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Attentional Impairments of Aphasic Patients in the Acute and Postacute Phase after Stroke

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Abstract

Attention deficits as well as aphasia are being frequently observed among post-stroke patients. However, studies analysing attentional deficits of aphasic patients in the acute phase after stroke are rare. Therefore, the aim of the study was to investigate attentional deficits in stroke patients with aphasia, the relationship between attentional and linguistic deficits as well as changes in these domains from acute to post-acute phase. Twelve patients with first insult in the left hemisphere, aged between 45 to 88 years were included. Each patient completed a linguistic and a neuropsychological assessment Bielefeld Aphasie Screening (BiAS); attention test of the Aphasie-Check-Liste (ACL); Reduced Symbol-Digit-Test (R-SDT) in the acute as well as in the post-acute phase after stroke. In the acute phase, 91.67% (n=11/12) of the aphasic patients showed attentional deficits. While the percentage of errors in the ACL attention test of the ACL negatively correlated with the necessary number of repetitions of the instructions in the BiAS (p<.01) in the acute phase; the number of necessary repetitions in the BiAS was associated with the processing time of the R-SDT (p<.05) in the post-acute phase. In this study, a significantly positive relationship between language functions and attentional performance was observed in both, the acute and post-acute phase after stroke.

Keywords: Stroke; Aphasia; Attention; Bielefeld aphasie screening; Aphasie check list; Reduced symbol digit test

Introduction

In Germany, approximately 200 to 250 people of 100.000 suffer a stroke every year [1]. Up to 30% of these patients are aphasic [1,2]. Aphasia is a centrally caused language disorder that occurs after substantial language acquisition due to acquired brain damage. The resulting impairments usually refer to all linguistic levels (phonology, morphology, syntax, lexicon, semantics, pragmatics) and both expressive and receptive language modalities (language production, language comprehension, reading, writing), but they may vary in pattern, degree and composition.

The architecture of the language processing network has been a field of research for almost 160 years since Broca described the association between "motor aphasia" and a lesion in the middle part of the left frontal lobe, the cortical speech center [3]. After Broca's fundamental work, Wernicke described the left posterior superior temporal gyrus of the dominant hemisphere as the neuroanatomical origin of language comprehension ("receptive aphasia") [3]. The so-called conduction aphasia is caused by a lesion of the arcuate fasciculus which connects Wernicke's and Broca's areas to each other resulting in difficulties repeating words while language reception and spontaneous speech production are intact [3]. In clinical practice, this historical model (Wernicke-Geschwind model) is still of major importance for understanding the classical categorization of aphasic syndromes: The sounds of the words are transferred through the auditory pathways to the primary auditory cortex and then to Wernicke's area, where the meaning of the words is extracted [3]. In order to produce oral speech, meanings and word concepts are activated and their representations mainly in the temporal and parietal gyrus send activation via the arcuate fasciculus to regions around Broca's area, where building word forms and morpho-syntactic structures is controlled and then passed on to the motor cortex [3] for planning speech and articulatory gestures.

Depending on the expansion of a middle cerebral artery infarction of the dominant hemisphere, language perception, production and conduction processes of oral and written language may be distorted to varying degrees, even resulting in a global aphasia when the whole territory is affected.

Stroke survivors do not only suffer from aphasia but also from a variety of cognitive impairments hampering rehabilitation including medical-nursing, sensorimotor, neuropsychological and psychopathological disorders such as hemiplegia, hemiparesis, hemianopsia, neglect, disorders of memory and other cognitive functions [4]. Those cognitive deficits include language, attention, memory, executive functions and visuospatial skills and show complex interactions [5-7]. Consequently, after a stroke, only the linguistic processes may be impaired, but aphasic problems are combined with other cognitive problems very often.

Cognitive impairments, especially deficits of attentional and executive functions being frequently observed among post-stroke patients may interact with language processing [6,8,9]. Moreover, attention deficits can result in behavioral changes such as increased distractibility [10,11]. Studies including patients following stroke without aphasia have shown that attentional impairments are more distinct in the acute phase than in the postacute phase [12].

