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# SPEECH MOTOR SKILL IN CHILDREN WHO STUTTER

Abstract

Speech performance could be the result of either the capacities of the system itself and/or the speech skills which have been learned over a period of time. Concept skill is considered as a fundamental characteristic of motor production whose development can be seen as a continuum proceeding through stages from a cognitive stage to an automatic performance. Results from different researches have revealed that a persons who stutters differs from a person with a normal speech production regarding the kinematic, orofacial nonspeech and speech tasks led as to a tentative conclusion that stutterers are more toward the weak and of the speech motor skill continuum and that there is dysfunction within the cortical and subcortical areas of the motor control system wider than that pertaining to speech motor behaviors alone.

The purpose of this investigation was to explore speech motor skill in children who stutter and to find out if there is a correlation between motor-speech skill tasks and subtests of Riley Instrument as well as to find out possibly differences between stutterers and non stutterers. Thirteen children who stutter participated in the study performing tasks built up in the protocol of Motor Speech Program. In the time of study subjects were involved in speech treatment in Polyclinic SUVAG. Results have been analyzed on the level of univariant statistics with software Statistica for Windows.

## INTRODUCTION

Many studies have been conducted to access speech characteristics of individuals who stutter and to detect factors that contribute to the breakdowns in speech production. Peters and Hulstijn (1987, 1989) suggested that the programming or initiation of an utterance could cause disturbance in stuttering. Kent (1985) suggested that the essence of stuttering is a reduced ability to generate temporal programs. Van Riper (1971) proposed the same. He considered stuttering as a disorder of temporal aspects of speech resulting from a deficient timing mechanism for speech. Van Lieshout et al. (1996) set up a study to find evidence that people who stutter differ from control speakers in the way they process information at the stage of motor plan assembly or the stage of muscle command preparation/execution. The results in the timing of peak amplitudes in the integrated electromyography signals of upper lip and lower lip (IEMG peak latency) were significantly different between the groups of subjects. These findings indicated that people who stutter have problems in the stage of preparation muscle commands. In the experiment described above, people who stutter also showed slightly longer word duration although differences were not statistically significant. Authors tried to put these findings in-line with group differences in IEMG peak latency, because they assumed (according to the theory proposed by Gottlieb, Corcos and Agarwal (1989)), that differences in the movement speed can affect IEMG peak latency, showing longer peak latencies for slower movements. Authors tried to explain these phenomena in the light of two possible hypotheses. The first hypothesis suggests that people who stutter show slower speech movement because of timing deficiencies at the sub-stages of muscle command initiation/execution. The second hypothesis proposes the idea that slower speech movements are consequence of a different control strategy used by people who stutter to avoid situations where their motor control system might get out of balance.

In the light of aforementioned, accuracy of speech movement could be the result of either the capacities of the system itself and/or the motor skills which are learned over a period of time. Concept skill is considered as a fundamental characteristic of motor production whose development can be seen as continuum proceeding through stages from a cognitive stage to an automatic performance (Peters at al, 2000). Results from different researches revealed that a persons who stutter differs from a person with normal speech production regarding the kinematic analyses of speech, orofacial nonspeech and finger movement (Ludo, Caruso, Gracco, 2003; Webster, 1997).

Laštovka (1995) investigated the subclinical tremor on the extremity muscles in stutterers at rest, without speaking and found out that after 60 s of contraction decreased of tremor was statistically significant. Smith (1989) reported that diverse muscles are subject to common oscillatory synaptic drive during disfluent behaviours and that this drive is disruptive to speech production. Those findings led as to a tentative conclusion that stutterers are more toward the weak and of the speech motor skill continuum and that there is dysfunction within the cortical and subcortical areas of the motor control system (extrapyramidal and cerebellar field) wider than that pertaining to speech motor behaviours alone.

The purpose of this study was to provide data on the motor-speech characteristic of the stuttering children and to assess the relationship between motor-speech variables and components of Riley Stuttering Severity Instrument. Further on, the purpose was to establish a relationship between the duration of therapy and motor-speech variables.

