An articulatory and acoustic study of cluttering

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ABSTRACT

Cluttering is, thus far, a lesser investigated fluency disorder. While decades ago pathologists focused on the personality of clutterers (e.g. aggressive, messy, hasty), more recent work is dedicated to neurological, phonetic, speech and even hand motor aspects in seeking to understand the disorder. This paper will present an articulatory and acoustic study of speech motor abilities of three clutterers and three control speakers by means of the electromagnetic midsagittal articulography. The speech material consisted of repetitive CV- syllables and foreign words. Our results generally provide evidence that clutterers show kinematic patterns for the repetitive syllables similar to those of the control group, but their results differ with respect to the foreign words. Results show much more variable articulation for all clutterers as well as reduction phenomena for one clutterer.

1 INTRODUCTION

Cluttering, like stuttering, belongs to the fluency disorders. Because there are disfunctions of several modalities, authors describe cluttering as a syndrome and not as a disorder in its own right. Neither speech pathologists nor researchers have found a unique definition of cluttering. We will describe a few characteristic symptoms of adult clutterers based on our practical experience.

The disfluencies appear as propulsions, i.e. a very rapid production of words or parts of sentences, but speech rate is fluctuating. It sounds like a "maschinegun" - a clutterer told us. Generally, besides the rapid, unintelligible and mumbled speech, phonetic peculiarities like elision, contamination or assimilation occur. In Table 1 some examples of the phonetic pecularities are shown which are a result of a pilot study, aiming to test the speech material.

The symptoms differ from clutterer to clutterer and they are not consistent within a single speaker either.

- inter- and intraverbal acceleration, especially in longer words with consonant accumulation as in foreign words
- repetition of single syllables or short words
- disturbance of the melodic, temporal and dynamic accent
- unnatural stress, monotone speech
- disrhythmia of respiration

However, when they concentrate on their speech and language production, clutterers can avoid the symptoms.

target word	**realised as**	**paraphrase**
Belletristik	Belle_ristik	elision
dimensionalistisch	dimensionali*li*stisch dimensionali*si*stisch	anaptyxis
Labilität	*K*abilität	substitution
proportionalisieren	proportio*nila*sieren	metathesis
Protagonist	Prot*o*gonist	assimilation

Table 1: Examples of phonetic peculiarities

A few authors have reported on speech motor deficits of clutterers. For example, in a case study Lees et al. [1] describe a 15-year-old boy with limited tongue movements. They call for detailed phonetic studies "to provide more information on the nature of these misarticulations". It is necessary to investigate the functioning of articulators.

Such examinations have been carried out for stutterers, e.g. by van Lieshout et al. [3] who analysed the kinematics by means of EMMA. To our knowledge comparable studies do not exist for clutterers.

The aim of our study is to analyse kinematic and acoustic data from clutterers in order to study their speech motor abilities. Additionally, we will compare these with data from normal speakers.

2 METHODS

Tongue, jaw and lower lip movements were recorded by means of a 10-channel EMMA (Carstens Medizintechnik AG 100). Four sensors were attached midsagittally to the tongue, one to the jaw (lower incisors) and one to the lower lip. Two sensors served as reference coils to compensate for helmet movements, one was attached to the nasion and one to the upper incisors. Simultaneously, the acoustic speech signal was recorded on DAT (at 48kHz sampling rate).

2.1 SUBJECTS

We recorded three clutterers (PM1, PM2 and PW3) and three control speakers (NM1, NM2, NW3) of German. For each group two males (M) and one female (W) aged between 21-36 years were analysed. All clutterers underwent speech therapy.

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2.2 SPEECH MATERIAL

The speech material included two parts: 1) repetitive syllable strings and 2) foreign words. The first part was adapted from an investigation by van Lieshout et al. [2] who studied lip coordination in syllable production. Our material consisted of nonsense CV syllables where C was either /p/, /t/ or /k/ and V was always tense /a/. The subjects were instructed to repeat each sequence as fast and as intelligibly as possible during a 10 second interval.