While attention deficits among aphasic patients in the chronic phase have been described in some studies as well as attention deficits in the acute phase after stroke in non-aphasic patients have been studied and described, studies analyzing attentional deficits of aphasic patients in the acute and early postacute phase after stroke are rare [5,9-17]. Therefore, the aim of the study was to investigate attentional impairments of aphasic patients in the acute and postacute phase in a follow-up design.

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Methods

The study was carried out at the BDH-Clinic Hessisch Oldendorf and at the Clinic of Neurology and Early Neurological Rehabilitation of the Medical Centre Osnabrück, two neurological centers in Germany with intensive care, stroke unit and inpatient neurological rehabilitation, between December 2015 and June 2016. Positive ethics votes have been obtained from Medical Council Westfalen-Lippe and University of Münster (2015-299-f-s) as well as from the ethic committee of the Medical School of Hannover (2960-2015).

Design and hypotheses

The primary aim of the study is to investigate associations between language and attentional deficits in aphasic stroke patients. Therefore, the following three hypotheses are defined: Firstly, a high percentage of aphasic patients suffer from deficits in sustained and selective attention, as has been shown for up to 60 percent of patients following stroke in general [12]. We assume that the attentional deficits in aphasic stroke patients are at least equally high as in patients with other cognitive deficits. Secondly, the attentional deficits of aphasic patients decline from acute to post-acute phase as has been shown for stroke patients [18]. Thirdly, specific language deficit profiles are associated with the amount of attentional problems both in the acute and post-acute phase following stroke. We assume a reduction of aphasic symptoms from acute to post-acute phase especially for word generation, complex sentence production and comprehension depending on a decline of attentional problems as these language domains have been shown to rely on attentional capacity [10,11,13].

Patients

Inclusion criteria were: patients with first insult in the left hemisphere, aged between 30 and 88 years, native German speaking, right-handed. Exclusion criteria were: history of other neurological or psychiatric diseases or not-corrected visual and/or auditory impairments.

The study group included 12 patients (4 male, 8 female) aged 45 to 88 years (73.58 ± 14.4 years, median 79 years) in the acute phase. A detailed overview of baseline characteristics is shown (Table 1).

Procedure

Each patient completed a linguistic and a neuropsychological assessment in the acute as well as in the post-acute phase after stroke. The acute phase after stroke was defined as four to six weeks post-stroke, with a duration of four months [19-22].

At each test interval, the assessments were performed on two consecutive days: The linguistic assessment was conducted on the first day and the neuropsychological assessment on the second day. When patients were not able to cooperate long enough in the acute phase, the linguistic assessment was divided into two parts of 15 minutes each [23]. The second assessment was not conducted with each patient enrolled in the study, as they were discharged early or suffered from additional illnesses. The detailed procedure of testing is presented (Figure 1).

Assessment of language functions

For the linguistic assessment, the Bielefeld Aphasie Screening (BiAS) was used [19,20]. This assessment comprises twelve subtests to assess the following four basic skills: speech comprehension, automatic speech, speech production and written speech [4]. Speech comprehension is tested with picture-based auditory comprehension of single words and sentences as well as with decision questions. To assess automatic speech, counting of words in a row, completion of proverbs and recall of phrases is performed. The ability for speech production is analysed with objects naming, describing pictures of specific situations and word fluency. In addition, picture-based reading comprehension for specific nouns, overt reading of words and writing after dictation is used to assess written speech. The patients used small magnetic letter plates for the writing task. For object naming, real objects were used instead of pictures. In addition to the performance in the twelve subtests, specific behavioural responses were documented and analysed, i.e. number of repetitions, uncertainties and self-corrections.