## METHOD

### Subjects

Twenty four individuals participated in the study. The group of children with no speech, hearing, neurological and other related problems included eleven children between the ages of 9-10.5 (mean age=9.5 years). These subjects served as the control group**.** The experimental group consisted of thirteen stuttering children between the ages of 8 – 10.5 (mean age=9.4 years). The stuttering children were identified on the basis of the experimenter's judgment of stuttering frequency during pretest spontaneous speech and reading task using Riley Stuttering Severity Instrument (SSI; Riley, 1972). One child was rated with mild stuttering, seven children were rated with moderate stuttering, three children were rated with severe stuttering and two children were rated with very severe stuttering. During the study, stuttering children were involved in the speech treatment in

SUVAG Polyclinic. All study subjects were native speakers of Croatian language and were healthy at the time of study.

**Experimental tasks and data collection**

All children were performing tasks built up in the protocol of Motor Speech Program (Model 5141). The Diadochokonetica Rate Protocol measures the client's ability to repeat a C-V combination (pa-pa) in a fast, constant level and rhythmic manner. Parameters used for analyse were: DDKavp /ms/ - average DDK period; DDKavr /s/ - average DDK rate; DDKcvp /%/ - coefficient of variation of DDK period.

The Second Formant Transition Protocol measures the client's ability to repeat a V-V combination (i-u) in a fast, rhythmic manner without vowel neutralization. Parameters used for analyses were: F2magn /Hz/ - magnitude of F2 variation; F2rate /s/ - rate of F2 variations; F2 reg /%/ - regularity of F2 variations.

Voice and Tremor Protocol measures amplitude or fundamental frequency tremors in prolonged phonation of vowel /a/. Parameters used for analyses were: $F_0$ /Hz/ - fundamental frequency; vF0 /%/ - variations in the fundamental frequency; vAm /%/ - coefficient of variations in the amplitude; MFTR /%/ - magnitude of frequency tremor; AFTR /%/ - magnitude of amplitude tremor.

The three components of SSI served as variables: FS-number of disfluencies in spontaneous speech and reading; D-the duration of three longest disfluencies; T-rating of distractibility of secondary behaviours. The duration of therapy was marked as DT.

The data was analyzed using t-test for independent samples with $\alpha$ set at 0.05. The correlation between those parameters and components of the SSI was measured using Spearman's rank correlation.

## RESULTS

Clinical characteristics of subjects participating in the study are summarized in Table 1 (descriptive statistics for stuttering sample) and Table 2 (descriptive statistics for control sample). Results of t-test for independent samples are presented in Table 3.

**The Diadochocinetic rate.** Stuttering subjects had a significantly longer diadochokinetic period [t (3.93), $p=0.0006$)] and a significantly slower diadochokinetic rate [t (-4.09), $p=0.0004$)] than control subjects. Although stuttering children showed greater coefficient of variation of DDK period those differences were not statistically significant.

**The Second Formant Transition.** Mean values of magnitude, rate and regularity of F2 transition did not differ significantly among groups although standard deviation for magnitude of F2 transition was greater in the group of stuttering children.

**Voice and Tremor.** Fundamental frequency, frequency and amplitude variation as well as tremor variable did not differ significantly among groups.

**The relationship between SSI components and duration of therapy and speech-motor parameters.** To examine the association between the speech-motor parameters and SSI components as well as the duration of therapy, the correlation analysis was applied. A statistically significant positive correlation was observed between the diadochokinetic period and number of disfluencies in spontaneous speech ($r = 0.58$); the diadochokinetic period and the duration of three longest disfluencies ($r = 0.62$); the diadochokinetic period and rating of distractibility of secondary behaviors ($r = 0.60$); the diadochocinetic period and duration of therapy ($r = 0.61$).

Statistically significant negative correlation was also between the diadochokinetic rate and number of disfluencies in spontaneous speech ($r =-0.59$); the diadochokinetic rate and the duration of three longest disfluencies ($r =-0.62$); the diadochokinetic rate and rating of distractibility of secondary behaviors ($r = -0.60$); the diadochocinetic rate and duration of therapy ($r = -0.60$).

The variation of $F_0$ correlated statistically significant with the rating of distractibility of secondary behaviors ($r = 0.56$). The magnitude of frequency tremor correlated statistically significantly with the number of disfluencies in spontaneous speech and reading ($r =0.56$).

