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Duration and Variability of Speech Segments in Fluent Speech of Children with and without Stuttering

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A B S T R A C T

The purpose of this study was to compare the duration and variability of speech segments of children who stutter with those of children who do not stutter and to identify changes in duration and variability of speech segments due to the effect of utterance length. Eighteen children participated (ranging from 6.3 to 7.9 years of age). The experimental task required the children to repeat a single word in isolation and the same word embedded in a sentence. Durations of speech segments and Coefficients of variation (Cv) were defined to assess temporal parameters of speech. Significant differences were found in the variability of speech segments on the sentence level, but not in duration. The findings supported the assumption that linguistic factors pose direct demands on the speech motor system and that the extra duration of speech segments observed in the speech of stuttering adults may be a kind of compensation strategy.

Key words: *motor control, stuttering, temporal parameters of speech*

Introduction

People who stutter tend to be less accurate and more variable than adults during the production of speech[1,2]. Research done in Croatian language confirmed the above mentioned research[3]. It was demonstrated that the segment duration in a child's speech is on average 13% longer than in adult speech. It was also demonstrated that the variability of the segment duration decreases from the youngest group (31.9%) to adults (18.1%). In general, the results from several studies reveal an increase in rate with age. But, the research done by Walker and Archibald[4] shows, contrary to expectations, that a developmental increase of the articulation rate did not occur; neither did the variability of rate decrease with age. In their research speech samples were elicited from 16 normally developing children at ages 4, 5 and 6. Although considerable individual differences in rate were identified, their results suggest that the course of development is not linear.

Two acoustic measures that have frequently been employed when comparing speech motor skills across different age groups or between disordered and normal speakers are the duration of different speech segments and the variability of inter and/or intra subject duration measures. The reason for investigating speech segment duration and variability in both children and adults lies in the assumption that both factors are viewed as general indicators of neuro-motor maturation of speech skills. Even attempts to minimize token-to-token differences had little or no influence on variability[5].

Also, it seems that duration reaches adult level earlier in the developmental process than variability. Smith[6] in his research hypothesized that »perhaps duration is in some way a more direct reflection of lower-level speech production skills and of the rate at which articulatory gestures are carried out, whereas the other may be more closely associated with higher-level organizational skills that a speaker has for performing such as gestures«. (p. 2171). Research conducted by Walsh and Smith[7] also suggests that in terms of the average target value, children reach temporal goals before spatial goals. It is im-

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portant to emphasize that overall sentence duration and speech movement variability are often not adult-like until the age of fourteen[8].

Recent studies which used direct measures of movement in normally fluent children and adults similarly revealed that children have less stability in generating patterned speech motor output compared to adults as syntactic complexity and utterance length increase[7,9–11]. The kinematics measure that has frequently been employed in those studies was spatiotemporal index (STI). The STI reflects the degree to which the patterning of movement output is consistent during the repeated production of the behavior[12]. Higher values of the STI could reflect instability in the nervous system command signals generated to control muscle activity but it could also be a sign of greater plasticity of the neural networks that interact to produce speech[11].

Because of these findings, it seems reasonable to conclude that increasing task demands like utterance length and/or syntactic complexity may have a greater impact on the speech motor production of children than they have on that of adults. Research conducted by Manner et al.[10] showed that children are quantitatively different from adults speakers regarding all three variables employed in their study (the STI, the phrase duration and the coefficient of variation for duration; substantial group differences were found). They also found that adults did not show an effect of length or syntactic complexity on the speech production system. Similar results were observed in research conducted by Kleinow and Smith[13]. However, in contrast, the influence of length and syntactic complexity on speech motor control in children and adults has been observed in a research conducted by Kleinow and Smith[9]. Those results led to the conclusion that neural pathways which process linguistic information are on some levels connected with neural pathways that process impulses responsible for processes of speech production.

How do these findings relate to instability in speech productions of people who stutter? Many studies have been conducted to assess speech characteristics of individuals who stutter and to identify factors that contribute to the breakdowns in their speech production, such as speech rate, utterance length and articulatory complexity. A frequent proposal has been that the underlying difficulties with the timing of speech movement may cause disturbances that are perceived as stuttering[14–17].

