Positional variability of articulatory gestures: Effects of practice and linguistic proficiency

Fabian Tomaschek
University of Tübingen

According to theories of articulation [3, 12], articulatory gestures are the invariant building blocks of words stored in the mental lexicon. Temporal variation in their execution is attributed to changes in speaking rate and prosodic variation in relation to contextual uncertainty and predictability [1]. While these theories account for systematic temporal variation, no assumptions are made about temporal and positional variation of articulatory gestures.

Investigations of hands movements have shown that short-term practice and local reduction of contextual uncertainty are associated with faster, smoother and less variable hand movements [6, 9]. Likewise, studies of articulation have shown that short-term and life-long practice leads to faster and smoother articulatory gestures [10, 11, 8]. In a similar vein, life-long learning is associated with a reduced variation of articulatory gestures [5, 4, 14, 2]. However, little is known how short-term practice and contextual uncertainty affect the positional variability of articulatory gestures.

We investigated this issue in a simple vertical articulatory gesture during which the tongue dorsum moved towards a vocalic target, as can be found in the German word 'sie' [zi] (they) (Fig. 1a). Since 'sie' is a highly frequent word in German, and thus a well-practiced articulatory gesture, little positional variation should be expected. 17 participants uttered 'sie + verb' phrases while tongue dorsum movements were recorded with Electromagnetic Articulography. Linguistic proficiency, and thus contextual uncertainty of 'sie', was operationalized as $P(sie|verb)$ [7]. Vertical tongue dorsum movements were fitted with GAMMs [13] which allow to fit both, the mean tractory and standard deviations serving as measure of positional variability.

The mean trajectory became smoother as a result of short-term practice during the experiment (Fig. 1b; tongue height is color coded: yellow = high, blue = low). In addition, short-term practice (measured by repetition) was associated with smaller positional variability (Fig. 1c, $F_{(3,3)}$=4923, <0.001). Crucially, a reduction of variability is associated with greater $P(sie|verb)$ (Fig. 1d, $F_{(8.4,9.3)}$=4162, p=<0.001, yellow = increased variability, blue = reduced variability). Crucially, the reduction of positional variability was located at the [i] target (cf. Fig. 1a).

These results indicate that short-term practice and linguistic proficiency modulate the articulation of even well-practiced articulatory gestures, thus challenging the assumption of invariant gestural representations in the mental lexicon [3, 12].

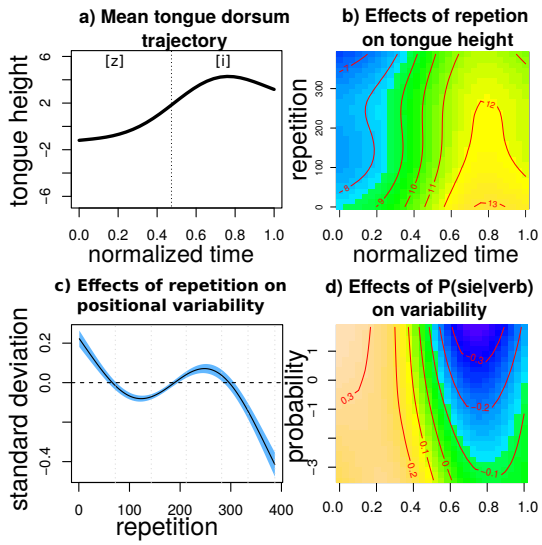

Figure 1 a) Mean tongue dorsum height (y-axis) as a function of time (x-axis). b) Effects of repetition during the experiment (y-axis) on mean tongue height (color coded) as a function of time (x-axis). Blue represents low tongue body positions, yellow represents high positions, green in between. c) Effects of repetition on articulatory variability (y-axis) around the mean articulatory trajectory as a function of repetition (x-axis). d) Changes in variability around the mean articulatory trajectory (color coded) as a function of $P(sie|verb)$ (x-axis) due to repetition during the experiment (y-axis). Blue represents low variability, yellow represents high variability, green in between.

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