SEQUENTIAL MOTION RATES IN THE DYSARTHRIA OF MULTIPLE SCLEROSIS: A TEMPORAL ANALYSIS

Kostas Konstantopoulos[a], *Marina Charalambous*[b] *& Jo Verhoeven*[b]

[a]Naval Army Hospital & [b]City University London, UK
sptx@ath.forthnet.grl; marina.lpdc@gmail.com; jo.verhoeven@city.ac.uk

ABSTRACT

Dysarthria is present in 23 - 51% of multiple sclerosis (MS) patients, and the perceived characteristics of dysarthria have been shown to predict quality of life in these individuals. Tests of maximum performance such as oral diadochokinesis and Sequential Motion Rates (SMRs) are used in many neurology clinics and are considered to be sensitive indices of dysarthria. This large scale study investigated the SMRs in two groups of participants, i.e. MS dysarthrics and pair matched controls. The main conclusion of this study is that speech rate was significantly lower in the MS dysarthrics. This was primarily caused by longer stop gap durations and to a lesser extent the duration of the word-final vowels. The significance of measuring SMR rate to the description of dysarthria in the MS participants in this study holds promise for being a marker of disease progression and may have implications for speech therapy in these patients.

Keywords: multiple sclerosis, dysarthria, sequential motion rate

1. INTRODUCTION

Research on dysarthria in neurological diseases such as stroke [15] and Parkinson's disease [13] has significantly increased, while it remains scarce in multiple sclerosis (MS). The dysarthria in MS is a predominantly mixed type (both ataxic and spastic) and perceptually determined speech problems mainly involve inaccurate consonant production, impaired loudness control, harshness, deficient pitch control, hypernasality, inappropriate pitch level and breathiness [2]. There are only very few studies on dysarthria in MS and these deal either with phonation [10] or speech and/or diadochokinesis (DDK) [5, 6, 7, 14, 17].

Diadochokinesis (DDK) refers to maximally rapid syllable repetition [14]. It involves the alternating motion rate (AMR) (defined as the rapid repetition of a single syllable /pa/, /ta/ or /ka/) and the sequential motion rate (SMR) (defined as the rapid repetition of a syllable sequence such as /pataka/) [14]. Both, AMRs and SMRs are used in clinical neurology to determine the efficiency of speech motor control [3] and they are considered as highly sensitive indices of motor speech impairments because they require maximum articulatory performance [8]. Recently, the instability in the duration of syllable production was found to be related to the course of e.g. Parkinson's and showed a promise as a marker of disease progression [13].

In the dysarthria of MS, the DDK rate (especially in the SMR task) has been reported to be slower than in healthy controls [14]. This finding agrees with earlier studies reporting slower DDK rates for patients with dysarthria resulting from other diseases [18]. However, a major drawback of these studies is that they did not adequately match the experimental with the control groups. In addition, they only studied a small number of participants and as a result, it is not known to what extent the reported results are reliable and can be extended to other clinical populations. Therefore, it was decided to carry out a carefully controlled study investigating SMR production in a large population of MS patients as compaired to pair-matched healthy controls.

2. MATERIALS AND METHODS

This investigation was a case control study in which speech samples were collected from an MS group and a pair-matched control group.

2.1. Participants

A total of 57 MS patients (28 males and 29 females) from the Neurology department of the Navy Hospital of Athens took part in the study. All patients were native speakers of Greek and presented with a conclusive diagnosis of MS on the basis of the MacDonald criteria [11] supplemented by the results of an MRI scan. None of these patients had any sign of cognitive impairment as assessed by the Mini Mental State examination [4]. In addition, participants had not had any visual/hearing problems, speech/language problems during childhood nor any other pathology (except MS) affecting speech and voice. The mean age of the MS participants was 35.20 years (range 21.5-62.2 years).

All these patients were screened for dysarthria by an experienced speech pathologist working in the Athens Navy hospital. This screening was based on a standard motor speech examination involving sustained phonation, AMRs/SMR tasks, reading of a standard passage and a monologue to evaluate articulation and voice. Twenty-seven MS patients (47%) were found to have dysarthria. Only these patients were included in the present study and this group will be referred to as the MS Dysarthric group.

The control group consisted of 27 participants who were pair-matched controls in age and gender to the speakers in the MS Dysarthric group. The mean age of the control group was 35.0 (range 20.2 – 65.2. The exclusion criteria that applied for the MS speakers were also maintained for the control group.

2.2. Materials

Participants were instructed to repeat the syllable sequence /pʌ-tʌ-kʌ/ as rapidly and as accurately as possible on a single exhalation. This procedure was clearly demonstrated to the participants by the experimenter prior to recording. Each subject had 3 production trials. The first 5 seconds of /pʌ-tʌ-kʌ/ of the second trial were selected for further analysis since a 3- to 5- second sample is usually regarded as sufficient for accurate clinical judgment [3].