The choice of the foreign words was based on our pilot study. Words consisted of four or five syllables and were embedded in the frame sentence "Sage … bitte" ("Say ... please"). In total 10 different words were recorded, each of them contained the syllable sequence /nali/. The /a/ within /nali/ was either pre-stressed 1 or pre-stressed 2. Every word was repeated 10 times in random order.

/nali/ pre-stressed 1	/nali/ pre-stressed 2
dimensionalistisch	dimensionalisieren
emotionalistisch	emotionalisieren
konstitutionalistisch	konstitutionalisieren
originalistisch	originalisieren
proportionalistisch	proportionalisieren

Table 2: Speech material- foreign words

2.3 ACOUSTIC AND ARTICULATORY ANALYSIS

Acoustic measurements

Acoustic data were downsampled to 16kHz. Concerning the syllable strings three acoustic landmarks were labelled: the time point of the burst, the onset and the offset of the vowel. Three durations were computed from these landmarks: (1) the voice onset time (VOT) of the stop as the interval between the burst and the onset of the second formant of the following vowel, (2) the vowel duration as the interval between the onset and the offset of the second formant and (3) the closure duration of the stop as the interval between the offset of the second formant and the burst.

Articulatory measurements

1. Repetitive syllable strings. The on- and offsets of the closing gestures (cl) for /p,t,k/ as well as the opening gesture (op) for /a/ were determined using a 20% threshold criterion at the relevant tangential velocity signal. For /pa/-syllables we chose the tangential velocity signal of the lower lip sensor, for /ta/ the tongue tip sensor and for /ka/ the tongue back sensor. The overall syllable duration was also calculated. Movement amplitudes for the opening and closing gestures were computed as the integral of the tangential velocity signal in the relevant interval (op or cl).

2. Foreign words. In the sequence /nali/ the two opening (gesture 2 and 4, see figure 1) and closing gestures (gestures 1 and 3) of the tongue tip sensor were analysed, but we will focus our attention in this work on gestures 2 and 3. The movement amplitudes for op and cl as well as the durations of the whole sequence (durall) and the second and third gesture (dur2+3) were computed.

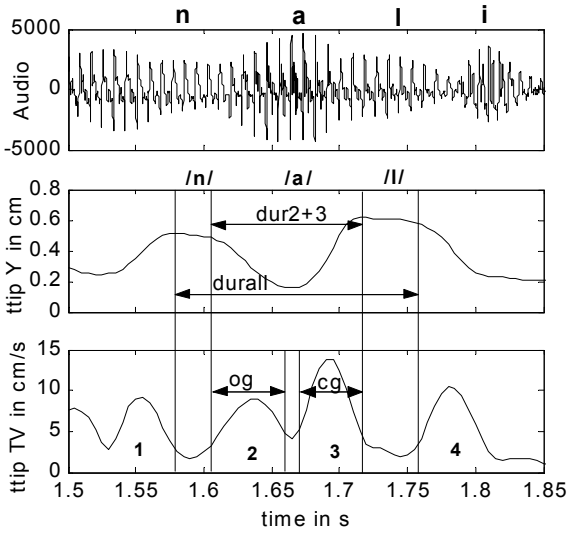

Figure 1: Articulatory labelling criteria for the foreign words; panel 1: audio, panel 2: vertical movement of the tongue tip sensor and panel 3:tangential velocity

3 RESULTS

3.1 SYLLABLE STRINGS

Acoustic results

In comparison to the vowel duration and the closure duration the results of VOT show the most consistent difference between the two groups.

VOTs of all clutterers were noticeably longer than the normal speakers. The exception was PM2. His VOT values were similar to the VOTs of the control speakers, although he produced more syllables during the defined time period.