Different researches[18,19] studied the question of whether people who stutter differ from normally fluent speakers in how they process information at the stage of motor plan assembly of speech and at the stage of muscle command preparation/execution. Results suggests that persons who stutter are slower than persons who do not stutter at planning and or/initiating motor movement associated with speech production. Problems in this stage can result in difficulties observed during initiation of speech, leading to the finding of increased stuttering on sentence-initial words[20].

Research conducted on normally speaking children[11] revealed that younger children spent more time on the beginning of utterances than adults, because they demonstrate a qualitatively different movement pattern from the adults. Those authors suggested that children might depend more on feedback to guide movements, particularly during their onset. A similar explanation about the movement strategy for speech production in children was proposed by Riely and Smith[21]. They proposed that children's movement strategy may reflect the need for more time to plan speech movement sequences and an increased reliance on sensory feedback. Also, people who stutter may have poorer speech motor skills, which makes it difficult to control muscle force over time[22,23]. Besides the position of a word in the sentence, utterance length plays an important role as a »linguistic« factor. Linguistic factors such as utterance length may influence stuttering behavior because they place extra demands on the speech mechanism. Research conducted by van Lieshout and Starkweatheron nonstuttering speakers showed a decrease in IEMG activity for longer sentences[24]. They speculated that this might be related to the use of a movement reduction strategy to allow higher speech rates with increased coarticulation. In discussing the implications of these findings for people who stutter, van Lieshout and Starkweather speculated that the increase in articulatory effort for initial words or longer utterances may bring the speech motor system of people who stutter to some critical point of instability. Employing kinematic variables in their research, Kleinow and Smith also confirmed that adults who stutter show increased variability in movement pattern as syntactic complexity and utterance length increase[13].

Studies conducted on children who stutter reported that they performed speech tasks with greater variability compared with children who do not stutter[1,25]. Also, several studies confirmed significantly longer voice onset time (VOT) in persons who stutter[26–28]. Research conducted by Ward has revealed longer VOT in speech of adults who stutter, but those differences were not statis-

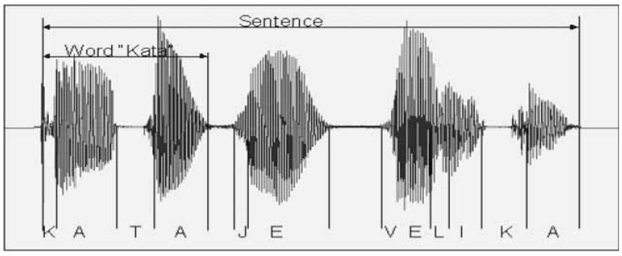

Fig. 1. The acoustic waveform of the sentence /KATA JE VELIKA/ with marked speech segments used in study. VOT of the consonant /k/ was recognizable as a sharp spike on the waveform. The duration of syllable /KA/ in a word and in a word embedded in a sentence was measured as the interval between the onset of the VOT of the consonant /k/ and the offset of the following vowel /a/. The duration of the word KATA was measured as an interval between the onset of the VOT of the consonant /k/ and the offset of the final vowel /a/. The duration of the sentence was measured as the onset of the VOT of the consonant /k/ and the offset of the final vowel /a/ in word VELIKA.

tically significant[29]. De Nil and Brutten conducted the study, which was designed to investigate the influence of time pressure on the VOTs of 10 young stutterers and a like number of age and sex-matched nonstutterers[30]. No statistically significant differences were found between the mean VOTs of stuttering and nonstuttering children. However, the VOTs of the stuttering children were significantly more variable than those of the nonstutterers. Variable VOT in persons who stutter can reflect limitations for maintaining temporal relationship between independent gestures (i.e. inter-gestural level). With regards to the role of utterance length, this could be even more demanding in longer utterance.

Variability and longer speech segments observed in their speech appear to be more than just a developmental characteristic of speech. There are several possible explanations for this phenomenon. Generally speaking, slower speech movement can be seen as a kind of compensatory strategy to avoid breakdowns in speech. Within this view, it is reasonable to hypothesize that relevant information about temporal characteristics of stuttered speech should be obtained from the speech samples extracted near the onset of stuttering when compensatory mechanisms are not yet developed or are less developed.

Therefore, the purpose of the current study is to compare the duration and variability of measured speech segments of children who stutter with those of children who do not stutter and to examine the effects of utterance length on these variables. Such comparisons should help provide additional information about the nature of processing challenges that may lead to stuttering.