Assessment of attentional functions

Attentional skills were tested with the attentional screening of the Aphasie-Check-Liste (ACL [21]). In the ACL, patients are asked to mark two target symbols in a row of slightly different symbols on a worksheet, which is conceptualized to test selective attention. In each of the six rows the patient has to stop after ten seconds. To ensure comparable test conditions, every patient (with and without hemiparesis) had to use the left non-dominant hand. Age-dependent cut-off-values were used to estimate attention deficits.

In addition, a the Reduced Symbol-Digit-Test (R-SDT), an adaptation of the symbol digit modalities test (SDMT) for

Patient	Gender (m/f)	Age (years)	Days post-stroke at acute phase	Days between acute and post-acute phase
P01	F	56	5	57
P02	M	54	31	21
P03	F	77	8	21
P04	F	85	12	34
P05	M	87	33	20
P06	M	72	12	50
P07	F	80	7	50
P08	F	88	10	N/A
P09	M	45	10	40
P10	F	80	7	N/A
P11	F	81	6	54
P12	F	78	8	N/A
Group	4/8	73.58	9.01	38.55
Note: M=male, F=female, N/A=not available.				

Table 1: Characteristics of the participants (P) and the period of assessments.

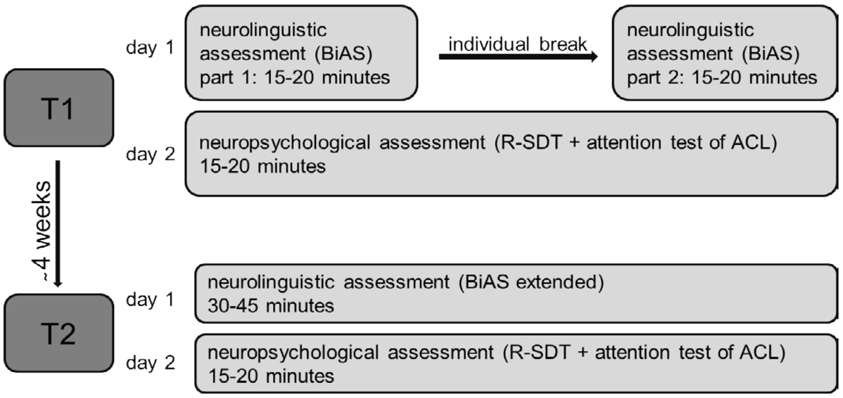

Figure 1: Overview of test intervals and procedures during the study.

Note: BiAS=Bielefeld Aphasie Screening, R-SDT=Reduced Symbol-Digit-Test, ACL=Aphasie-Check-Lists

neurologically handicapped patients was used [24]. The SDMT was modified to fit patients with a hemiparesis [24]. During testing, a small box (size: 12.8×1×25.9 cm) and small digit plates were used. The task required putting the digit plates into small slots in the box. Patients used the left non-dominant hand. Small stripes, each with six symbols, were presented one after the other (instead of a whole worksheet with symbols as in the SDMT) [24]. The performance was quantified by documenting the processing time in seconds and the number of errors. An example of one stripe and the target combination (presented to the patient) is shown in Figure 2.

Data from both tests were used to obtain the following parameters: number of aphasic patients with attentional deficits, severity of attentional deficits, and degree of correlation between aphasic and attentional deficits. Further, the defined behavioral responses in the BiAS were analyzed as potential indicators for attention disorders.

For the second assessment in the post-acute phase, only data of nine patients were available (eight in case of the R-SDT). For these patients only, a comparison between the acute and post-acute phase was possible.

Statistics

For statistical analyses, IBM SPSS Statistics version 22 was used. Two-tailed p value <.05 was considered significant. Changes of language and attentional functions from acute and post-acute phase were examined with t-tests for dependent samples.

For BiAS, the overall performance across all 12 subtests was determined and compared between acute and post-acute phase. Overall performance was used to determine the severity of aphasic symptoms. The following severity categories are defined: “severe” (<24.65%), “moderate” (25.00-79.51%), “mild” (80.56-89.58%), “minimal” (89.9-94.44%) and “no aphasia” (>89.9%). Finally, the performance in the four domains was compared for both test intervals on patient level.