Table 1. Descriptive statistics for stuttering sample

| | Valid N | Mean | Min | Max | SD |
|---|---|---|---|---|---|
| DDKAVP | 13 | 205.43 | 179.87 | 242.06 | 16.82 |
| F2MAGN | 13 | 633.13 | 223.28 | 940.66 | 235.47 |
| F2REG | 13 | 72.93 | 56.52 | 89.29 | 11.23 |
| F0 | 13 | 237.74 | 193.98 | 287.20 | 27.29 |
| MFTR | 13 | .30 | .10 | .87 | .19 |
| VF0 | 13 | 1.32 | .46 | 4.45 | 1.01 |
| F2RATE | 13 | 2.32 | 1.55 | 3.17 | .50 |
| FS | 13 | 12.38 | 2.00 | 18.00 | 4.09 |
| T | 13 | 6.61 | 3.00 | 12.00 | 3.25 |
| DT | 13 | 12.76 | 3.00 | 28.00 | 8.04 |
| DDKAVR | 13 | 4.89 | 4.11 | 5.55 | .39 |
| MATR | 13 | 2.17 | 1.22 | 3.67 | .69 |
| D | 13 | 3.15 | 1.00 | 4.00 | .80 |
| VAM | 13 | 10.17 | 4.44 | 14.17 | 2.90 |
| DDKCVP | 13 | 26.11 | 9.21 | 82.30 | 19.30 |

Table 2. Descriptive Statistics for control sample

| | Valid N | Mean | Min | Max | SD |
|---|---|---|---|---|---|
| DDKAVP | 11 | 178.69 | 160.54 | 212.02 | 16.25 |
| DDKAVR | 11 | 5.62 | 4.70 | 6.22 | .48 |
| DDKCVP | 11 | 15.47 | 8.70 | 35.25 | 9.15 |
| F2MAGN | 11 | 615.03 | 517.05 | 793.84 | 90.38 |
| F2RATE | 11 | 2.43 | 1.85 | 3.39 | .48 |
| F2REG | 11 | 77.16 | 49.06 | 91.91 | 13.80 |
| F0 | 11 | 252.22 | 232.72 | 288.18 | 14.85 |
| VF0 | 11 | 1.14 | .80 | 2.32 | .43 |
| VAM | 11 | 12.84 | 6.48 | 18.20 | 3.64 |
| MFTR | 11 | .38 | .19 | .59 | .12 |
| MATR | 11 | 2.34 | 1.82 | 3.39 | .52 |

Figure 1. Results of all participants in study

EMBED STATISTICAGraph

Table 3. t-test for independent samples (marked effects are significant at $p < .05000$)

| | G_1:1 | G_2:2 | t-value | df | p |
|---|---|---|---|---|---|
| DDKAVP | 205.43 | 178.69 | 3.93 | 22 | **.000698** |
| DDKAVR | 4.8 | 5.62 | -4.09 | 22 | **.000481** |
| DDKCVP | 26.11 | 15.47 | 1.67 | 22 | .108650 |
| F2MAGN | 633.13 | 615.03 | .23 | 22 | .812713 |
| F2RATE | 2.32 | 2.43 | -.51 | 22 | .610120 |
| F2REG | 72.93 | 77.16 | -.82 | 22 | .416642 |
| F0 | 237.74 | 252.22 | -1.57 | 22 | .130542 |
| VF0 | 1.32 | 1.14 | .56 | 22 | .578393 |
| VAM | 10.17 | 12.84 | -1.99 | 22 | .058458 |
| MFTR | .30 | .38 | -1.27 | 22 | .214343 |
| MATR | 2.17 | 2.34 | -.64 | 22 | .527736 |

Table 4. Correlations between SSI components and duration of therapy and speech-motor parameters (marked correlations are significant at $p < .05000$)

| | FS | D | T | DT |
|---|---|---|---|---|
| DDKAVP | .58 | .62 | .60 | .61 |
| DDKAVR | -.59 | -.62 | -.60 | -.60 |
| DDKCVP | .21 | .23 | .40 | .34 |
| F2MAGN | -.15 | -.23 | .21 | -.28 |
| F2RATE | .05 | -.05 | -.25 | -.18 |
| F2REG | -.17 | -.26 | .00 | -.26 |
| F0 | -.06 | -.19 | -.13 | .04 |
| VF0 | .48 | .41 | .56 | -.04 |
| VAM | -.03 | .22 | .11 | .51 |
| MFTR | .56 | .45 | .52 | -.00 |