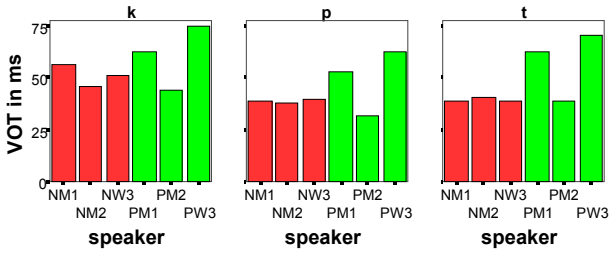

Figure 2: VOT – Means for the syllable strings /pa/, /ta/ and /ka/, values for normal speakers are red (dark grey) and clutterers green (light grey).

Articulatory results

Articulatory analysis of displacement of the relevant articulator and syllable duration revealed no significant difference between the two groups. In general clutterers produced fewer syllables than the normal speakers (again with the exception of PM2). Table 3 shows the number of produced syllables of the syllable string /pa/. Compared to the other syllable strings speaker PM2 produced always the most syllables (84 * /ka/ and 89 * /ta/).

speaker	NM1	NM2	NW3	PM1	PM2	PW3
number	79	70	76	67	85	58

Table 3: Number of syllables of the syllable string /pa/ during two repetitions of the 10 second time interval

3.2 FOREIGN WORDS

The barplot (figure 3) displays the mean duration of the second and the third gesture, split by speaker and stress. Clutterers show generally shorter durations than normal speakers. The exception is the long, pre-stressed 2 variant of PW3.

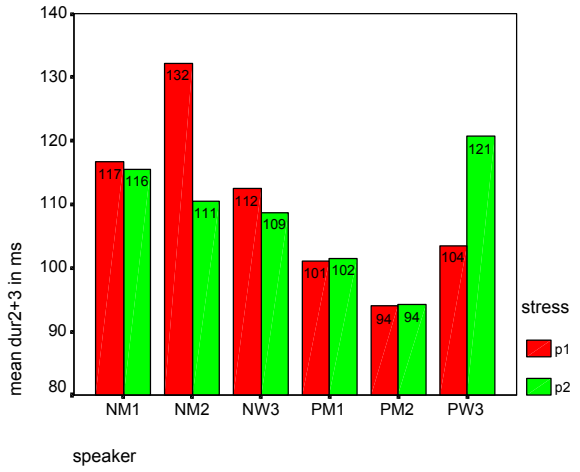

Figure 3: Mean duration of the tongue tip movement during the og to /a/, the target position for the vowel /a/ and cg to /l/, red color (dark) for pre-stressed 1 (p1) and green color (light) for pre-stressed 2 (p2) condition

speaker	NM1	NM2	NW3	PM1	PM2	PW3
V in %	2,8	3,5	2,9	13,6	11,3	9,6

Table 4: Variation coefficient (V) in percent for the total duration of the pre-stressed 1 version /nal/

Table 4 displays the variation coefficient of the total duration of /nal/ (labelled durall in figure 1). A higher coefficient was found for the clutterers. It was within the range of 9.6% up to 13.6% of the mean value, whereas the coefficient was maximally 3.5% for normal speakers.

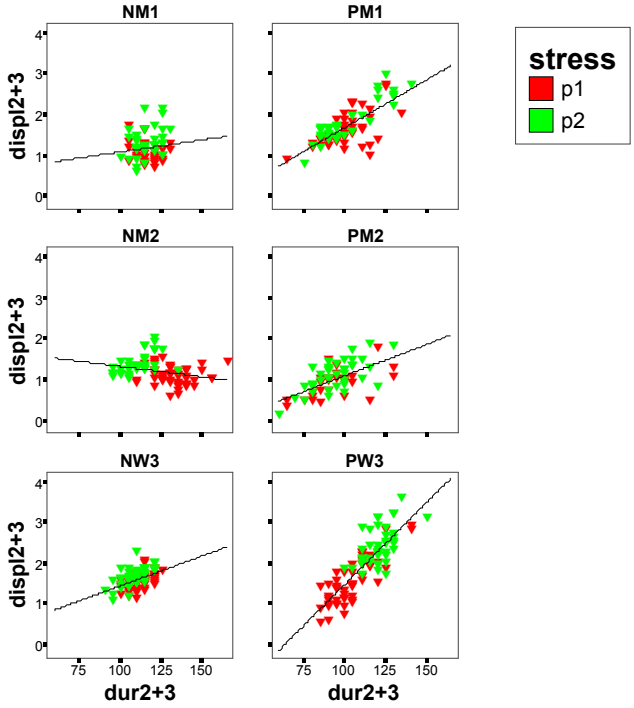

Figure 4: Relationship between duration and displacements split by speakers and pre-stressed 1 (p1) /pre-stressed 2 (p2) condition