Data from both attentional tests (ACL, R-SDT) were used to obtain the following parameters: number of aphasic patients with attentional deficits, severity of attentional deficits and changes of attentional deficits from first to second assessment. Behavioural responses observed during the BiAS (number of repetitions, uncertainties and self-corrections) were analysed as potential indicators for attention disorders, too. Additionally, associations between aphasic and attentional deficits were examined with Spearman’s correlation coefficient.

Results

Assessments during the acute phase were performed on day 9.01 ± 12.42 (range: 5 to 33 days) after stroke onset. The second assessment (post-acute phase) was conducted 38.55 ± 14.24 days (range: 20 to 57 days) after the first testing.

Language deficits (BiAS)

The overall performance of each participant and the corresponding severity categories are presented (Table 2). In the acute phase (n=12), most patients (n=7; 58%) suffered from moderate aphasia, followed by mild (n=3; 25%) and severe (n=2; 17%) aphasic symptoms. In the post-acute phase (n=9), two patients (22%) improved and had no aphasia anymore, while one patient (11%) had mild and six patients (67%) moderate aphasic symptoms. The overall performance is composed of the performance in each of the four main BiAS domains and was 58.68 ± 25.30% for the acute and 66.78 ± 24.16% for the post-acute phase (t(8)=-4.961; p<.01). On individual subject level, two patients improved in the four BiAS subtests from acute to post-acute phase (P06: t(3)=-4.362, p<.05; P11: t(3)=-6.676, p<.01).

Attentional deficits (ACL, R-SDT)

The ACL provides standardized data to assess attentional deficits in the acute phase. Therefore, all patients were able to perform the test. The R-SDT, however, could be handled by few patients, only (see Table 3). In the acute phase, 11 patients (91.67%) showed attentional deficits according to the ACL. Among patients with data on both test intervals (n=9), eight patients (88.9 %) demonstrated attentional deficits in the acute phase and seven patients (77.8 %) in the post-acute phase. One patient improved to an adequate attentional performance from acute to post-acute phase. Altogether, there was no change with respect to the number of errors and omissions, while the total number of processed items (ΔN=22.22 ± 19.20; t(8)=-3.472, p<.01) and the number of error-corrected items (ΔN=19.33 ± 19.91 items; t(8)=-2.913, p<.05) improved from acute to post-acute phase. Despite these improvements in attentional measures, it should be noted that seven out of nine patients (78%) scored lower than the cut-off values of the ACL.

Four patients accomplished the R-SDT both in the acute and the post-acute phase. These patients needed less time for test completion in the post-acute phase (328.53 ± 239.511 s) than in the acute phase (451.67 ± 302.06 s; t(3)=3.192, p<.05). With respect to the number of errors, no changes between both test intervals were observed.

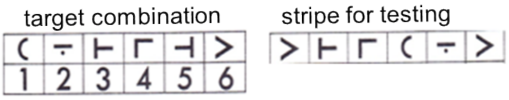

Figure 2: Target combination (left) presented to patient and small stripe for testing (right).

Patient	Acute phase	Severity category	Post-acute phase	Severity category
P01	87.83	mild	97.55	no aphasia
P02	55.55	moderate	56.78	moderate
P03	27.45	moderate	52.78	moderate
P04	20.50	severe	28.50	moderate
P05	49.28	moderate	59.38	moderate
P06	17.34	severe	44.73	moderate
P07	67.01	moderate	79.51	moderate
P08	69.44	moderate	N/A	N/A
P09	84.03	mild	97.57	no aphasia
P10	85.76	mild	N/A	N/A
P11	61.80	moderate	84.36	mild
P12	78.12	moderate	N/A	N/A
Note: N/A=not available, BiAS=Bielefeld Aphasie Screening.				

