Paraverbal speech stylistics in patients with chest pain and normal coronary angiography: is this method helpful in diagnosing underlying pathology?

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Paraverbal speech stylistics in patients with chest pain and normal coronary angiography: is this method helpful in diagnosing underlying pathology?

K. Laederach-Hofmann, S. Friedrich, L. Mussgay, R. Jürgensen

The aim of this study was to establish whether an analysis of speech stylistics proves useful in identifying subjects with angina pectoris-like chest pain and syndrome-X (SYX) or panic disease (PD).

We studied 32 patients, 16 of them suffering from PD, and 16 suffering from SYX. The two groups consisted of women and men, 8/8 from each sex, and were aged 58.6 ± 10.8 years (mean ± SD) and 59.8 ± 9.6, for PD and SYX, respectively. All patients suffered from angina pectoris (AP) and had a normal coronary angiography before this study. Whereas SYX patients had positive exercise testing (showing stress-induced ischaemia), patients suffering from PD had normal exercise testing and fulfilled the criteria for PD, anamnestically and in specially developed questionnaires.

All patients were interviewed using a semi-structured non-stress interview. In addition, 20 of them were interviewed in a stress-type interview thereafter. Speech stylistics were assessed during patients’ speech sequences where they described pain and others where they spoke about non-conflict contents. To determine speech stylistics we used the method developed by ourselves and published elsewhere. The speech analysis was performed in a blinded manner as was the group allocation.

The basal movement for the two groups differed in systolic blood pressure (129.0 ± 13.6 mm Hg (mean ± SD), vs. 117.5 ± 31.8 mm Hg, (p<0.05) for PD and SYX respectively), and disease duration (3.3 ± 1.4 years, vs. 2.4 ± 1.2 years (p=NS) for PD and SYX, respectively). In non-stress interviews, PD patients showed a significantly lower speed of speech, in both pain and non-pain sections (200.4 ± 33.1 syllables/min vs. 208.3 ± 23.1 syllables/min for pain (p<0.05) in PD and SYX, respectively; and 202.8 ± 36.9 syllables/min vs. 217.3 ± 32.2 syllables/min for non-pain sections (p<0.001) in PD and SYX, respectively).

Similar significant differences were observed in pain and non-pain sections for plosive words, repeated words, and silence latency. In simultaneous speech, only the PD group showed differences between pain and non-pain sections. No differences were noted in uneven speed of speech, speed volume, and swallowed words. Group differences were more prominent during stress-interviews in pain and non-pain sections for speed of speech, plosive words, and repeated words. Swallowed words differed only in non-pain sections.

The proposed method seems useful to differentiate between several verbal contents and their related emotive involvement as well as to identify patients without PD suffering from angina pectoris-like chest pain (= SYX), J Clin Bas Cardiol 1998; 1: 25–9.

Key Words: Speech-stylistics, angina pectoris, syndrome-X, panic disease

Reports on verbal semantic structure are to be found preferentially in linguistic work [11]. Another approach is the ethological one, where an analysis of mimic patterns related to speech contents and emotions is performed [12, 13]. These approaches, bearing in mind their correlative nature, seem to be highly applicable to clinical situations. In particular, the speech stylistic approach might answer the question as to what extent patients with normal coronary angiograms and angina pectoris-like chest pain may differ in their paraverbal speech behaviour. Earlier research used the same method to differentiate patients with peripheral from coronary angiopathy [14] or patients with type-A behavior [15]. However, paraverbal analysis is not universally accepted. One problem seems to be that it has first to be clarified whether the respective behaviour leading to the speech style is developing independently of the disease investigated. Support for the hypothesis that the two do not develop independently are the findings of anger and cholesterol interaction [16, 17]. Another concern might include the socially accepted learning of aggressive and competitive behaviour (as defined as type-A) which has not been related to any kind of disease. Thirdly, some flaws in interpretation and determination of the various parameters are often mentioned. The latter has led to the construction of models like hardness [18] or thoughtness [19] as a coronary

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prone pattern. Computer assisted analysis of speech has recently gained significance in analysing individual aspects of human speech, eg, in emotion research. We therefore decided to use the speech-stylistics, described by Bortner et al. [20] as a method to determine speech-variables and eventually attribute them to a defined pathology.

