Introduction

A patient's ability to participate in and cope with communication in daily life is strongly influenced by his spontaneous speech production. Detailed analysis of spontaneous speech should, therefore, be part of every aphasia examination, and spontaneous speech should be considered in defining treatment goals.
For assessment of spontaneous speech production, many clinicians use rating scales (e.g. the Boston Diagnostic Aphasia Examination, BDAE, or the Aachen Aphasia Test, AAT) by which the patient's abilities are evaluated on different linguistic and/or communicative levels. These scales often contain only few parameters and lack sufficient interrater-reliability. Quantitative methods provide a liable alternative by analyzing basic parameters of speech production. Basic parameters have the advantage that less experience is required to identify them in spontaneous speech samples, especially when compared to the classification of aphasic symptoms. The reason why this kind of analysis, however, is not often used in clinical practice is that counting and calculating the basic parameters is very time-consuming. Therefore, we present a computer-assisted method for analysis of German spontaneous speech allowing a detailed analysis of basic parameters in an acceptable amount of time.

The aim of the present study is to establish basic parameters as an assessment instrument for the analysis of spontaneous speech in aphasia. Our hypothesis is that basic parameters are more sensitive to change than conventional rating scales. Additionally, we intend to find specific patterns of recovery in patients differing in duration (post-acute vs. chronic) and type of aphasia (fluent vs. non-fluent).

Methods

Twenty-eight aphasic patients participated in the study. Their mean age was 47.4 yrs (range 22-74 yrs), their mean duration of aphasia 18.4 months (range 1-86 months). Fourteen patients presented with fluent aphasia (AAT syntax-scale 1 or 2), fourteen with non-fluent aphasia (AAT syntax-scale 3 or 4). There were no significant differences in age, but the fluent group showed a significantly lower severity of aphasia as measured by the mean profile level (p<.01) and a significantly shorter duration of aphasia (p<.05). When classified according to duration post onset instead of type of aphasia, the following two groups can be distinguished: Fourteen patients (nine fluent, five non-fluent) were in the postacute stage and fourteen (five fluent, nine non-fluent) in the chronic stage of aphasia (>24 months post onset). There were no significant differences in any clinical parameters between these two groups. The different groups of patients and their clinical data are shown in table 1.

Table 1: Patients: clinical data

Patients	Stage	total	male	female	duration (months): mean	(range)	age (years): mean	(range)
fluent	post-acute	9	8	1	5.6	(1-10)	49.22	(36-68)
	chronic	5	3	2	19.4	(13-36)	50.2	(44-57)
	total	**14**	**11**	**3**	**10.5**	**(1-36)**	**49.57**	**(36-68)**
non-fluent	post-acute	5	2	3	6.0	(2-11)	48.2	(34-74)
	chronic	9	3	6	37.4	(18-68)	43.44	(22-58)
	total	**14**	**5**	**9**	**26.2**	**(2-86)**	**45.14**	**(22-74)**
total		**28**	**16**	**12**	**18.4**	**(1-86)**	**47.36**	**(22-74)**

Spontaneous speech was elicited before and after seven weeks of intensive language treatment using a semi-standardized interview. The first 60 clause-like units (CLUs) were transcribed according to detailed transcription guidelines worked out together with the computer program (if a patient did not produce 60 CLUs, the whole transrcipt was used). We focussed on the following four basic parameters: percentage words (W), percentage open class words (OWC), syntactic completeness (COMPL) and mean length of utterances (MLU).

To test for short-term consistency, the transcripts were divided into two parts (chronologically and randomly), which were analyzed separately and which formed the basis for estimating reliability and critical differences for significant change[1]. For each patient significant differences between pre- and post-test were analysed and compared to significant change on the rating scales of the Aachen Aphasia Test. A 3-factorial-ANOVA was carried out with the repeated measures factor time (pre- and post-treatment) and the grouping factors duration (postacute, chronical) and type of aphasia (fluent, non-fluent).

Results

The results are shown in table 2, significant changes for basic parameters and for the rating scales are presented in table 3. Four patients showed significant change in at least one of the spontaneous speech rating scales of the Aachen Aphasia Test. In contrast, significant change was observed in at least one of the basic parameters in sixteen patients. Twelve of them showed improvement, i.e. a higher percentage of either words, open class words or complete phrases or a longer MLU[2] or a combination of these. Among the latter, two patients had a significant improvement on the AAT rating scale „Communicative Abilities" or „Phonological Structure". Four patients showed significant decrease in one or more basic parameters, two of which had achieved significant improvement on the AAT rating scale „Formulaic Language". Whether these observations can be regarded as an improvement or a decrease in performance will be discussed in the next section.
Altogether, sixteen patients showed significant differences with regard to basic parameters, while only four of them improved significantly on the AAT rating scales. For twelve patients there was no evidence of change, neither on the rating scale nor in the basic parameters.