Table 2: Participant's overall performance in BiAS (in percent) and corresponding severity categories for both test intervals.

	Acute phase				Post-acute phase			
	ACL attention test		R-SDT		ACL attention test		R-SDT	
Patient	Processed items (n)	Errors (%)	Processing time (sec)	Errors (n)	Processed items (n)	Errors (%)	Processing time (sec)	Errors (n)
P01	125	1.60	159.3	1	139	2.87	139.9	0
P02	47	2.12	812.1	0	53	0	606.0	2
P03	17	0.00	N/A	N/A	55	23.63	724.7	47
P04	16	12.50	N/A	N/A	23	56.50	N/A	N/A
P05	15	13.33	N/A	N/A	33	18.18	374.7	48
P06	6	0.00	N/A	N/A	18	5.55	973	35
P07	22	22.73	585	5	28	10.71	450.8	3
P08	7	28.57	N/A	N/A	N/A	N/A	N/A	N/A
P09	45	0.00	250.3	0	106	0	117.4	1
P10	43	0.00	1000	26	N/A	N/A	N/A	N/A
P11	42	30.95	N/A	N/A	80	13.75	290.8	3
P12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Note: N/A=not available, R-SDT=Reduced Symbol-Digit-Test, ACL=Aphasie-Check-Liste.								

Table 3: Attentional performance of the participants at both test intervals determined with attentional part of the ACL and the R-SDT.

In the post-acute phase, ACL and R-SDT scores were correlated. Specifically, the total number of processed items of the ACL negatively correlated with processing time (r=-0.762, p<.05) and number of errors (r=-0.647, p<.05) of the R-SDT. In addition, the percentage of errors in the ACL correlated significantly with the number of errors in the R-SDT (r=0.819, p<.01).

Relationship between language and attentional deficits

Significant correlations were detected between the total number of processed items in the ACL and the overall performance in the BiAS both, in the acute (r=0.655, p<.05) and the post-acute phase (r=0.800, p<.01) after stroke (see Table 4). Further, the majority of the BiAS subtests significantly correlated with the total number of processed items of the ACL (five out of twelve subtests in the acute and seven out of twelve subtests in the post-acute phase). None of the tasks of the BiAS showed significant correlations with the percentage of errors in the ACL in the acute phase and two significant correlations were found in the post-acute phase.

During the post-acute phase, patients with higher overall performance in BiAS needed less processing time (r=-0.976, p<.01) and made fewer errors (r=-0.683, p<.05) in the R-SDT. In detail, ten out of twelve subtests showed significant correlations with at least one attentional parameter in the post-acute phase (see Table 4 for individual results). The "word fluency" subtest of the BiAS requires complex word retrieval skills and is thus assumed to be highly demanding for attentional skills. While word fluency was not related to items of attentional scales in the acute phase, significant correlations were observed in the post-acute phase: Patients with higher word fluency performance processed more items (ACL: r=0.743, p<.05), needed less processing time (R-SDT: r=-0.976, p<.01) and made fewer errors (R-SDT: r=-0.683, p<.05).

The percentage of errors in the ACL attention scale correlated negatively with the necessary number of repetitions of the instructions in the BiAS (r=-0.731, p<.01). Patients who needed more repetitions of the BiAS instructions in the post-acute phase also needed more time to