Methods

Subjects

Eighteen children, divided evenly into two groups, participated. One group of children with no speech, hearing, neurological, or other related problems, served as control. It included 7 boys and 2 girls ages 6.5–7.5 (X=6.9 years).

Demographic descriptions of children in the control group were obtained from their teacher (informed consent for participation was secured from the children's parents and the study had been approved by an ethics board). Parents completed a medical case history form and returned it to the children's teachers. These children were judged by the first investigator to be being normally fluent (exhibiting fewer than 3% stutter-like disfluencies per 100 words of conversational speech). The conversational speech was recorded and played to an independent SLP. Interjudge reliability coefficient was 0.82.

The experimental group consisted of 9 children who stutter, 5 boys and 4 girls ages 6.3–7.9 (X=7.2 years). Children were identified and recruited for the study during the initial phase of speech therapy (minimally two and maximally six months from the stuttering onset rec-

TABLE 1
DESCRIPTIVE STATISTICS FOR GROUP 1 AND GROUP 2

	Group 1		Group 2	
	X	SD	X	SD
Duration variable				
DVOTWORD [ms]	53.111	12.869	50.666	5.873
DSYLLWORD [ms]	231.311	41.396	240.333	39.576
DWORD [ms]	547.588	73.849	576.411	58.777
DVOTSENT [ms]	49.111	11.805	46.333	4.949
DSYLLSENT[ms]	194.222	52.959	183.555	19.203
DSENT [ms]	1229.556	245.584	1151.667	140.786
Coefficient of Variation				
CvVOTWORD [%]	18.277	8.257	13.733	4.058
CvSYLLWORD [%]	10.155	2.601	8.244	3.415
CvWORD [%]	9.940	8.482	5.967	1.873
CvVOTSENT [%]	29.12	11.314	13.377	6.233
CvSYLLSENT [%]	14.78	5.327	7.466	2.469
CvSENT [%]	6.702	3.375	4.822	1.025

DVOTWORD [ms] – the duration of the voice onset time of the /k/ in an isolated word [Kata]
DVOTSENT [ms] – the duration of the voice onset time of the /k/ in the same words when embedded in a sentence
DSYLLWORD [ms] – the duration of the initial syllables [ka] in an isolated word [Kata]
DSYLLSENT [ms]- the duration of the initial syllables [ka] in the same words when embedded in a sentence
DWORD [ms] – The duration of the word [Kata]
DSENT[ms] – The duration of a sentence [Kata je velika]
Coefficient of variation (Cv) was calculated for each duration variable by the formula Cv=SD/Xx100 (X=Mean; SD=Standard deviation)

ognized by parents as stuttering). However, according the parents' reports, five children (3 boys and 2 girls) also had short disfluent episodes between age three and four. In addition, parents reported that two of the boys spoke faster than their peers but without repetitions of syllables and sounds until a few months prior to enrollment in therapy. Enrollment in therapy was based on the experimenter's judgment of stuttering frequency in a pretest spontaneous speaking task using spontaneous speech recorded on audio and video tape. Stuttering was defined as any cessation in a word or in a sentence marked by audible or inaudible repetitions or prolongation of syllable/word fragments, including periods of silence between words/syllables during which the subject was perceived as attempting to produce the subsequent sound. The assessment of fluency was made by the first author of this study. Audio/video tapes of all the children (children from experimental and control group) presented in mixed-up order were given to an independent SLP who was not aware of the original diagnosis. Interjudge reliability for overall stuttering severity instrument – SSI (frequency of stuttering in spontaneous speech, duration of three longest disfluencies and rating of distractibility of secondary behaviors) resulted in r=0.99. Additionally, children had to be rated as having at least a moderate degree of stuttering, that is, 16 points on the Stuttering Severity Instrument[31]. One child was rated as exhibiting moderate stuttering, 6 children were rated as severe, and 2 as having very severe stuttering. All participants were native speakers of the Croatian language and were healthy at the time of study

During the study, children who stutter were involved in the initial phase of speech therapy in SUVAG Polyclinic. One of the treatment's first objectives is to reduce stuttering by means of a delayed auditory feedback (DAF) device. All were involved in speech treatment for the first time. There was no avoidance of speech situations nor any other secondary behaviors such as changing or avoiding words which made us conclude that children were either not fully aware of or were not concerned about their disfluencies. Speech recordings used in the study were made during the first few therapy sessions..

