Articulation in children with developmental speech disorders

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Introduction

A central issue in studies on developmental speech disorders, especially with regard to childhood apraxia of speech (CAS) and phonological disorder (PD) is the distinction between phonological and motoric processes. Acoustic studies suggest that children with CAS produce incorrect realizations of correctly selected phonemes, whereas the opposite is postulated for children with PD. Thus conceived, the underlying impairment is located at different levels of speech production in these two groups of children.

Aim of the present study

Characterize phonological and motor processes in developmental speech disorders using kinematic and dynamic pattern analyses of speech motor behavior.

Method

Participants

- 14 participants (6 female; 8 male) in 4 groups:
- CAS (n=4, 6;05-8;09 yrs;mnths), Mix (n==3, 6;07-8;09), PD (n==1, 6;02), and Controls (n==6, 6;3-9;7).

Task

- Repeat /pa:s/ and /spa:/ at a normal speaking rate.

Data collection

- Electro-Magnetic Midsaggital Articulography (EMMA; Carstens AG100).

Data analysis [van Lieshout et al., 2007]

- Tongue tip and lower lip closing movements:
  - kinematics: amplitude, velocity, duration;
  - dynamics: stiffness (peak velocity/amplitude) and cSTI (cyclic spatio-temporal index) (Fig. 1).
- Intra- and intergestural coordination: intra: upper -lower lip (bilabial closure); inter: bilabial closure-tongue tip:
  - dynamic patterns: mean relative phase and phase variability (Fig. 1).

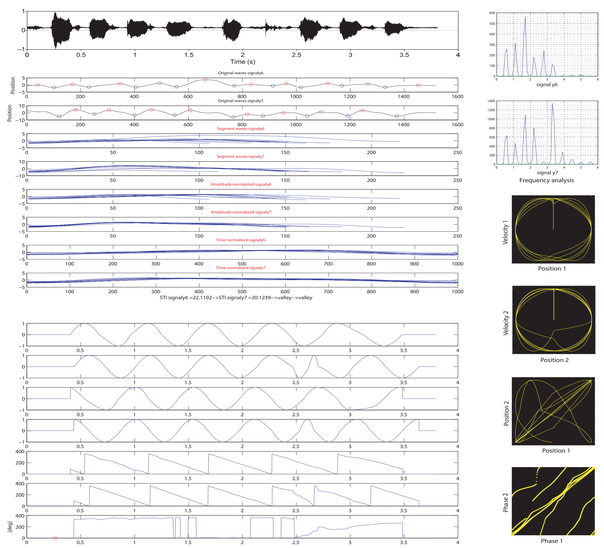

FIGURE 1: Dynamic pattern analysis of relative phase and phase variability of an example waveform (top).

Results

Kinematics (Fig. 2, 3)

- The CAS and Mix groups tend to larger amplitudes, velocity and duration in the closing movements of tongue tip and lower lip.

Dynamics (Fig. 2, 3; Table 1)

- The CAS group shows a larger stiffness than controls for /pa:s/, but not for /spa:/. The Mix and PD children show a stiffness that is equal or less than controls.
- The CAS group shows less variability than controls on the cSTI-index.

Relative phase (Fig. 4)

- Mean relative phase and phase variability do not show clear differences between groups, syllable structures (/pa:s/ vs /spa/) or gestural coordination (inter vs intra).
- Mean relative phase and phase variability show very large standard deviations.

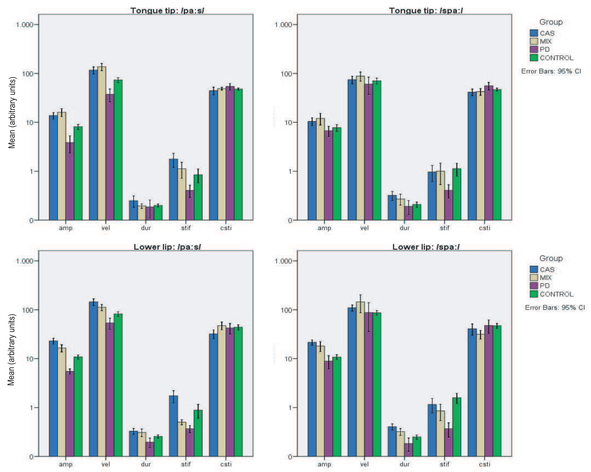

FIGURE 2: Kinematic and dynamic parameters by task, groups compared.