		Acute phase		**Post-acute phase**			
BiAS		ACL number of items (n=11)	ACL percentage of errors (n=11)	ACL number of items (n=11)	ACL percentage of errors (n=9)	R-SDT processing time (n=8)	R-SDT number of errors (n=8)
Overall performance (%)		0.655*	0.014	0.800**	-0.561	-0.976**	-0.683*
Number of repetitions		0.097	-0.731**	-0.279	-0.110	0.764*	0.439
Number of uncertainties		0.027	0.365	-0.485	-0.437	0.429	0.060
Number of self-corrections		0.143	0.078	-0.638*	-0.295	0.295	0.099
1	Word comprehension	0.711**	0.031	0.604*	-0.880**	-0.651*	-0.778*
2	Sentence comprehension	0.233	-0.317	0.507	-0.522	-0.753*	-0.565
3	Decision questions	0.051	0.442	0.343	-0.291	-0.702*	-0.064
4	Word counting	0.637*	0.068	0.606	-0.696*	-0.620	-0.850**
5	Completion of proverbs	0.517	0.143	0.791*	0.556	-0.945**	-0.710*
6	Recall of phrases	0.516	0.308	0.731*	-0.465	-0.694*	-0.724*
7	Object naming	0.505	0.172	0.707*	-0.367	-0.577	-0.249
8	Picture description	0.508	-0.153	0.632	-0.291	-0.868**	-0.771*
9	Word fluency	0.499	-0.359	0.743*	-0.484	-0.868**	-0.771*
10	Reading comprehension	0.565*	-0.267	0.410	0.150	-0.169	0.283
11	Word reading	0.559*	0.052	0.743*	-0.312	-0.702*	-0.385
12	Write after dictation	0.655*	-0.376	0.782**	-0.379	-0.778*	-0.696*

Note: BiAS=Bielefeld Aphasie Screening, R-SDT=Reduced Symbol-Digit-Test, ACL=Aphasie-Check-Liste; significance levels of Spearman's rho correlation: *p<.05; **p<.01.

Table 4: Correlations between language and attentional test performances.

perform the R-SDT (r=0.746, p<.05). In addition, patients who needed more self-corrections during the BiAS processed less items in the ACL (r=-0.638, p<.05). Changes of behavioral responses from acute to post-acute phase did not reach level of significance.

Discussion

The main focus of the present study was to investigate attentional deficits in stroke patients with aphasia, the relationship between attentional and linguistic deficits as well as changes in these domains from acute to post-acute phase. In the current study, the majority of patients (91.67%) suffered from attentional deficits in the acute phase after stroke. This result is in line with previous studies, demonstrating that 46 to 92% of stroke patients have attentional deficits in the acute phase of recovery [3]. In the post-acute phase, about six weeks post stroke, the number of attentional deficits significantly declines, being as low as 20 to 43% [18].

The small sample size (n=12 in acute phase, n=9 in post-acute phase) of our study might lead to an overestimation of the prevalence of attentional deficits among post-stroke patients. However, a high prevalence can be expected in a larger sample, too, since linguistic impairments have an impact on attentional performances among stroke survivors [12,17]. One example is aphasia-related problems of comprehension, affecting the understanding of task instructions and limiting a successful processing of the given task.

It has to be pointed out that both assessments used in the current study, the ACL attention scale and the R-SDT, address complex nonverbal attentional performances, which leads to a high sensitivity for attentional deficits among aphasic patients [20,24]. It is reasonable to believe that tests investigating less complex attentional performances (e.g., the Burgauer Bedside-Screening [26]) might be successfully completed by a higher number of patients. Sensitivity and specificity of both measures will have to be focused in further studies for aphasic and non-aphasic patients suffering from stroke in the acute and post-acute phase.

The results from this study support the hypothesis that attention deficits improve from the acute to the post-acute phase after stroke. However, the fact that the performance of most patients remained below the defined cut-off-values during the post-acute phase gives evidence to the persistent character of stroke-related attentional deficits [18,27]. It should be noted that the measurements were collected early in the post-acute phase after stroke. Further assessments in the late post-acute phase as well as in the chronic phase are necessary to improve evidence [22].

Relationship between language and attentional deficits

Language and attentional functions were related in both, the acute and the post-acute phase after stroke indicating that attentional deficits are frequent among aphasic stroke patients. Moreover, attentional skills have a significant impact on the performance in language tests during the early phases after stroke. Different subtests of the BiAS were confounded with attentional performance. In previous studies, linguistic performance was influenced by attentional functions, too [8,9,11]. Word fluency, for example, requires the coordination of multiple cognitive processes and neural subsystems [28,29]. However, the comparison of the data between the acute and the post-acute phase showed higher correlation coefficients in the post-acute phase, which was an unexpected result. As mentioned above, the assessment of attentional functions with the R-SDT was probably too demanding for the tested patients because it addresses more complex attentional components than the ACL.