Figure 4 plots the duration against tongue tip displacement of the second and third gesture. Apart from NM1 and NM2, a strong relationship was found for all speakers. In contrast to the normal speaker NW3, the results of all clutterers are more variable.

4 DISCUSSION

The method of EMMA proves to be a suitable method for analysing kinematic parameters of cluttering. The presented results show clearly that the pathology of cluttering is better represented by the foreign words than by the syllable strings.

Presumably this is due to more “real speech” than the nonsense character of the syllable strings.

Acoustic analysis

The VOTs of the clutterers were remarkably longer than the VOTs of normal speakers (except PM2). Normally we would expect that clutterers produce the syllables faster and with shorter VOTs than normal speakers do.

It is possible that by reproducing the syllable strings, the clutterers can carefully focus their attention on the given task and successfully apply their previously learned behavior patterns from speech therapy. Although they are able to produce more syllables in the given time period, they articulate a smaller number of syllables, but produce these more precisely and more intelligibly.

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Articulatory analysis

Interestingly, the articulation of the speaker PM2 caused problems with the analysis of the foreign words, whereas his production for the syllable strings (VOT) were similar to the control group. Comparing the pre-stressed 1 and pre-stressed 2 /nali/, he tended to reduce gestures: half of the data showed only two instead of the four gestures (cf. figure 1). We assume that the closing gesture from /a/ to /l/ was reduced to such an amount that only /nai/ was produced.

According to Munhall and Löfqvist [4] gestures can overlap in the fast speech rate condition. Although they were observing laryngeal gestural aggregation, we believe that this idea can be transferred to the tongue tip movements of PM2.

As can be seen in figure 4 there is a strong relationship between duration and displacement for all clutterers, i.e. shorter durations were accompanied by shorter displacements. With increasing speaking rate, clutterers show reduced amplitudes. In contrast, for normal speakers, speaking rate has no influence on the amplitudes. Additionally, the study shows more variable kinematic movements for all clutterers. This observation confirms the fact that the symptoms of clutterers appear inconsistently, e.g. they vary overall durations of the same word from one repetition to the other. In particular, this applied for the pre-stressed 1 condition of /nali/, where the variability of the data was three times higher than for the normal speakers (see Table 4).

5 CONCLUSIONS

The aim of this study was the examination of acoustic and kinematic data from clutterers in comparison to normal speakers. We found differences (1) in acoustic analysis of the syllable strings and (2) in kinematic analysis of the foreign words. The results provide evidence that:

(1) Clutterers can control movements of single articulators like normal speakers but probably have difficulties in temporal coordination, since VOT is a consequence of laryngeal-oral timing.

(2) Except for one speaker, clutterers articulate with a higher speech rate.

(3) One clutterer reduced gestures.

(4) All clutterers produce tongue tip gestures more variably than normal speakers.

The results of the kinematic analysis could be used as a suggestion for speech therapists: reducing speech rate is one possible solution for treatment, but it is also important to train the precise target positions in order to compensate for the reduction of gestures. Maybe the advice to speak more intelligibly helps the clutterer more than the permanent pressure to reduce speech rate.

Up to now our results do not generally provide evidence that clutterers show limited tongue movements as Lees et al. [1] reported.

Our future work will focus on: first, the effects of gestural reduction on the acoustics and second, on tongue and jaw coordination. We want to investigate coordination abilities of clutterers, according to the other kinematic studies of stuttering.

ACKNOWLEDGMENTS

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