| | | | | |
|---|---|---|---|---|
| MATR | .07 | .00 | -.20 | -.12 |

**DISCUSSION**

The data from this study reveal that stuttering children showed reduced performance on the diadochocinetic tasks. The average DDK period is the average time between C-V vocalization and the period is inversely related to the rate. Stuttering children showed difficulties to achieve the same period duration of C-V vocalization repeated at a fast rate as non-stuttering children. Repeating syllable /pa/ in a fast, constant-level and rhythmic manner probably put extra demands on their speech-motor system. Those extra demands may cause them loosing control over a speech production. A research conducted by Boucher (2002) revealed that stuttering subjects did not present a consistent gradation in the velocity of labial closures and this created variations in pressure that influenced vocal-fold behavior. Disrupting of speech production caused by abnormal-velocity changes serves to explain why a slowing of speech has a beneficial effect on stuttering frequency. It seems reasonable to conclude that a stuttering slowness is not the core characteristic of stuttering but a compensatory strategy designed to avoid breakdown in the speech production in a manner to harmonize components which are involved in speech production**.** Max and al. (2004) stated that movement of people who stutter are appropriately timed relative to another movement within and across the articulatory, phonatory, and respiratory subsystem

The Second Formant Transition Protocol also measures the ability to repeat V-V combinations in a fast and rhythmical manner. The combination of vowels /i/ and /u/ require the child's ability to change articulatory positions (tongue and lip positions) thereby assessing articulatory motility. There were no statistically significant between-group differences on any of the variables in this protocol. However, it must be emphasized that the dispersion of results on the magnitude of F2 variation was greater in the group of stuttering children. Because of great variability between stuttering subjects it would be not warranted to rulings out the role of articulatory motility although it can be proposed hypothesis which lean on Boucher's approach base on articulatory compression which serve to impound air within oral cavity. Rapid changes of vowel /i/ and /u/ do not involve labial closures and perhaps are less demanding on speech-motor system so compensatory mechanisms in a form of slowness of rate or neutralization of vowel do not turn on during this task.

There were no differences between-group regarding average $F_0$ and long-term variation of frequency and amplitude. Part of therapy session is sustaining of vowel /a/ for some time, so this result may be influenced by the fact that subjects were involved in therapy at the time of experiment. There were not differences regarding frequency or amplitude tremor.

A significant correlation observed between the DDK period and rate and components of SSI led as to conclude that longer duration and slower rate of DDK are a reflection of current status of their stuttering. A research conducted by de Andrade at al. (2003) revealed that the stuttering severity and the speech rate present significant variation, i.e., the more severe the stuttering is, the lower the speech rate in words and syllables per minute. The DDK rate is not measuring a speech rate, but certain connection can be made. Longer duration of therapy assuming that stuttering is resist on therapy procedure so child must put extra demands to control fluency which could result in more longer duration of speech segments. The magnitude of the frequency tremor showed positive correlation with a number of disfluencies in spontaneous speech and reading. It is most likely that an increased number of disfluencies (blocks, repetitions, prolongations and tremors) also increased tremor in muscles involved in phonation. Stabile phonation without long term variation of $F_0$ depends, among other factors, on stabile postures of articulatory organs involved in phonation. Maladaptive behaviours may include muscular tension in the lips or tongue when articulating sounds or phonating which decrease a long-term variation of $F_{0.}$

It must be emphasized that one must be careful when equating acoustic speech-motor variables with specific motor skill for speech production as the mapping between the mentioned levels is neither direct nor linear. The hypothesis mentioned above is just a possible hypothesis which requires extensive research with larger participant sample.

## CONCLUSION

On the basis of the present study we have been led to conclude that stuttering children showed difficulties to achieve the same period duration of C-V vocalization repeated at a fast rate as non-stuttering children. It seems reasonable to conclude that a stuttering slowness is not the core characteristic of stuttering but a compensatory strategy designed to avoid breakdown in the speech production in a manner to harmonize components which are involved in speech production**.** The present results do not appear to support the role of articulatory motility in stuttering but it would be too premature to ignore it because of great variability between stuttering subjects.

However, additional studies are needed for further analysis and for the examination of speech motor processes in children who stutter both at different levels of speech production and with a larger subject sample.

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