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Research Article

Conditions favoring biomechanically driven CV co-occurrence in lexicons

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ABSTRACT

After having received serious consideration in the 1990s, the hypothesis that biomechanics is phonologized into probabilistic phonotactics subsided for methodological difficulties, while related child language studies gained ground.

This paper aims at restoring the original adult language orientation of the discussion of biomechanically driven consonant–vowel co-occurrence. It presents new, detailed evidence on two languages, British English and Brazilian Portuguese, where there is clear lexical support for two CV co-occurrence biases attributable to biomechanics: a trend for the combination of coronal consonants with front vowels, and a trend against the combination of dorsal consonants with front vowels. It also shows that such biases are stronger under conditions that complicate speech planning.

The analysis uses log-linear modeling in conjunction with other statistical techniques to assure comparability with previous studies and reliability of multiple comparisons.

Low overall effect sizes indicate that biomechanically driven CV biases only weakly affect free combination. However, under such complicating conditions as repetition or lack of stress combined with occlusion/obstruence in initial position, effect sizes grow and significant factor interactions emerge, suggesting that such biases help simplify speech planning.

Revisiting the phonologization of biomechanics hypothesis with today's tools supports it sufficiently to justify further pursuit and search for explanations.

1. Introduction

1.1. Aims

The question whether lexicons tend towards biomechanically driven consonant/vowel co-occurrence has been on the agenda of the field of phonetics/phonology for three decades (Janson, 1986; Maddieson & Precoda, 1992). Attempts to pursue it started in the 1980s, spread to psycholinguistics in the 1990s, and subsided in the 2000s, to reappear only indirectly in the present decade.

The reason for this revival is a controversy between two theoretical frameworks disputing the explanation of CV biases in child language: Frame/Content Theory (henceforth FC; MacNeilage & Davis, 1990, 2000a), an attempt to explain phonological ontogeny in relation to phylogeny, and Articulatory Phonology (henceforth AP; Browman & Goldstein, 1989, 1992), an attempt to integrate phonetics and phonology. The dispute concerns the ontogeny of the syllable: FC assumes that segment-sized articulatory gestures emerge from syllable-sized mandible oscillations (MacNeilage & Davis, 2011), whereas AP assumes that various speech organs oscillate in synergy to give rise to the early syllable (Giulivi, Whalen, Goldstein, Nam, & Levitt, 2011).

Since the late 1990s, comparisons between adult and child language have been restricted to the segment inventory of babbling (i.e., stops, nasals and glides), focusing exclusively on shared biases (MacNeilage & Davis, 2000a; MacNeilage, Davis, Kinney, & Matyear, 2000; Whalen et al., 2012). This inevitably sacrificed comparability with earlier corpus studies, besides leading to the covert assumption that the most important question about adult CV co-occurrence is whether it preserves young children's patterns.

By contrast, this paper aims at confirming that lexicons have reliable CV biases of their own and inquiring into their possible causes. The analysis encompasses the full segment inventories of the target lexicons to identify deviations from free combination and

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proceeds to investigate why they should occur at all. The hypothesis is that biomechanically driven CV biases give a free ride to pronounceability where segmental, positional and prosodic factors strain speech planning. Their facilitative role is due to the synergetic value of certain preferred combinations, which coincide partially with those encountered by Nam, Goldstein, Giulivi, Levitt, and Whalen (2013) in a simulation geared to child language, but based on an adult vocal tract model (see Section 1.2 below). Such biases are in favor of certain combinations: *coronal C/front V, dorsal C/central V, and dorsal C/back V*. However, as we will see below, their roles in child and adult language need not be the same if we consider the literature on co-articulation resistance (Iskarous et al., 2013; Recasens, Pallarès, & Fontdevila, 1997).

The same positional, prosodic and segmental pressures acting on phonological systems to produce phonetically motivated synchronic and/or diachronic phonological processes (Greenlee & Ohala, 1980; Kirby, 2013) may also act on probabilistic phonotactics to produce a certain amount of deviation from free segment combination. With respect to CV co-occurrence, it is plausible that concomitance with certain conditions that complicate speech planning enhances the probability of the abovementioned combinations.