2.3. Recording procedures

Participants' speech was recorded in a sound proof booth of the ENT department of the Navy hospital of Athens. The recordings were made by means of a portable TCD-D9 SONY DAT tape recorder and a high quality electret microphone which was positioned approximately 12 cm from every participant's mouth. The recordings took place in the morning or in the early afternoon to avoid fatigue in the subjects.

2.4. Analysis procedures

The temporal analysis of the Sequential Motion Rates was carried out in PRAAT [1] by means of a script which automatically extracted the duration of each /pʌ-tʌ-kʌ/ combination and the duration of all the segments in each /pʌ-tʌ-kʌ/ token on the basis of a previous annotation. As mentioned earlier, for each participant exactly the first 5 seconds of /pʌ-tʌ-kʌ/ repetition of the second trial were selected and annotated. Two annotation tiers were used: on the first tier each /pʌ-tʌ-kʌ/ delivery was annotated as a separate word, while the second tier consisted of an annotation of the individual speech segments within each word.

The speech segments that were annotated were: the release burst of /p/, the duration of the first vowel /ʌ/, the silence duration of /t/, the release burst of /t/, the duration of the second vowel /ʌ/, the silence duration of /k/, the release burst of /k/ and the duration of the third vowel /ʌ/.

3. RESULTS

In this study the durations of a total number of 490 /pʌ-tʌ-kʌ/ realisations were obtained as well as the durations of a total number of 4,410 speech segments within these /pʌ-tʌ-kʌ/ realisations. These durations were analysed by means of a series of t-tests with the experimental group as the independent variable. Various analyses were carried out with different dependent variables.

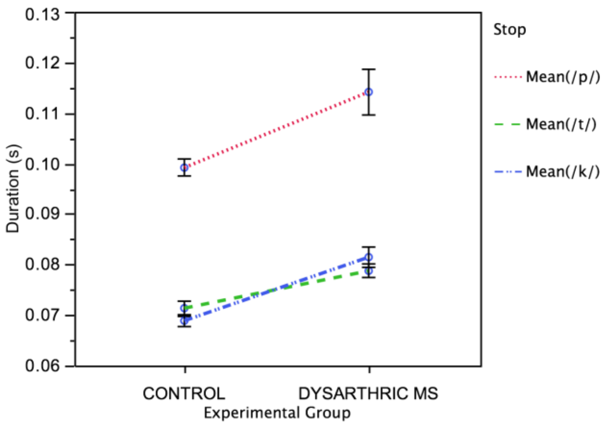
In the first analysis the dependent variable was the articulation rate expressed in syllables per second. The second set of analyses related to the durations of individual segments within the /pʌ-tʌ-kʌ/ tokens.

Since this analysis procedure involves multiple testing on the same data, a Bonferroni adjustment of p-values was applied. Specifically, since 10 separate analyses were carried out a Bonferroni correction of 0.05/10 = 0.005. This means that an effect was only considered significant at 0.05 level when the p-value resulting from the statistical analysis was smaller than 0.005.

The analysis of articulation rate revealed a significant difference between the two groups ($t(52)=3.430881$, $p=0.0012$): articulation rate in the MS Dysarthric group was significantly slower than in the control group (6.17 syll/sec vs. 6.97 syll/sec).

The analysis of stop segment durations revealed that the stop gap durations were significantly longer in the MS Dysarthric group (/p/: $t(434)=3.3648$, $p=0.0008$; /t/: $t(488)=3.7381$, $p=0.0002$; /k/: $t(488)=5.9797$, $p < 0.0001$). These durations are illustrated in Fig. 1:

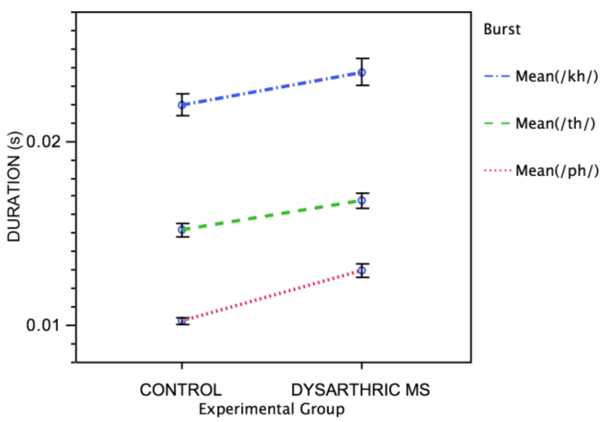
Figure 1: Stop gap durations in the healthy control speakers and the MS dysarthric speakers.



