly articulated token of each syllable was selected per speaker and digitized in an individual sound file at a sampling rate of 44.1 kHz with 16-bit quantization recording. Using Praat software (Institute of Phonetic Sciences, University of Amsterdam, NL), each syllable was scaled to 68 dB and cut, at zero crossing points, 100 ms preceding the consonantal burst and 100 ms following it. Another set of masked syllables was then created. For each syllable, a Gaussian white-noise, de-emphasized to better match the frequency spectrum of /pa/ and /ta/ syllables and with a 5 ms rise decay envelope was generated. The mask was 100 ms in duration and was presented simultaneously from the consonantal burst of the syllable, with a signal-to-noise ratio (SNR) of -5 dB.

Procedure

Except for the motor training task (tongue or lip motor training), the experimental design and apparatus were identical in both Experiment 1 and Experiment 2. The experiments were carried-out in a quiet, darkened room. Participants sat in front of a computer monitor at a distance of approximately 50 cm. The acoustic stimuli were presented at a comfortable sound level through headphones, with the same sound level for all participants. Participants underwent two identical syllable identification tasks: one immediately followed the motor training task (motor), the other one was performed without prior motor training (control; see below). The interval between tasks was half an hour and their order of the motor training was fully counterbalanced across participants in each experiment.

Presentation software (Neurobehavioral Systems, Albany, CA) was used to control the stimulus presentation and to record key responses. In the syllable decision task, each trial started with a fixation cue (the '+' symbol) presented in the middle of the screen for 500 ms, followed by the presentation of a syllable for 200 ms, and ended with a blank screen for 2500 ms. Participants were instructed to produce a motor response as fast and accurately as possible, by pressing, with either their right index or ring finger, one of two keys corresponding to /pa/ or /ta/ syllable. The response key designation was fully counterbalanced across participants in each experiment.

Before starting the experiment, participants received a short training. During each experimental session, a brief summary of the instructions was first presented on the screen. 8 practice trials were also included at the beginning of the task and were removed from the analysis. Except these practice trials, the syllable decision task included 80 randomly presented trials (20 /pa/, 20 /ta/, 20 /pa/$_{noise}$, 20 /ta/$_{noise}$).

Motor Training

Procedure. In the tongue motor training task, participants were asked to repeatedly raise and press their tongue to the anterior (hard) palate while keeping their mouth closed (to prevent mylohyoid activity related to mandible movements). In the lip motor training task, participants were asked to repeatedly protrude their lips 'as for doing a silent kiss'. Participants were first trained to produce the above-mentioned tongue-elevation or lip-protrusion movements with maximum voluntary contraction of the related muscle while receiving visual feedback indicating the amount of electromyographic (EMG) activity on a second computer monitor. Then, they were briefly trained to repeatedly perform tongue/lip movements with, for each movement, the instruction to maintain a level of contraction of around 80% of their maximum voluntary contraction for 2 s, then to relax for 2 s, and so on. To this aim, a fixation cue (the '+' symbol) was presented in the middle of the screen for 2 s and ended with a blank screen for 2 s. Finally, participants performed the motor training task, consisting of 150 tongue or lip movements (2 s contraction / 2 s relaxation) for 10 min. The 10 min duration of the motor training task was selected according to previous single-pulse transcranial magnetic stimulation (TMS) studies showing that short-term motor training in a tongue-task is associated with rapid neuroplasticity of the orofacial primary motor area in the human cerebral cortex, as reflected in significantly enhanced tongue motor evoked potentials (MEP) and reduced motor threshold (Svenson et al., 2006; Boudreau et al., 2007).

