

Word-internal coarticulation patterns in Italian children with speech sound disorders of unknown origin: an acoustic study

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INTRODUCTION

Speech sound disorders of unknown origin (SSDUO) are considered as an output disorder, characterized by incorrect articulation of mostly consonantal speech-sounds; also formant transitions, however, a nonsegmental parameter, appear incomplete or acoustically incorrect, suggesting poor control of coarticulation between vocalic and consonantal gestures.

GOAL OF THE STUDY

- To determine whether, to what extent and in what aspects, coarticulatory effects between vocalic and consonantal gestures are affected by SSDUO and deviate from implementation of normal production patterns by children in typical development (TD) at same age stages

- To identify acoustic characteristics in SSDUO speech, that might be used to better specify an acoustic typology of SSDUO and as time markers for the time course of SSDUO.

Such markers could help us improve our understanding of the etiology of SSDUO, and to highlight deficits in the underlying mechanisms of speech motor control typical of SSDUO.

COARTICULATION IN CV SEQUENCES

Development of intra-syllabic CV coarticulation and of cross-syllabic VC coarticulation was observed in Italian SSDUO vs. TD children.

CV and VC formant transitions, in disyllabic words containing a reduplicated CVCV pattern, were analyzed, at childhood (4-6years) and at school-age (7-12 years).

Reduplicated CVCV structures were selected (e.g. 'nana'), so that V1=V2., in order to minimize mutual influences of vowels across consonantal contexts (Öhman, 1965).

Initial second formant transitions of the vowels after labial, dental and velar stop consonants ([p, t, k]), and final second formant transitions of the vowels before labial, dental and velar stop consonants ([p, t, k]), were analyzed and compared in the speech of 6 SSDUO and 6 TD children.

Vowels [a], [i] and [u] in first (stressed) and second (unstressed) syllable were analyzed, based on samples from 8 SSDUO and 8 TD children.

METHODS

Subjects and assessment tests

16 Italian-speaking children were selected, referred, diagnosed and tested at the Center for Research and Therapy of Stuttering and Voice and Speech Disorders (Centro ricerca e cura della balbuzie e disturbi della voce e del linguaggio, or CRC), Rome, Italy.

4 children diagnosed with SSDUO, and 4 children in typical development, were selected at two age stages: childhood (4-6years) and school age (7-12 years), for a total of 16 children (Table 1).

Children diagnosed with SSDUO, based on a battery of tests for language assessment (Peabody receptive language test for syntactic and lexical components, Rustioni screening test, Boston naming test, and TVL morpho-syntactic expressive language test) and for articulatory evaluation (Fussi-Cantagallo).

ITALIAN CHILDREN	Childhood				School-age			
	SSDUO	Normal	SSDUO	Normal	SSDUO	Normal	SSDUO	Normal
P.F. (M)	4.4	5.11	4.9	6.4	8.3	7.7	7.9	6.10
D.D. (F)	5.11	5.11	5.10	6.7	7.4	10.10	10.7	8.5
S.A. (M)	4.4	5.11	4.9	6.4	8.3	7.7	7.9	6.10
P.S. (M)	4.4	5.11	4.9	6.4	8.3	7.7	7.9	6.10
C.G. (M)	4.4	5.11	4.9	6.4	8.3	7.7	7.9	6.10
I.E. (M)	4.4	5.11	4.9	6.4	8.3	7.7	7.9	6.10
M.C. (F)	4.4	5.11	4.9	6.4	8.3	7.7	7.9	6.10
G.V. (M)	4.4	5.11	4.9	6.4	8.3	7.7	7.9	6.10

Table 1. Subjects and respective ages

Measurements and data analysis

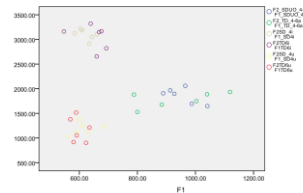
- Extent of movement of the tongue body to achieve vowel targets, both in vertical (represented by F1) and in horizontal dimension (F2). F1 and F2 values (calculated for vowels [u, i, a], in SSDUO and TD children speech

- Extent and rate of tongue advancement combined in the F2 slope index measure, representing adequacy of intra- and cross-syllabic vocalic/consonantal gestures coordination.