Table 2: Results of spontaneous speech analysis using basic parameters

		Pre-test			**Post-test**		
		Mean	**Range**	**SD**	**Mean**	**Range**	**SD**
Percentage Words	**fluent**	**84.2**	64.3-94.0	8.6	**85.8**	58.7-95.5	9.5
	non-fluent	**59.8**	30.0-82.0	16.3	**63.2**	25.3-88.1	18.9
Percentage Open Class Words	**fluent**	**25.2**	12.4-32.6	5.0	**29.0**	23.5-37.4	4.0
	non-fluent	**45.1**	26.6-74.1	12.5	**50.6**	25.2-78.9	15.3
Syntactic Completeness	**fluent**	**58.2**	28.3-90.3	19.2	**66.0**	39.3-91.7	15.6
	non-fluent	**17.1**	.0-44.8	14.8	**17.0**	.0-53.4	19.3
MLU	**fluent**	**5.4**	4.4-6.6	.7	**5.8**	4.5-7.4	.9
	non-fluent	**3.0**	1.6-4.5	.8	**3.3**	1.5-5.5	1.1

[1] Critical differences were determined separately for fluent and non-fluent patients.
[2] We classify an increase in the amount of open class words and MLU as normal, if it does not exceed the mean of a group of normal speakers in a previous study plus two standard deviations, i.e. approx. 33% open class words and an MLU of 7.5 words respectively. According to this criterion all significant increases observed in this study can be classified as improvement.

Table 3: Significant changes from pre- to post-test for individual patients (n=28) in basic parameters and rating scales

AAT rating scales	Quantitative method: Basic parameters			total
	improvement	no change	decrease	
improvement	2	0	2	4
no change	10	12	2	24
decrease	0	0	0	0
total	12	12	4	28

The 3-factorial-ANOVA revealed a significant main effect for type of aphasia, i.e. fluent vs. non-fluent, for all four basic parameters (W: $F(1, 24)=20.78$, $p<.001$; OWC: $F(1, 24)=25.75$, $p<.001$; COMPL: $F(1, 24)=50.20$, $p<.001$; MLU: $F(1, 24)=55.15$, $p<.001$). A significant main effect of time, i.e. pre- vs. post-test, was observed only for W ($F(1, 24)=5.31$, $p=.03$) and OWC ($F(1, 24)=27.453$, $p<.001$). No 2-way interaction was significant. For OWC the 3-way interaction between time, duration and type of aphasia was significant ($F(1, 24)=6.55$, $p=.017$).
Subsequent two-tailed independent-samples t-tests confirmed the difference between the fluent and the non-fluent patients for all parameters in the pre- and post-test ($p<.001$). The comparison of postacute and chronic patients, however, showed no significant differences in any basic parameter.

Discussion

We exspected basic parameters of spontaneous speech production to be more sensitive to small changes in performance than rating scales. This was confirmed by the results of the spontaneous speech analysis. While sixteen patients showed significant change between pre- and post-test in one or more basic parameters, only four of them differed significantly in at least one of the rating scales. Most of the results in the post-test can unambigiously be interpreted as an improvement. The remaining four patients exhibit various patterns. One patient produced significantly less complete CLUs in the post-test, another one presents with a reduced MLU and percentage of words, both obviously indicating a deterioration of performance. Two patients showed on the one hand a decrease in the percentage of words, syntactic completeness and/or MLU, but on the other hand they were rated significantly better on the AAT-scale „Formulaic language“ in the post-test. Therefore, it seems reasonable to assume that these patients have improved at least in some respects, namely in using less automatized, formulaic language. This change may lead to a decrease in the percentage of words (because more interjections or neologisms are used instead of automatisms), in syntactic completeness or MLU. In this context a more extensive discussion is necessary about how to deal with automatized language.

The ANOVA showed, above all, a significant main effect for type of aphasia, and a t-test confirmed the significant differences between fluent and non-fluent aphasia for all four basic parameters, whereas no differences were found when comparing post-acute to chronic patients. This supports the clinical classification of fluent and non-fluent aphasia. The different patterns of recovery in these two groups based on our results will be discussed in more detail as will be the implications for assessment and therapy of aphasia.

To summarize, the basic parameters proved to be much more sensitive to change than the AAT rating scales. Thus, with the computer-assisted analysis of basic spontaneous speech parameters, we present a clinically applicable instrument to measure even small changes during the course of recovery from aphasia.