Title: Profiling Speech Motor Control: Validation of Novel and Existing Acoustic Features

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Introduction

The purpose of this study was to evaluate the construct validity of five acoustic features with the ultimate goal of developing a motor-based framework for assessing disordered speech. Within the dysarthria literature, features that index articulatory impairment have been found to account for most of the loss in intelligibility in comparison to measures from other speech subsystems [1]. Articulatory impairment is, however, broadly defined and may be used to indicate a wide range of problems regarding articulatory coordination and control. Moreover, the measures used to characterize different aspects of articulatory impairment have varied significantly across studies and few have been scientifically validated. There is, therefore, a critical need for a framework within which we can characterize speech motor deficits using a set of quantitative, interpretable, and validated measures [2,3,4].

The proposed pilot study is a first step in developing a comprehensive, hypothesis-driven articulatory feature set that probes five key components of speech and limb motor performance: *distinctiveness*, *consistency*, *coordination*, *rhythm*, and *speed*. We use speech rate manipulation as a validation technique because prior research has shown that changes in speaking rate impact the five proposed components of articulatory motor control in healthy control subjects [5,6,7,8].

Methods

Six healthy English-speaking controls (M = 1, F = 5) between 25 and 35 years of age were included in this study. Participants were asked to perform three repetitions of the sequential motion rate (SMR) task in three different rate conditions: 1) normal rate, 2) half of their normal rate, and 3) double their normal rate [6]. The five components were indexed using novel and existing acoustic measures of speech (see Figure 1).

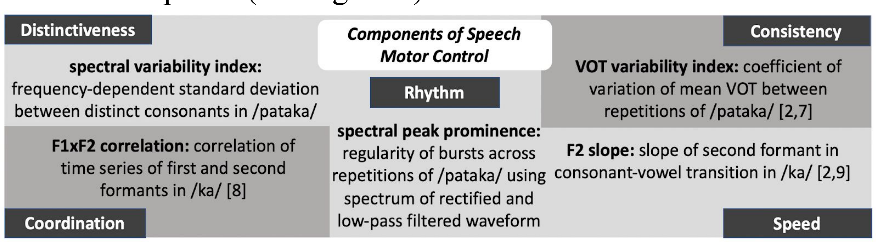
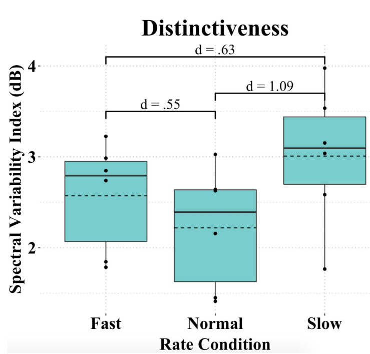
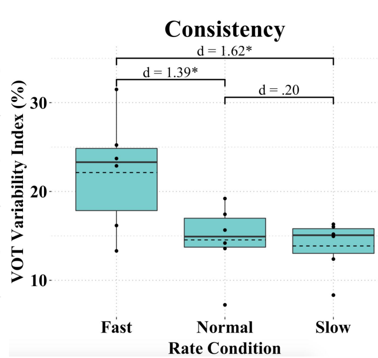


Figure 1. Five key components of articulatory motor control and their corresponding acoustic features.

Results





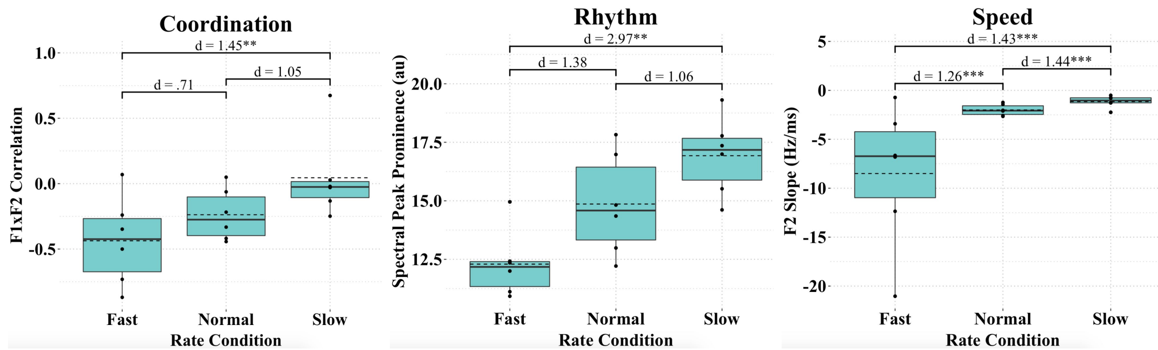


Figure 2. Boxplots comparing the participants' performance on *distinctiveness*, *consistency*, *coordination*, *rhythm*, and *speed* across the three rate conditions (dotted line = mean, solid line = median).

Discussion

The results of our study demonstrate that the proposed framework has potential as an objective, interpretable, and valid tool for profiling speech motor deficits. Concurrent validity was supported by three of the five features (i.e., *distinctiveness*, *coordination*, and *speed)* on the basis that these variables changed in the expected direction based on prior research [5,6,10,11]. The trend for *distinctiveness* was consistent with literature demonstrating increased articulatory specification at slower articulation rates [5,6]. Similarly, our *coordination* findings agreed with research illustrating a destabilizing effect of slow articulatory rate on speech movements, as a reduced formant correlation may correspond with less coupling of tongue movements [10]. Our results for *speed* were also consistent with findings of increased tongue movement at faster articulation rates [11]. In contrast to the aforementioned measures, the effect of articulatory rate on *rhythm* is less established [11], but our results demonstrated that rhythm regularity increased in the slow condition. One feature--*consistency*--was not validated by the paradigm; contrary to the pattern found in prior research [5], we noted an *increase* in phonetic variability upon decreases in articulation rate. This discrepancy, however, may be due to the foci of consistency being measured, as previous literature examined jaw movement variability, whereas we investigated variability in subglottal and supraglottal coordination. The next step in this research will be to validate these proposed features using biomechanical approaches.

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