In different studies [21] investigations were performed to determine the origin of pain, resembling AP but not originating from the heart itself. Equally experimental pain procedures were used in the determination of ischaemia pathophysiology [22, 23]. Obviously, the most plausible explanation is a pain memory, localized in the spinal and palaeocortical brain structures, with the innervation pattern allowing fibres from the heart radiating centrally in close connections with somatosensory inputs (eg, from the left arm) [5]. To complete these concepts, we stress the work of Droste et al. revealing the insights in the respective anatomical and physiological phenomena, especially in the questions of central pain processing mechanisms [24].

**Study Aims**

This study was undertaken to determine whether patients with angina pectoris suffering from either SYX or having PD show different speech behaviour. Both groups were controlled for sex, age, type-A behaviour (by means of elements out of the Bortner-scale [20]), and depression (by means of the Hamilton depression scale [25]). We therefore hypothesised that speech stylistics (a) may help to identify patients with SYX or PD, both with angina pectoris and normal coronary vessels, and (b) that there may exist variables allowing a valid differentiation of these groups.

**Patients and Methods**

Thirty-two patients, 16 women and 16 men were studied. Sixteen of them, 8 men and 8 women, aged 58.6 ± 10.8 years (mean ± SD) suffered from panic disorder substantiated by means of a validated questionnaire (STAI) and a clinical interview (following DSM-IV diagnosis). The other group consisted of 16 patients equally, 8 women and 8 men, aged 59.8 ± 9.6 with syndrome-X, diagnosed as chronic angina pectoris-like chest pain, a normal coronary angiography and the non-invasive investigations performed blind to the diagnoses and to the results of the coronary angiography and the non-invasive investigations performed before. Each of the 52 interviews (with a mean duration of 24 minutes) was examined and divided into 2 sections, the first including verbal contents of pain description or pain-related topics, the second section incorporated verbal contents about non-pain topics, mostly leisure time or non-conflictual themes. Inter-rater reliability testing was not established because of known good correlations of our speech-stylistic rating system, confirmed by another study [14].

Because of multiple interruptions in the content-ductus of patient’s speech, several sections of pain description were concentrated to smaller complete time sections, usually more than 120 seconds to perform a valid analysis of speech stylistics (SPESTY). All the following values were transformed to values per minute or normalised by their respective means (see below) to ascertain comparability.

In the 32 first interviews, mean duration of the indicator (pain content) sequences was 140 seconds, and 102 seconds for the reference sequences (non-pain contents) respectively. In the 20 second interviews, mean duration of indicator sequences (IS) was 113 sec, and 51 seconds for the reference sequences (non-pain contents) respectively. All interviews were rated by the same person (SF), who was blind to the diagnoses and to the results of the coronary angiography and the non-invasive investigations performed before. Each of the 52 interviews (with a mean duration of 24 minutes) was examined and divided into 2 sections, the first including verbal contents of pain description or pain-related topics, the second section incorporated verbal contents about non-pain topics, mostly leisure time or non-conflictual themes. Inter-rater reliability testing was not established because of known good correlations of our speech-stylistic rating system, confirmed by another study [14].

**Catalogue of Speech Stylistics**

To classify different speech behavior, a similar set of variables was used as in our previous work [14]. The set of variables consisted of:

- **RW** (repeated words): repetition of identical word, part of words, part of sentences, included in one of the above defined sequences. The RW were counted per effective speech of the patient and transformed in events per minute.
- **SW** (swallowed words): number of syllables not clearly pronounced by the patient, counted as events per time of speech, normalized in events per minute.
- **IR** (interruptions): all interruptions of the interviewer by the patient, measured as event per time (seconds).
- **SIM** (simultaneous speech): parallel speech of the patient and the interviewer, measured as time (seconds).
- **SL** (silence latency): the time elapsed between the end of the interviewer’s question and the beginning of the patient’s answer, measured as time (seconds).
- **SS** (speed of speech): number of syllables per effective speech, counted as number per minute.
- **PW** (plosive words): short, intense, vivacious increases of speech volume, measured as events per effective speech per minute.
- **SV** (speech volume): average speech volume in one speech unit, rated in a 5 point Likert scale from 1 (low) to 5 (very loud).
**Table 1:** Basal characteristics (mean ± SD) of study patients (SYX denotes syndrome-X, PD means panic disease) during interview I (non-stress interview) and interview II (stress-interview). Significance *p < 0.005.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>SYX (N=16)</th>
<th>PD (N=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>years</td>
<td>59.4 ± 9.6</td>
<td>58.6 ± 10.8</td>
</tr>
<tr>
<td>Sex m/f ratio</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Disease Duration years</td>
<td></td>
<td>2.4 ± 1.2</td>
<td>3.3 ± 1.4</td>
</tr>
<tr>
<td>Systolic Blood Pressure mmHg</td>
<td></td>
<td>117.5 ± 31.8</td>
<td>129.0 ± 13.6</td>
</tr>
<tr>
<td>Diastolic Blood Pressure mmHg</td>
<td></td>
<td>76.9 ± 6.3</td>
<td>77.5 ± 6.3</td>
</tr>
<tr>
<td>Heart Rate bpm</td>
<td></td>
<td>70.6 ± 8.9</td>
<td>70.2 ± 9.0</td>
</tr>
<tr>
<td>Repeated Words RW number of</td>
<td></td>
<td>2.7 ± 0.6</td>
<td>2.6 ± 0.5</td>
</tr>
<tr>
<td>Speed of Speech SS syllables/min</td>
<td></td>
<td>208.2 ± 23.1</td>
<td>217.3 ± 32.2</td>
</tr>
<tr>
<td>Silence Latency SL seconds per question</td>
<td></td>
<td>3.5 ± 2.7</td>
<td>1.3 ± 1.5</td>
</tr>
<tr>
<td>Uneven Speed USS change of velocity per min</td>
<td></td>
<td>5.1 ± 2.3</td>
<td>3.4 ± 1.5</td>
</tr>
<tr>
<td>Plosive Words PW number per min</td>
<td></td>
<td>3.4 ± 1.3</td>
<td>2.3 ± 1.2</td>
</tr>
<tr>
<td>Repeated Words RW number of syllables per min</td>
<td></td>
<td>3.7 ± 1.7</td>
<td>2.8 ± 1.3</td>
</tr>
<tr>
<td>Swallowed Words SW number of syllables per min</td>
<td></td>
<td>3.8 ± 2.3</td>
<td>3.2 ± 2.1</td>
</tr>
<tr>
<td>Simultaneous Speech SIM syllables per min</td>
<td></td>
<td>0.6 ± 0.5</td>
<td>0.6 ± 0.8</td>
</tr>
<tr>
<td>Speech Volume SV 1=low to 5=very loud</td>
<td></td>
<td>2.7 ± 0.6</td>
<td>2.6 ± 0.5</td>
</tr>
</tbody>
</table>

The comparison whether the values of the different variables (see table 2) revealed significant inter-group differences for speed of speech (p < 0.05, higher for PD), and plosive words (p < 0.01, higher for PD) in interview I and II for SYX and PD respectively. A significant intra-group difference was noted only for PD between interview I and II for plosive words (p < 0.001), and overall speed of speech (p < 0.05). No significant differences were found in the group of SYX patients.

Our results show that a differentiation of patients with SYX and those suffering from PD is possible by means of paraverbal speech stylistics. In particular, the parameters PW, RW and USS seem to be very useful in this respect. They are maximally different in these patient populations in pain as well as in non-pain description parts of the interview. For SS a clear cut significant difference was seen between patients with PD and SYX in the stress-interview, whereas the latter had a higher difference in pain and no-pain sections than the former (p < 0.05). This finding underscores the usefulness of stress-interviews in the two patient populations. For PW the differences in the two populations were significant in pain sections, where in SYX a lower response-rate to stress was found than in PD (p < 0.001). In no-pain sections there were similar group differences. These groups were even more pronounced, and PD patients showed a reduction of PW during stress-interviewing in contrast to SYX who had more PW (p < 0.001 for groups). RWs were found increased in both populations during the stress-interview in pain and no-pain sections equally with significant differences between the two interviews only in no-pain sections (p < 0.01). No group effect was found.

**Results**

As shown in Table 1 no statistically significant differences were found between the two populations. However, a slightly longer disease duration was noted for PD subjects (p = NS), as well as a significantly higher systolic blood pressure in the group with PD (F=5.47, p < 0.005).

These included the variables SS and PW. For SYX SS showed a significant difference (p < 0.05) in interview I compared with interview II for the non-pain sections, as well as for the pain sections in interview I only (p < 0.05). The PW in SYX patients showed a significant difference in interview II for the no-pain sections (p < 0.01) and for interviews I and II for either (p < 0.05).

In PD patients only no-pain sections revealed significant differences in interview I, and II for SS and PW (p < 0.01).