Stop gap durations in the MS dysarthric speakers measured 114 ms for /p/, 78 ms for /t/ and 81 ms for /k/. For the control speakers these durations were 99 ms for /p/, 71 ms for /t/ and 68 ms for /k/. Overall, stop gap durations were 11.66 ms longer in the MS Dysarthric group.

The analysis of stop bursts indicated that overall their durations were longer in the MS Dysarthric group, but that the difference only reached statistical significance for /ph/ (/ph/: t(488)=7.1536, p<0.0001; /th/: t(488)=2.8135, p=0.0051; /kh/: t(488)=1.8572, p = 0.0639). Stop burst durations are illustrated in Fig. 2:

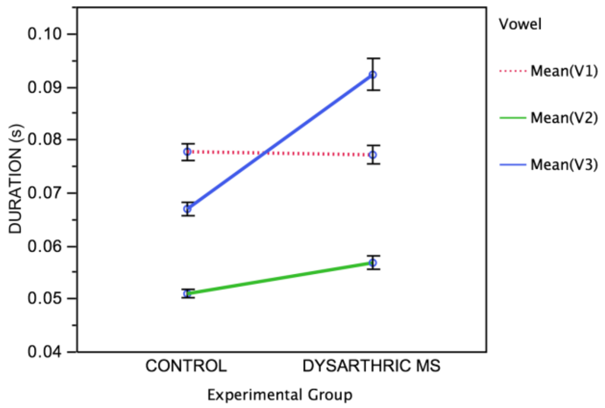
Figure 2: Stop burst durations in the healthy control speakers and the MS dysarthric speakers.



Stop burst durations in the MS dysarthric speakers measured 12 ms for /p/, 16 ms for /t/ and 23 ms for /k/. For the control speakers these durations were 10 ms for /p/, 15 ms for /t/ and 21 ms for /k/.

The analysis of vowel durations showed that the only the vowels in the second and third syllable were significantly longer in the MS Dysarthric group: /V1/: t(488)=0.2655, p=0.7907; /V2/: t(488)=3.9682, p<0.0001; /V3/: t(488)=7.9189, p<0.0001). Vowel durations are illustrated in Fig. 3:

Figure 3: Vowel durations in the healthy control speakers and the MS dysarthric speakers.



In the MS Dysarthric group the vowel durations were as follows: V1=77 ms, V2=56 ms and V3 =92 ms. The vowel durations in the control speakers was: V1=77 ms, V2=50 ms and V3=66 ms.

4. DISCUSSION

The results of this study indicate that the articulation rate in both groups is considerably faster than typical values for normal conversational speech that have been reported in e.g. [16] which suggested an average articulation rate of 4.64 syll/s. This confirms that in the present study both experimental groups were performing well above the standard rate and this is precisely what the SMR task is meant to do in order to put speakers' articulatory system to the test.

The second finding of this study is that articulation rate in the MS Dysarthric group (6.17 syll/s) is significantly lower than in the control speakers (6.97 syll/s). This agrees well with earlier studies reporting slower DDK rates in patients with dysarthria resulting from other diseases [12] and studies on dysarthria in MS [14]. In the present study, articulation rate in the MS speakers was 11.47 % lower than in the control speakers. This lower articulation rate of the MS dysarthric group may have to be accounted for by a slight incoordination of the muscles in the oropharyngeal area and fatigue, which is one of the most significant neurological signs in the disability of MS. Thus, the MS dysarthric group produced fewer /pʌ-tʌ-kʌ/ tokens, perhaps because the speakers failed to achieve rapid antagonistic muscle contractions.

The slower speech rate in the MS dysarthric group was mainly caused by significantly longer stop gap durations and longer duration of the vowels in the second and particularly the third syllable. Lengthening of stop gap duration has been reported in some studies to distinguish dysarthria from normal speech [14]. This finding agrees with the clinical observations that some sounds are more difficult in dysarthria compared to others.

Also, the fact that the vowel durations of the second and third vowels are significantly different in the two experimental populations may be an indication of discoordination and fatigue in the speakers with MS. Furthermore, vowel lengthening has been associated with ataxic dysarthria, which is one of the two dysarthrias that are commonly observed in multiple sclerosis [9].

5. CONCLUSION

From this study it can be concluded that SMR rate is relevant for the description of dysarthria in the Greek MS participants with dysarthria. SMR rate thus constitutes a very simple way of determining dysarthria, holds promise for being a marker of disease progression and may guide the speech therapy process. Further research is needed though to relate these findings to running speech and to neuroimaging data.

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