Experimental tasks and procedures

The primary testing stimuli were the word »KATA« (pronounced Kata) and the sentence »KATA JE VELIKA«, pronounced [Kata je velika]. KATA is a Croatian name, and KATA JE VELIKA means KATA IS BIG. This task was selected because of its appropriateness for children. All the words employed in the study are frequently used in the Croatian language and children should have been familiar with them. Consonant sounds are more likely to be stuttered on than vowels, and plosive sounds carry a greater risk of stuttering. This is likely due to the fact that the articulators must move with greater precision and with a smaller time frame than for the other sounds if the phoneme is not to be misperceived. The timing of VOT reflects one part of this subtle set of articulatory timing relationships because it requires precision of laryngeal control, airflow and articulation. Stuttering occurs more frequently at the beginning of a sentence[32], particularly if the planned utterances are long[33], and rarely on single-word utterance or word list[34]. The prediction was that the duration and variability of speech segments containing plosive sounds at the beginning of a word will be a demanding task for stuttering children, and that the greater variability would be observed in the longer utterance.

For the measurement of duration, we used a stopwatch that incorporated a signal light. The children were prompted to say the word and phrase in response to a light signal. The signal light was adjusted so that it turned on every three seconds during the word productions and every four seconds during sentence productions. Adjustments like this were needed to insure similar length of the pause between utterances in both tasks (approximately two seconds). The first task employed word and the second, sentence productions. Each word or sentence was repeated ten times. Children were instructed to repeat them with minimal differences in rhythm and rate, and to produce each utterance in a separate breath. After the first task was completed, the experimenter proceeded to the second task, allowing a 5-min break between tasks.

The experimental utterances were recorded individually for each child in a quiet room with a Sony mini-disc MDS – S40 recorder and Sony ECM-MS957 microphone. To familiarize the children with the speech tasks, they were given a practice session in which they produced the target word and sentence. Practice items were not included in data analysis.

Analysis

For children who stutter, only tokens judged to have been spoken fluently were analyzed, so that fluent speech was used for both groups. Trials that were judged disfluent or with articulation errors were repeated until experimenters reached full agreement that no disfluencies or articulation errors were present. Online judgments of fluency were made by the first author and a speech and language pathologist from Polyclinic SUVAG where children were enrolled in therapy. Trials had continued until 10 fluent productions were obtained. Given these methods, only segments that had been identified as fluent and accurately articulated were selected for acoustic analysis. For the single word repeating task, in total 3.22% of the data for the controls and 10.89% of the data for the children who stutter, were left out of the analysis. For the sentence repeating task, in total 8.16% of the data for the controls and 15.88% of the data for the children who stutter were left out of the analysis. Clearly, the sentence repeating task induced more errors than the single word repeating task.

Six sets of acoustic measurements were made for each participant:

1. Duration of the voice onset time of the /k/ in an isolated word (VOTWORD) and in the same word when embedded in a sentence (VOTSENT),

2. Duration of the initial syllable [ka] in an isolated word (SYLLWORD) and in the same word when embedded in a sentence (SYLLSENT),
3. Duration of the word KATA (DWORD),
4. Duration of the sentence KATA JE VELIKA (DSENT).

In total, 60 speech segments were analyzed for each participant. The acoustic measures were made without the experimenter being aware of the participants' group membership (the experimenter was present during the recordings and some bias may be introduced due the fact that she maybe recognized the children's voices). The individual mean was calculated as an average score obtained from ten repetitions. The group mean was calculated as an average score obtained from individual means. The Coefficient of variation for each variable was calculated[35] (using a formula Cv=SD/Xx100). We decided to use Coefficient of Variation (Cv) because it is a measure of within-participant variation and it is often used in cases where the mean and standard deviation comes from repeated measures of the same participant. Coefficient of Variation is a relative measure which allows us to compare a degree of variation for measured speech segments.

All subjects were given a practice session in which they produced the target word and the sentence in order to familiarize themselves with the speech tasks.