Slope index was defined as the absolute mean F2 slope in Hz/ms (Kent et al., 1989; 1991), obtained by dividing transition extent (Hz) by transition duration (msec). The transition extent was obtained by measuring on a wideband spectrogram, the change in frequency (Hz) between the lowest and highest point of the transition slope. Transition duration (in msec) was calculated as the difference between the point of offset and onset of the transitions.

Slope index calculated for V1C2 and C2V2 transitions, and compared for SSDUO vs. TD children at same age stages. Corpus was elicited, 1 time per child.

F2-F1 plot for [a], [i], [u] in SSDUO and TD children at childhood



F2-F1 plot for vowels [i], [a], [u] Italian SSDUO vs. TD children at school-age

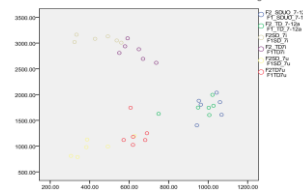


Fig. 1 F2-F1 plots showing mean Formant values for vowels [i], [a] [u], pronounced by Italian SSDUO vs. TD children, at childhood (a) and at school-age (b)

Tests results	[i] - school age	[u] - school age
F1	t(38) = 2.77, p = .01; η² = .28	t(38) = 3.85, p = .001; η² = .16
F2	t(34) = -2.6, p = .05; η² = .12	t(33) = 2.07, p = .05; η² = .09

Table 2. Significant t-tests results for differences in vocalic formants between SSDUO and TD children

RESULTS

Formant patterns

F1 and F2 values for vowels [a] [i] and [u] produced by SSDUO vs. TD children at each age stage, have been compared, as measures of implementation of tongue body movements in the vertical and horizontal dimensions, respectively: t-tests results (Table 2) showed that only vowels [i] and [u] in different consonantal contexts, as produced by children at school-age, differed between SSDUO and TD pronunciations (see Fig. 1 a and b).

F2 Slope index	VC	CV
TD_4-6ys	11 (26)	16.8 (33)
SSDUO_4-6ys	6.9 (17)	10.6 (22)
TD_7-12ys	5.5 (12.5)	7.9 (10.6)
SSDUO_7-12ys	.04 (10.6)	4.6 (15)

Table 3. Slope index (F2 transitions extent/duration, in Hz/msec) for children in Typical Development (TD), used as age norms, and SSDUO children, at Childhood (4-6 years) and School Age (7-12 years). Slope index values are reported separately for the cross-syllabic (VC transitions) condition and for the intrasyllabic (CV transitions) condition. Standard deviation is in parentheses

Slope index

A lower F2 slope index appears consistently for the SSDUO children, at the two age stages, than in TD (Table 3).

Transitions extent and rate indicate mobility of the tongue (Weismer, 2008; Hixon, 2008); slope index represents range of displacement of the articulatory movements and speed of that displacement (Ferrand, 2007). Slope index used to obtain diagnostic information regarding deviations of tongue movement from normal trajectories.

Formant measures and slope index highly correlated with intelligibility of vocalic (Ziegler and von Cramon, 1983; Ferrand, 2007) and consonantal components of a syllable (Kent et al. 1989; 1991; Weismer et al. 1992), so that

- deficits in formant and slope index may reflect poor control of VC and CV coarticulation, and result in low intelligibility.

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Same results seem to emerge in the cross-syllabic context (VC F2 slope) and in the intrasyllabic context (CV F2 slope), although the difference with the TD children tends to become smaller in the latter context at school age.

DISCUSSION AND CONCLUSIONS

- Differences in SSDUO vs. TD children's production of vocalic gestures, emerge at the school age period for the implementation of [i] and [u]; at this age, SSDUO children's pronunciations of the extreme vowels [i] and [u] start differing from the age normal realizations.

- F2 slope index showed lower values for the SSDUO children, than in normals, indicating overall weaker and slower tongue movement and reduced range of articulatory motion, in SSDUO children (Kent et al., 1991; Ferrand, 2007).

Results might support use of a training task to increase speed in production of transitional portions of sequences including stops in context of [i] and [u] vowels, especially across syllables. Such contextual repetition may facilitate acquisition of control of spatiotemporal coordination of articulatory gestures within disyllabic words and improve accuracy in production of stops in non-homorganic vocalic contexts.