Speech intelligibility decreases with degradation of somatosensory feedback via topical benzocaine application.

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Speech sensory feedback is inherently multimodal, with information from audition, somatosensation, and proprioception combining in ongoing articulatory control. Perturbation of feedback across perceptual modalities allows us to probe the nature of the representations underlying speech production and determine how information from different sensory streams comes together in the control process. Such multisensory integration has been shown to vary across speakers in the relative strength or weighting of somatosensory versus auditory feedback[1], predicting the magnitude of response to perturbation in either modality.

Further study into the multisensory relationship in speech feedback is warranted, but the methodologies required to perform feedback perturbation constitute a substantial barrier for widespread inquiry. The challenges are particularly large for somatosensory perturbation; effective manipulation methods have included a mechanical system linked to a custom dental apparatus that allows perturbation of the jaw with minimal acoustic effects[1], and application of anesthetic agents performed by a physician[2]. While these methods have obvious strengths, they are not accessible or feasible procedures to adopt for all speech researchers. In a series of two studies, therefore, we tested the potential for a commonly-available topical anesthetic (20% benzocaine suspension) to be used as a more accessible means of degrading somatosensory feedback in the vocal tract. In particular, we examined the impact of somatosensory degradation on perceptual intelligibility of speech, as measuring perceptual judgments from naïve listeners makes minimal assumptions regarding possible loci of change in normal speech motor control.

Experiment 1 – Benzocaine degradation. Participants (N = 25) produced speech in response to 139 orthographic word prompts in two sensory conditions: baseline, with normal sensory feedback; and following application of 0.1 mL 20% benzocaine gel (Orajel) to the participants' upper and lower lips and tongue blade. Speech was recorded (Audio-Technica AT4041) and used as stimuli in a "playback" perceptual study assessing relative intelligibility across the conditions.

Perceptual study of intelligibility. Naïve listeners (N = 33) heard tokens of speech from the baseline and benzocaine conditions in random order, and were asked to judge "which was easier to understand" in a 2AFC task. Listeners responded to a subset of 413 items sampling all 25 talkers, and responses were analyzed with respect to "chance;" significant deviations from a 50% rate of selection of either condition as "easier to understand" were taken as evidence of a change in intelligibility, broadly defined by our listeners.

Results and discussion. Listeners judged speech produced in the baseline as slightly more intelligible overall (M = 51.6%, SD = 5.6%), but not at rates significantly above chance ($t(32)$ = 1.6, p = .112). Therefore, we cannot say that 0.1 mL application of benzocaine had an effect on speech intelligibility in the absence of other factors. It may be unreasonable to assume, however,

that a partial disruption of somatosensory feedback would impact intelligibility in these talkers given their unimpeded access to acoustic feedback and the robust control it enables. Experiment 2 therefore tested the effects of an identical benzocaine application in the context of a previously-reported degradation of auditory feedback.

Experiment 2 – Simultaneous somatosensory and auditory degradation. Manipulation of auditory speech feedback via degradation of spectral resolution had been previously shown to decrease talkers' intelligibility[3]. In Expt. 2, therefore, we examined the effects of benzocaine application along with simultaneous auditory spectral degradation. A new set of speakers (N = 15) completed the same speech production protocol, in baseline normal conditions and with simultaneous auditory/somatosensory degradation. The recorded speech was once again used in a 2AFC perceptual playback study assessing relative intelligibility across the two conditions (listener N = 30).

Results and discussion. Listeners found speech produced with the bisensory degradation significantly less intelligible than speech from the unperturbed baseline ($t(29) = 7.5$, $p < .0001$), choosing baseline tokens as "easier to understand" 59.5% of the time (SD = 6.9%). This drop in intelligibility was also compared to the decrease observed with auditory-only degradation. A post-hoc analysis of listeners in this study and those in [3] found that the intelligibility decrease with benzocaine application was significantly greater than with auditory degradation alone ($M_{\text{A-only}}$ = 55.5% baseline preference; independent samples $t(67) = 2.1$, $p = .044$).

Discussion and conclusions. In these studies, we aimed to determine whether controlled application of a widely-available anesthetic used for oral pain relief might cause sufficient disruption of somatosensory feedback to impact global speech intelligibility. In Expt. 1, we did not see significant changes in naïve listeners' intelligibility judgments between speech produced with and without benzocaine application, but in the context of a simultaneous auditory degradation, we did see benzocaine effects. Speakers with benzocaine *and* auditory degradation showed greater drops in intelligibility than had been observed with the same auditory manipulation alone[3]. It appears, therefore, that topical benzocaine does degrade somatosensory information to a degree relevant for speech motor control, and its effects are sufficient to impact global intelligibility when other feedback streams cannot be used to compensate. Application of benzocaine is therefore a promising new avenue for feedback perturbation research in speech to explore.

References

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