The voice samples were digitally transferred to a PC by S/PDIF interface. The measurement of all of the temporal variables was conducted using the PRAAT computer program (version 4.5). Acoustic duration (in sec) was measured from oscillographic traces displayed on the monitor (Figure 1). Mainly for practical reasons, we expressed speech measures in milliseconds, not seconds. Voice Onset Time of the consonant /k/ was measured as the interval between the release of the oral occlusion and the first glottal pulse of the following vowel. The release was recognizable as a sharp spike on the waveform. Duration of the syllable /KA/ in a word and in a word embedded in a sentence was measured as the interval between the onset of the VOT of the consonant /k/ and the offset of the following vowel /a/. The fragment vowel offset was defined as the last vertical striation on the oscillograph following which there was a gap. We did not measure the stop gap duration of the consonant /k/, because we found it difficult to determinate the onset of the gap duration with stops in the word-initial position. The duration of the word KATA was measured as an interval between the onset of the VOT of the consonant /k/ and the offset of the final vowel /a/. The duration of the sentence was measured as the onset of the VOT of the consonant /k/ and the offset of the final vowel /a/ in the word VELIKA.

The statistical analysis was based on the values of temporal parameters that were defined as variables. Before the start of the study, we did not predict which analysis would result in the rejection of the null hypothesis. All data were analyzed using a mixed-design ANOVA with repeated measures using group as between-subject factor and utterance length as within-subject factor. A significant level of 0.05 were set for all tests.

Reliability

An independent speech-language pathologist, who had no specific knowledge of the purpose of the study, reanalyzed twenty-five percent of the original recordings to assess the reliability of the speech measurements. More than a year after the original evaluations, the first author also reanalyzed 25% of the original recorded samples. The reliability was determined using the Pearson product-moment correlation. The interjudge reliability for VOT durations in a word: r=.90; the intrajudge reliability for VOT duration in a word: r=.92; the interjudge reliability for syllable durations in a word: r=.92; the intrajudge reliability for syllable durations in a word: r=94; the interjudge reliability for word durations: r=.94; the intrajudge reliability for word durations: r=96; the interjudge reliability for sentence durations: r=.95; the intrajudge reliability for sentence duration: r=.96; the interjudge reliability for VOT durations in a sentence: r=.86; the intrajudge reliability for VOT duration in a sentence: r=.89; the interjudge reliability for syllable durations in a sentence: r=.89; the intrajudge reliability for syllable durations in a sentence: r=91.

Results

Duration of speech segments

The mean and standard deviation for each of the six duration variables in a word and in a sentence (the duration of VOT, the duration of a syllable, the duration of a word and the duration of a sentence) for children who stutter and control are displayed in Table 1. Results indicated no significant differences between groups. No Group × Duration interaction was observed [F (5, 80)=0.868, p=0.51].

Variability of speech segments

The Coefficient of Variation was calculated for each duration variable. The mean and standard deviations for each variable in a group of children who stutter and in a group of normally speaking children are presented in Table 1. Children who stutter had significantly higher values than the normally speaking children [F (1, 16)=25.361, p<0.001]. For variables, CvVOTSENT [F(1, 16)=13.369, p=0.002] and CvSYLLSENT [F(1, 16)=13.937, p=0.001], the differences were statistically significant. A significant effect of Variability x Group was also observed [F (5, 80)=3.859, p=0.003].

Utterance length

To examine the influence of utterance length on the duration of speech segments, a repeated measure ANOVA was performed to assess the effect of group and within-subject differences. Embedding the word /KATA/ in utterance of increased length /KATA JE VELIKA/ did significantly affect the duration of voice onset time of /k/ [F (1, 16)=6,493, p=0,021] and duration of syllable /ka/ [F (1, 16)=47.882, p<0,001]. But, no duration of VOT (word *vs.* sentence) × Group interaction [F (1, 16)= 0.014, p=0.92] or duration of syllable (word *vs.* sentence) X Group interaction [F (1, 16)=2.106, p=0.165] was observed.

The most apparent effect for the utterance length was the greater variability of VOT /k/ and syllable /ka/ in a sentence in the speech of children who stutter. A significant effect of CvSYLL (word *vs.* sentence) × Group [F (1, 16)=6.36, p=0.022] and CvVOT (word *vs.* sentence) × Group [F (1, 16)=5.599, p=0.03] was observed. Because a significant Condition × Group interaction was observed, additional statistical tests (Univariate Test of Significance for Planned Comparison) were performed. The variability of VOT /k/ and syllable /ka/ in a sentence were statistically significant in the speech of children who stutter [CvVOTWORD *vs.* CvVOTSENT (F(1, 16)=10.498, p=0.005); CvSYLLWORD *vs.* CvSYLLSENT (F(1, 16)= 9.326, p=0.007)] There were no significant differences between variability of those segments in word vs, sentence position in speech of normally-speaking children [CvVOTWORD *vs.* CvVOTSENT (F(1, 16)=0.011, p= 0.916); CvSYLLWORD *vs.* CvSYLLSENT (F(1, 16)=0.262, p=0.615)].

