An electromagnetic articulographic investigation of feedback mechanisms in childhood apraxia of speech.

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1. Introduction

Childhood apraxia of speech (CAS) is a pediatric motor speech disorder that causes disrupted speech articulation. In CAS patients, phoneme articulation and sequencing are described as imprecise and inconsistent compared to healthy children. The articulatory distortions (e.g. sound substitutions, additions, deletions, …) are of such a nature that speech can become incomprehensible. The deficits are due to an issue at the level of phoneme sequencing and motor programming of the movements necessary to articulate speech sounds [1]. CAS affects approximately 1-2 in 1000 children [2]. Performance on a diadochokinesia (DDK) task (*pa*, *ta, ka* and *pataka*-repetitions) is esteemed a most relevant task for differential diagnosis. Therapy in CAS is currently focused on either corrective auditory feedback or on kinesthetic feedback stimulation. Although it previously was investigated and demonstrated that children suffering from CAS have issues with feedforward speech processing [e.g. 3], feedback investigations have been limited to acoustic evaluations of (compensation to) auditory feedback interruption. Since current therapeutic strategies often prove insufficient to alleviate symptoms, it seemed necessary to situate the problem in CAS. Since CAS is defined as a motor speech problem with issues pertaining to the level of planning and programming, it equally seemed better to focus on the motor movements rather than the acoustic signal only. Hence, electromagnetic articulography (EMA), already performed in children with CAS [3] seemed a good alternative.

2. Research objectives

- To investigate whether DDK is a task which allows to differentiate CAS from normal population in terms of kinesthetic deviations.
- To investigate, via electromagnetic articulography, the articulation of children with CAS for neutral articulation condition, a condition with auditory and kinesthetic feedback disruption and to see whether they compensate better to perturbation affecting one or the other condition.

3. Methods

For this pilot, three children with the rare condition of CAS and three healthy matched controls (see table 1) were evaluated on a DDK task (randomized repetition of /pa/, /ta/, /ka/ or /pataka/, at maximum performance, for 10 seconds), followed by a sentence reading paradigm. Sentences consisted of the carrier phrase "ik heb de XXX gezegd", the stimulus was always an open syllable of the type CV or the more complex form CCV (C= /b/, /g/, /s/, /pl/, /kl/, /sx/ and V= /a/, /i/, /u/), because children with CAS are said to perform less well when they have to repeat consonant clusters [4]. They all underwent three conditions, one neutral (no interruption), one with auditory feedback masking via pink noise that started at the moment the sentence appeared on the presentation screen and one with kinesthetic feedback disruption, wherein the jaw was blocked as children were asked to bite on a bite stick, taking away one degree of freedom for oral movement. Participants were tested with EMA via the NDI Wave (Northern Digital Inc.), the experiment was programmed in Marta for Matlab [5]. Sensor placement can be seen in figure 1. Data were analyzed in Mview for Matlab. As can be seen only one sensor was placed on the tongue (TT), because it was esteemed that more would impede the possibilty of natural speech (small oral cavity). The tongue body and back were visualized via ultrasound, the data of which were not analyzed for the purpose of this contribution.

Code	Gender	Age	Handedness	Duration of SLT
CAS1	Male	12	Right	6 years
CAS2	Female	11	Right	9 years
CAS3	Male	11	Left	7 years
CON1	Male	13	Left	1 year
CON2	Female	11	Right	6 months
CON3	Male	11	Right	N/A

Table. 1. Controls had SLT in order to increasing reading pace at school. None of the controls had speech motor issues.

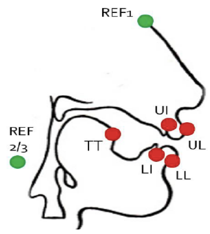

Figure 1. Sensor placement. Only tongue tip received a sensor as oral cavity of the participants was small, this was remedied via the use of ultrasound, the data of which are not yet the subject of current abstract

4. Results and discussion

Results for the repetition rate for alternating motion rate (AMR) (number of pa, ka, and ta gestures realized within the given time frame) were in line with expectations for CAS as it has previously been mentioned that these rates are not significantly different from what is expected in healthy controls. Between-subject variability was higher in CAS. However, also in line with previous literature [6] this was not the case for the sequential motion rates (SMR) (/pataka/), which were slower than for controls. Between-subject variability was lower in the CAS children than the controls for SMR. Peak velocity towards maximum constriction for lip aperture for /pa/ and /ta/-movement was comparable for all subjects, but was slower for CAS for the /pataka/ repetition. Feedback perturbation analyses were done for the /baa/ (simple) versus /plaa/ (complex) gestures. Gesture rates were longer for all CAS participants than controls for the complex stimuli. The gesture duration was not markedly affected by the perturbation. Peak velocity was most affected in CAS under the somatosensory disruption condition, also gesture duration was lower due to incompleteness and incorrectness of the realizations. Moreover, for the CAS subjects, there was a large variation in maximum constriction location during normal speech production. This variation was reduced during somatosensory and auditory feedback disruption. This suggests that CAS subjects may rely on sensory feedback over feedforward commands, but when feedback is disrupted they revert to underdeveloped feedforward commands.

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