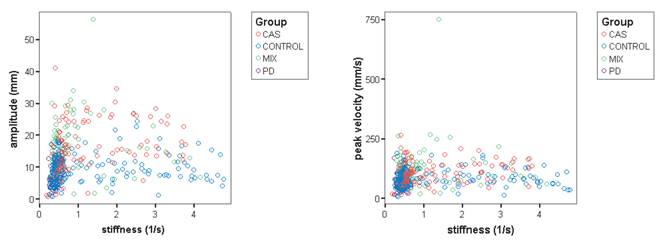

FIGURE 3: Scatterplots of amplitude (left) and peak velocity (right) against stiffness, groups differentiated.

TABLE 1: Dynamics of tongue tip and lower lip closing movements. * indicates a general effect of group (p<.05, Kruskall-Wallis).

Parameter	Articulator	/pa:s/	/spa:/
stiffness	tongue tip	CAS>Mix>Control>PD*	Control=Mix=CAS>PD
	lower lip	CAS>Control>Mix>PD*	Control>CAS>Mix>PD*
cSTI	tongue tip	PD>Control>Mix=CAS	PD>Mix>Control>CAS
	lower lip	PD=Control>CAS>Mix*	Mix>Control=PD>CAS*

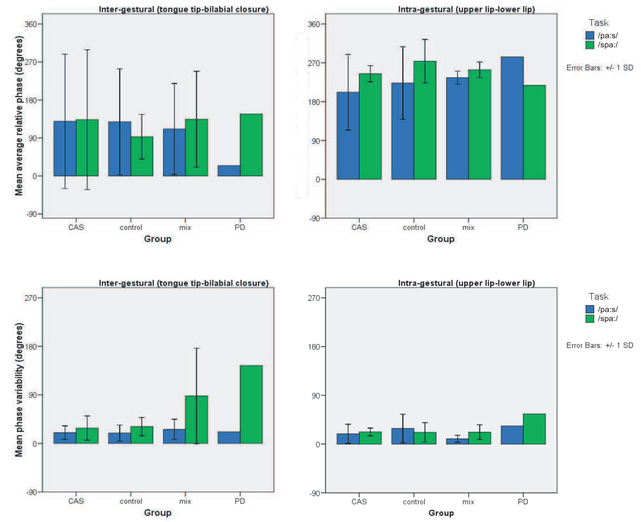

FIGURE 4: Average relative phase (top) and relative phase variability (bottom).

Discussion

Context effects

- Previous research using ddk-tasks [van den Berg et al., 2006] found the closing movements of the lower lip of children with CAS to be less flexible (i.e. larger stiffness) than controls. The current study confirms these results and extends them for tongue tip closing movements, and at the same time limits them to syllables without consonant clusters.
- The results indicate that the motoric realization of speech sounds in CAS is dependent on syllable structure:
  - within the syllable, the closing movements of tongue tip and lower lip in the cluster /sp/ are as flexible as controls;
  - across syllabic boundaries, these movements are less flexible than controls.

Gestural coordination

- The results show no clear differences in phase variability between inter- and intra-gestural coordination.

Analysis

- Dynamic pattern analysis of relative phase and phase variability proves to be troublesome with kids and/or consonant clusters.
- Question: is the large standard deviation of relative phase and phase variability due to speakers, task, or analysis?

Future research

- Improve tasks and data-collection to further enable dynamic pattern characterization.
- Possible solutions for the analysis of dynamics:
  - metronome guided speech;
  - different speech tasks (e.g. api-ipa, ddk-tasks);
  - record longer sweeps;
  - different dynamic analysis?