Discussion

In the present study, two groups did not significantly differ in the duration of the measured speech segments. These results corroborate the findings for adults[12,13] and children who stutter[30]. Similar results were obtained in a research done by Throneburg and Yairi[36]. They compared the duration characteristic of single-syllable whole-word repetitions in the speech of preschool children who stutter recorded near the onset of stuttering to those of control nonstuttering children. The duration of the spoken repetition units was very similar in both groups of children.

When we compared durations of speech segments in a word versus in a sentence, the speech patterns within groups was similar, that is, the duration of speech segments decreases in sentences for both groups. Also, the results of the present study suggest that such decrease in duration of the speech segments in a longer utterance could be due to the use of movement reduction strategy to increase coartculation. The durational analysis done by Sadagopan and Smith[37] suggests that around the age of 9, children begin to use adult-like pre-speech processes to plan the timing of the sentence internal phrase, and maturation of these planning processes continues through late adolescence. Based on our findings, we conclude that children who stutter use the same speech mechanism for speech control as normally-speaking children, as far as the duration is considered. There were statistically significant group differences in regards to the variability of particular speech segments: the voice onset time for /k/ in the initial position in the first word of the sentence (CvVOTSENT) and the initial syllable /ka/ in the first word of the sentence (CvSYLLSENT). The variability of those speech segments might reflect a need for flexibility to meet the demands on speech motor skills made by increased demands associated with longer utterance. The increased variability can be seen as a poorer speech control over speech movement. Under this view, when the processing demands increase, breakdowns in speech production are more likely to occur[36]. Along this line of thinking, we can assume that over time children who stutter develop different control strategies intended to achieve better control over the speech movement[38,39]. Van Lieshout et al. proposed a similar explanation[19]. They suggested that people who stutter use different strategies to initiate and control their speech movement than individuals who do not stutter. Research done by Namasivayam and al. is also along this line of thinking[40]. Results from their research reveal that an increase in variability of movement coordination was not observed in people who stutter relative to control group (this effect was associated with significantly larger upper lip movement amplitude in people who stutter relative to people who not stutter). The authors suggested that a probable reason for avoiding increased variability in movement coordination by people who stutter could be related to the fact that instability may lead to a phase shift, which might push people who stutter into a region of control space characterized by disfluent behaviors. For people who do not stutter, such a risk is not a treat, so they show no compensatory behavior. Also, an intriguing explanation was proposed by Watkins and al.[41]. They found functional abnormalities in many cortical and subcortical motor areas related to speech production. They suspected that the structural abnormalities cause the functional ones, but they cannot rule out the possibility that a history of stuttering during development might have resulted in abnormal development of these white matter tracks.

Within-subjects analysis of our study revealed that children who stutter were more variable on speech segments extracted from sentences than from isolated words. Other authors also proposed the idea that the length and complexity of utterances play an important role in provoking stuttering[16,42]. Kleinow and Smith explored influences of length and syntactic complexity on the speech motor stability in the fluent speech of adults who stutter[13]. Results indicated that the speech motor stability of people who stutter decreased when the length and syntactic complexity of utterances increased. Research done on fluent adults and children showed that increases in syntactic complexity and utterance length were associated with increases in the speech motor coordination variability as well as the increases in the sympathetic nervous system response in both speaker groups[9].

Findings from our study showed that, like adults who stutter, children who stutter are also less consistent when performing longer utterances compared to normally fluent children. The research conducted by Logan and Conture revealed that increases in both length and complexity may contribute to decreased fluency in children who stutter[43]. From our study and studies cited above, it can be hypothesized that longer utterances make extra demands on the speech mechanism. Motor planning and motor execution is probably different when a longer utterance is produced. Along this line of thinking, we can support the idea that different variables may interact in stuttering causing its onset and maintenance.