**Discussion**

The comparison whether the values of the different variables (see table 2) revealed significant inter-group differences for speed of speech (p < 0.05, higher for PD), and plosive words (p < 0.01, higher for PD) in interview I and II for SYX and PD respectively. A significant intra-group difference was noted only for PD between interview I and II for plosive words (p < 0.001), and overall speed of speech (p < 0.05). No significant differences were found in the group of SYX patients.

ANOVA procedure for repeated measures was performed. These included the variables SS and PW. For SYX SS showed a significant difference (p < 0.05) in interview I compared with interview II for the non-pain sections, as well as for the pain sections in interview II only (p < 0.05). The PW in SYX patients showed a significant difference in interview II for the no-pain sections (p < 0.01) and for interviews I and II for either (p < 0.05).

In PD patients only no-pain sections revealed significant differences in interview I, and II for SS and PW (p < 0.01).

**Table 2:** Mean Values (± SD) of Speech Analysis in Patients with Syndrome-X (SYX) or Panic Disease (PD) during pain (P) and no pain (NP) description

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Acronym</th>
<th>Unit</th>
<th>Non-stress-interview</th>
<th>Stress-interview</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SYX</td>
<td>PD</td>
<td>SYX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P</td>
<td>NP</td>
<td>P</td>
</tr>
<tr>
<td>Speed of Speech</td>
<td>SS</td>
<td>syllables/min</td>
<td>208.2 ± 23.1</td>
<td>168.5 ± 42.4</td>
</tr>
<tr>
<td>Silence Latency</td>
<td>SL</td>
<td>seconds per question</td>
<td>3.5 ± 2.7</td>
<td>4.1 ± 3.6</td>
</tr>
<tr>
<td>Uneven Speed of Speech</td>
<td>USS</td>
<td>change of velocity per min</td>
<td>5.1 ± 2.3</td>
<td>4.3 ± 1.9</td>
</tr>
<tr>
<td>Plosive Words</td>
<td>PW</td>
<td>number per min</td>
<td>3.4 ± 1.3</td>
<td>3.7 ± 2.5</td>
</tr>
<tr>
<td>Repeated Words</td>
<td>RW</td>
<td>number of syllables per min</td>
<td>3.7 ± 1.7</td>
<td>3.7 ± 2.1</td>
</tr>
<tr>
<td>Swallowed Words</td>
<td>SW</td>
<td>number of syllables per min</td>
<td>3.8 ± 2.3</td>
<td>4.9 ± 2.9</td>
</tr>
<tr>
<td>Simultaneous Speech</td>
<td>SIM</td>
<td>syllables per min</td>
<td>0.6 ± 0.5</td>
<td>0.5 ± 0.6</td>
</tr>
<tr>
<td>Speech Volume</td>
<td>SV</td>
<td>1=low to 5=very loud</td>
<td>2.7 ± 0.6</td>
<td>2.4 ± 0.4</td>
</tr>
</tbody>
</table>

**Statistics**

To compare the respective variables between PD and SYX groups, and referring to the two interview sessions (I = non-stress, and II = moderate stress) the ANOVA procedure for repeated measures was used. Because of simplicity, only SL, SS, PW and USS were included. To compare the different speech stylistics with the respective groups we conducted ANOVA-testing.

Every section (IS, RS) was rated 4 times consecutively, where 3 times 2 and once 3 parameters were assessed concurrently.

**ANOVA procedure for repeated measures was performed.** These included the variables SS and PW. For SYX SS showed a significant difference (p < 0.05) in interview I compared with interview II for the non-pain sections, as well as for the pain sections in interview II only (p < 0.05). The PW in SYX patients showed a significant difference in interview II for the no-pain sections (p < 0.01) and for interviews I and II for either (p < 0.05).

In PD patients only no-pain sections revealed significant differences in interview I, and II for SS and PW (p < 0.01).

**Discussion**

Our results show that a differentiation of patients with SYX and those suffering from PD is possible by means of paraverbal speech stylistics. In particular, the parameters PW, RW and USS seem to be very useful in this respect. They are maximally different in these patient populations in pain as well as in non-pain description parts of the interview. For SS a clear cut significant difference was seen between patients with PD and SYX in the stress-interview, whereas the latter had a higher difference in pain and no-pain sections than the former (p < 0.05). This finding underscores the usefulness of stress-interviews in the two patient populations. For PW the differences in the two populations were significant in pain sections, where in SYX a lower response-rate to stress was found than in PD (p < 0.001). In no-pain sections there were similar group differences. These groups were even more pronounced, and PD patients showed a reduction of PW during stress-interviewing in contrast to SYX who had more PW (p < 0.001 for groups). RWs were found increased in both populations during the stress-interview in pain and no-pain sections equally with significant differences between the two interviews only in no-pain sections (p < 0.01). No group effect was found.