One such complication is repetition. Based on naturalistic reports of speech errors, Dell (1984) ran two experiments to test the hypothesis that repeated sounds in a planned utterance cause phoneme exchanges, anticipations, and perseverations. Besides confirming the hypothesis, he found that repetition induces misordering of sounds. Later research adopting his experimental paradigm found that many apparent exchanges or substitutions actually contribute to stabilize the dynamics of speech plans (Pouplier, 2007). In turn, Walter (2007) drew on linguistic safeguards against repetition to design experimental tests of what she termed the “biomechanical repetition avoidance hypothesis”. Her evidence suggests that repetition of a place of articulation gesture severely strains articulation. Together, these works justify the hypothesis that CV combinations tend to be synergetic if repeated.

Another condition that may strain speech planning is position. Initial position stages a host of linguistic phenomena believed to facilitate planning, including initial strengthening (Keating, Cho, Fougeron, & Hsu, 2003). The fact that beginnings decelerate speech suggests that initiation is somehow difficult. MacNeilage and Davis (2000a) had independently pursued this idea through the study of a phenomenon called the labial–coronal effect (henceforth LC), observed in speech acquisition as well as in several genetically distant or unrelated languages. LC refers to the fact that, in CVC sequences containing a labial and a coronal, the labial tends to precede the coronal (L–C order) rather than the reverse (C–L order). The authors explain this effect by attributing greater simplicity to labial articulation. Other explanations were proposed later (e.g., Rochet-Capellan & Schwartz, 2007; Lancia & Fuchs, 2011), but did not challenge their basic tenet about the difficulty of “simultaneously initiating the respiratory, phonatory and articulatory components of the speech apparatus” (MacNeilage & Davis, 2000b, p. 156). Initiation may also depend on the temporal control of speech. For example, Mooshammer et al. (2012) found that the time to initiate words with different syllable structures (V, VC, CV, CVC, etc.) varied inversely with phonotactic probability, i.e., the most familiar syllable structures were facilitative. Together, these studies lead to the hypothesis that initiation may benefit from concomitance with other facilitators such as biomechanically driven CV combination.

Stress contours are still another complication for speech planning. De Jong, Beckman, and Edwards (1993) found that extent of co-articulation is inversely proportional to degree of stress in American English. They then conducted a series of experiments to show that stress contours do not simply implement sonority contrasts, but actually involve a complex interplay between various degrees of articulatory overshoot and undershoot. Harrington, Fletcher, and Roberts (1995) further examined the extent of overlap between the opening and closing jaw movements involved in stress distinctions and concluded that the mechanism underlying unstressed vowel reduction is truncation. By truncation they mean the cutoff of the entire final, steady-state part of the vowel opening gesture (the traditional target) caused by extensive overlap between this very gesture and its closing counterpart. In view of these facts, it is plausible that the smaller distances in tongue body position found by Nam et al. (2013, p. 72) in synergetic CV combinations enable the speaker to control the amount of truncation in unstressed position for efficient adjustment of undershoot. This leads to the hypothesis that languages tend to use synergetic CVs at points where the stress contour cannot allow for extreme reduction because of other articulatory demands. In many languages, such points lie at or close to initial position.

A final factor complicating speech planning is manner of articulation. Here two hypotheses are tenable. The first predicts that synergetic CVs will be favored with obstruents, due to the heavy aerodynamic demands that they place on coordination and co-articulation (Recasens & Espinosa, 2007). The other hypothesis predicts that this preference will be more evident with stops and affricates, due to the additional demands of relative laryngeal timing (Löfqvist & Yoshioka, 1981; Westbury & Keating, 1986).

To sum up, the basic stake of this paper is that lexical phonotactics may incorporate mechanisms that facilitate speech planning—among which synergetic CV combinations are the easiest to investigate, given the amount of available knowledge, briefly reviewed below.

1.2. Background

Biomechanics was not the first concern of the CV co-occurrence literature. Ohala and Kawasaki (1984), followed by Kawasaki-Fukumori (1992), relied on the sonority principle to argue for a need for sufficient acoustic contrast between C and V on the basis of survey data on categorical gaps in CV co-occurrence.

Janson (1986) took issue with this claim through an analysis of text corpora of five unrelated languages (Finnish, Latin, Latvian, Setswana, and Turkish), finding some consistent preferences that contradicted acoustic contrast. He submitted the alternative hypothesis that CV co-occurrence frequencies reflect articulatory economy. His grounds lay in the statistical support found for the following biases: labial C/rounded V, dorsal C/back V, and, to a lesser extent, coronal C/front V. His notion of economy, a precursor of