One of the widely examined variables thought to influence speech of persons who stutter is utterance length[44]. It was observed that less stuttering occurred in the reading of a shorter sentence compared to when it was the initial part of a longer sentence[43]. A research done by Gaines and al. indicated that a sentence in which an episode of stuttering occurred within the first three words was significantly longer and more complex than a sentence that was free of perceptible stuttering and all other forms of fluency failure[45]. The production of longer utterance required advance planning for more phonetic targets, so it may be considered a spatial variable in speech production[44]. The length of utterance may be viewed as a linguistic variable, as the longer utterance would typically be more syntactically complex than shorter ones

So, if utterance length affects motor planning, it seems reasonable that utterance length may also affect motor execution. This way, linguistic factors could cause stuttering behavior to occur due to direct demands on the speech motor system[24]. Consonant sounds are more likely to be stuttered on than vowels, and plosive sounds carry a greater risk of stuttering. In other words, in our study, utterance length in combination with voiceless plosive on the beginning of the target sentence may have extra demands on speech output of children who stutter.

The findings in our investigation indicated that longer utterance is associated with an increase in variability of measured speech segments which could lead us to a tentative conclusion that children who stutter have limits in their ability to integrate spatial linguistic and motor functions.

The application of more challenging tasks (increased motor and linguistic complexity) than those used in this study will be required to further examine this issue in children who stutter. Also, there is a possibility that people utilize different strategies, or different neurological pathways, when reading phrases versus single words. Reading phrases assumes a certain level of syntactic processing while reading single words would be a relatively syntax-free process. To avoid this dilemma, future studies should compare groups of children using phrases of varying lengths and complexities.

Finally, we would like to emphasize that one must be careful when equating acoustic variability with specific motor skills for speech production. But, the results from studies which employed direct measures of movement in people who stutter corroborate our findings. Therefore, combining the present results with those from the previous studies, one can conclude that there is growing evidence that stuttering is a homogeneous disorder when it comes to the origin of the problems, and in the same time, heterogeneous because of different dealings with requirements from linguistic and other nature that place demands on their speech motor system.

Conclusion

The findings from the current research showed that the speech segments extracted from the fluent speech of children who stutter very close to the stuttering onset are essentially of the same duration as the speech segments of normally fluent children. Thus, we can assume that a longer duration of the speech segments seen in adults may be compensatory mechanisms intended to achieve better control over the speech movement. Therefore, more data about possible compensatory mechanisms is needed and it needs to be tested whether children who stutter are different not only from normally fluent children, but also from children whose stuttering persists. The description of the compensatory mechanisms in children who stutter could reveal if such mechanisms are based upon adaptive behavior (therapy effect), or upon a weakness within their neuromotor system. In addition, it could help in addressing the question why some strategies are effective or ineffective in achieving and maintaining fluent speech.

Although differences in durations of speech segments were not observed in this study between children who did and did not stutter, the efficiency of their speech control did not seem to be the same. As reported, there were statistically significant group differences with regards to the variability of particular speech segments. The results also indicated that the variability of the measured speech segment increased when the length of the stimulus utterance became longer. From this positive finding, it may be suggested that utterance length may have a direct impact on speech motor stability in children who stutter. Discovering more about the nature of the relationship among stuttering, acoustic segment duration, variability of acoustic segments, linguistic complexity and speech motor control is the goal of future investigations. We hope that further research into how individuals control their stuttering will make treatments more effective, and at the same time help to understand the nature of this puzzling disorder.

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TRAJANJE I VARIJABILNOST GOVORNIH SEGMENATA U GOVORU DJECE KOJA MUCAJU I DJECE UREDNOG GOVORNOG RAZVOJA

SAŽETAK

Svrha ovog ispitivanja bila je usporediti trajanje i varijabilnost govornih segmenata djeca koja mucaju i djece urednog govornog statusa kao i ustanoviti promjene na razini ispitanih varijabli koje se javljaju kao posljedica učinka duljine govornog izričaja. Istraživanjem je bilo obuhvaćeno 18 ispitanika (u dobi od 6,3 do 7,9 godina). Eksperimentalni zadatak sastojao se od ponavljanja izolirane riječi te rečenice koja je sadržavala tu istu riječ. Trajanje i koeficijent varijabilnosti (Cv) promatranih govornih segmenata bili su odabrani kako bi se ispitali vremenski aspekti govora. Značajna razlika dobivena je kod varijabilnosti govornih segmenata na razini rečenice, ali ne i kod trajanja. Dobiveni rezultati potvrđuju pretpostavku da lingvistički čimbenici postavljaju direktne zahtjeve na govorno motorički sustav te da produljeno trajanje uočeno u govoru odraslih osoba koje mucaju može biti oblik kompenzacijskih strategija.