In another study with a group of similar patients [28], differences were found in affective adjectives used for pain description.

An earlier study by Melamed et al. [29] showed, that noise stress is an option to differentiate patients with type-A behaviour to those with type-B in blood pressure and heart rate analysis. When type-A and B behaviour is excluded, as in our study, the variables PW and SS are nevertheless helpful even in...
diagnosing SYX and PD. Speech stylistics as a diagnostic tool could eventually be optimised when stress application could become more standardised. Moreover, speech stylistics turned out to be a useful instrument in diagnosing chest pain, as various studies in our work have shown.

Scherwitz [30] compared 193 patients suffering from CHD to a healthy control group of 384 individuals and was able to show that speech stylistics associated with type-A behaviour are significantly associated with CHD. The respective parameters were voice emphasis representing in part our PW and latency of answering, parameters that showed no association to PW or SYX in our study population. More than ten years ago a study investigating patients during a non-stress interview found that those suffering from type-A behaviour had a higher uneven speed of speech, plosive words, and uneven speed of speech, as well as a more controlled and hesitating speech style, compared with non-type-A patients. Chesney et al. [31] compared type-A to type-B individuals with the FACS of Eckman and Friesen [32], and included speech stylistics. They found a correlation of some FACS-parameters with syllabic emphasis, loudness of voice, hostility, and speaking rate. The respective results of this study may apply on SYX patients only when the symptoms (such as pain) are clearly caused by a disturbed coronary circulation – which is by no means certain in our population [5].

In an epidemiological survey, Katon et al. [33] found patients with normal coronary angiography and typical or atypical angina pectoris to be significantly younger, often of female gender, and having more psychopathology such as panic attacks, depression, phobias, or vegetative concomitant symptoms. However, in our study patients with overt panic disease were not included. McCroskery [34] analysed in their work patients with negative coronary angiography and showed, that psychometric tests may show a positive correlation to a negative coronary angiography.

The question as to whether linguistic instruments are useful in the evaluation of chest pain has been raised by several researchers. In 1977 Schucker et al. [15] found a positive association of paraverbal speech stylistics: patients with coronary heart disease expressing type-A behaviour had more plosive words, a faster speed of speech, and a higher overall volume of voice. However, later scientific reports found a strong association of type-A behaviour and speech-stylistics in another patient group suffering from peripheral arterio-occlusive disease with pain [14], and the usefulness in pain assessment was highly doubtful. Nevertheless, our work revealed that even with exclusion of type-A patients these parameters may show a supplementary reliability in measuring pain.

It has often been suspected, that patients with PD and AP might have different pain origins. If this hypothesis is true, pain processing must be influenced by psychosocial elements, certainly having repercussions even onto other central nervous systems, such as speech generation. This thesis had been formulated by Friesen & Ekman [32] and others [5, 21, 35].
Thus, our results show that in comparison with the results of another study where patients with CAD and SYX were investigated, the latter behave differently to CAD in respect to pain parameters even in verbal analysis [36]. In our study, patients were selected in respect to sex, age, and educational level. It has been suggested in the past, that a sex-difference in several of the speech stylistics may exist. This has been found by Nicholson & Kinura [37], who reported a higher speed of speech and a higher repetition rate in males than in females. Their study population consisted of normal young people without any disease. In addition, an analysis of our data showed, that no such difference exists in our population which has moreover a well balanced sex ratio of 1:1. Equally no patients with personality disturbances and important psychic dysfunctioning were included in our study.

Conclusion

After exclusion of confounding factors such as sex, age and educational level, as well as overt type-A or B behaviour, some aspects of speech stylistics seem useful in differentiation between patients suffering from SYX and PD, both complaining of angina-like chest pain. Nevertheless, a quite simple, and in future even computerised method, might be to count syllables per minute (speed of speech), repeated words, and plosive words in a stressed patient and to compare the difference of these values to the resting evaluation.

Acknowledgements

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References

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