Electromyography. Continuous EMG recordings from the mylohyoid (tongue motor training, Experiment 1) or the orbicularis oris (lip motor training, Experiment 2) muscles were acquired with a Biopac MP150 Data Acquisition System controlled by the Acqknowledge software (Biopac systems, Goleta, U.S.A.). The EMG signal was amplified (1000x), sampled at 1 kHz, and stored for offline analysis (band pass filtering: 30–500 Hz). Each muscle was recorded using Ag/AgCl surface electrodes (ELS254s shielded electrodes with 4 mm diameter recordings; Biopac systems, Goleta, U.S.A.) with a bipolar montage. In the tongue motor training, the two electrodes were placed 5 cm apart under the subject's chin, symmetrically to the midline. This recording was designed to capture surface EMG activity from the mylohyoid muscle (Cattaneo et al., 2007). This muscle is responsible for raising the tongue and lowering the mandible for mastication and swallowing (and in speech for producing high vowels and velar consonants; Epstein et al. 2002). Because increasing tongue-to-palate pressure has been shown to coincide with increased mylohyoid activity (Palmer et al., 2008), this recording provides an indirect measure of tongue elevation in the motor training (see below). In the lip motor training, lip muscle activity was directly recorded by means of two electrodes placed 2 cm apart on the right orbicularis oris superior muscle.

When debriefed at the end of the experiment, all participants reported having performed the motor task without difficulties. Because of low quality EMG signal due to poor electrode contacts (e.g., beard, mustache contact electrodes lost during the task), EMG data from 5 participants in the lip motor training task and 6 participants in the tongue motor training task could not be analyzed. For the other participants, visual monitoring of the EMG signal confirmed that both motor training tasks were perfectly performed. For each participant, the EMG signal was rectified and the mean areas under the curve (AUC) corresponding to 5 adjacent bins of 2 min were calculated. To allow comparison between participants, these values were normalized by expressing them as a percentage of the mean AUC obtained for the whole motor training task (10 min). For each articulator, an analysis of variance (ANOVA) was performed on these data with the Bin (1-5) as a within-subject independent variable. During both lip and motor training, a constant level of EMG activity was observed with no significant differences found across the five bins (tongue motor training: $F(4,52) = 1.75$; lip motor training: $F(4,40) = 0.50$).

<u>Data Analysis</u>

The percentage of errors and the mean RT observed in each condition (/pa/, /ta/, /pa/, $/pa/_{noise}$, $/ta/_{noise}$) were computed for each participant and each session (see Fig. 1). An ANOVA was performed on mean RTs with experimental Session (motor, control), Noise (with, without noise) and Syllable (/pa/, /ta/) as within-subject independent variables and Experiment (tongue motor training, lip motor training) as a between-subjects independent variable.

Regarding perceptual scores, because of the large differences in error rates between the noise and no-noise conditions and between responses to /pa/ and /ta/, we focused on the signal detection parameters, d-prime and beta. The d-prime measure indicates the ability to distinguish between the two syllables, regardless of the bias to respond /pa/. A d-prime of 0.0 indicates a complete inability to discriminate, and the larger the d-prime the better the discrimination. The beta measure indexes the bias to respond /pa/. As the bias to respond /pa/ increases, resulting in a higher hit-rate and false-alarm-rate, beta decreases. Conversely, as the bias to respond /pa/ decreases, resulting in a lower hit-rate and false-alarm-rate, beta increases.

For each participant, each session, and each condition, d-prime and beta scores were computed based on hit rates and false alarm rates. We treated trials in which /pa/ was presented as signal trials and trials in which /ta/ was presented as noise trials. Hence, a hit is calling a syllable /pa/ when /pa/ was presented, and a false alarm is calling a syllable /pa/ when /ta/ was presented. There were participants for whom the hit rate was 1.0 (mainly with no-noise trials) or the false alarm rate was 0.0, and in those cases d-prime and beta are undefined. Consequently, the hit rate was computed as the number of hits minus 0.5 and the false alarm rate was computed as the number of false alarms plus 0.5 (see Macmillan and Creelman, 2005, p.324). Then, we calculated d-prime using the formula d-prime = z(hit rate) – z(false alarm rate), and we calculated beta using the formula beta = exp(-d'*.5*(z(hit rate)+z(false alarm rate))).

Two separate ANOVAs were performed on d-prime and beta scores with the experimental Session (motor, control) and the Noise (with, without noise) as within-subject independent variables and the Experiment (tongue motor training, lip motor training) as a between-subjects independent variable.

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