The intensity domain, which is the basis for complex attention skills, may be affected in the acute phase after stroke [8,16,25]. Consequently, a decrease of vigilance might have an impact on the processing of hierarchical higher functions. Another possible explanation might be the arousal of the patient, which was probably hampered by the setting of the tests used (i.e. time pressure). In summary, a complex network of attention deficits might be evident in the acute phase. There are not only attentional deficits but also a variety of other cognitive disorders such as executive and memory dysfunctions resulting from a stroke [4]. Due to complex interconnections, these impairments might also interact with the performance in attentional tests [5–7]. Thus, it may be hypothesized that the observed deficits of the patients in the acute phase might rather be caused by a complex of multiple factors than by a single impairment. Altogether, these factors might impair the ability of stroke patients to solve the tasks during the first days after stroke. In addition, just like language functions, attentional skills underlie fluctuations [19,20]. There is a considerable variability of attentional performance among aphasic patients [16].

Aphasic symptoms are more stable in the post-acute phase after stroke onset [8]. A similar process of stabilizing initial fluctuations might be true for attentional skills. Barker-Collo et al. [12] assume processes of restitution in the early phase after stroke. In this case, attentional skills get more stable and might be easier to detect by attentional assessments during the post-acute phase. The lower correlation coefficients in the acute phase compared to the post-acute phase observed in the current study, might be explained by these mechanisms. A comparison of both domains (language and attentional functions) in the early and late post-acute (up to the chronic) phase might reveal the expected decrease of correlative interconnection and thus less functional overlay of attentional functions and language. However, attentional deficits are still persisting [18,27,28]. There are interactions described between both domains among aphasic patients at a later stage after stroke [11,14].

Behavioral responses as expression of attentional deficits

There was a negative correlation between the number of repetitions in the BiAS and the percentage of errors in the ACL in the acute phase. Actually, a positive correlation was hypothesized: the more severe the attentional deficits are, the more repetitions are necessary for successful completion of the task. The result may lead to another conclusion: a better attentional performance is accompanied by more repetitions. This might indicate that the patients are well aware of their deficits. They still have sufficient self-control and notice that they can get over it by asking for repetition. Attentional deficits may restrict the transmission of information into the working memory [6,30,31].

In the post-acute phase, the number of repetitions in the BiAS correlates with the processing time in the R-SDT, a temporal aspect of attention. In general, slower processing times in attentional tasks are interpreted as poorer attentional performance. Based on the explanation of findings during the acute phase ("better attentional performance with more repetitions"), an alternative interpretation is possible: reduction of processing speed in favor of higher accuracy. Patients with a longer processing time (R-SDT) and a higher number of repetitions (BiAS) may process the information more carefully and more accurately because of more pronounced processes of self-control during the execution of the tasks. Thus, even in the post-acute phase, repetitions might not only be due to more severe deficits. Moreover, the number of repetitions might be evaluated as result of the severity of the disease: Patients with less linguistic and attentional impairments are in need of fewer repetitions to complete the tasks, because their information intake processes are intact. Moderate to severely impaired patients, on the other hand, may have limited awareness of the disorder and/or reduced opportunities for self-monitoring processes. Thus, they might demand fewer or no repetitions although they would need them. Patients with slight to moderate disabilities might still have adequate self-control processes, because they notice their problems and the potential help by asking for a repetition, which results in a higher number of repetitions. Moreover, asking for a repetition might also depend on individual personal characteristics such as motivation and feeling shame for not understanding a task. In the post-acute phase, the number of self-corrections (BiAS) was negatively correlated with the processing time (ACL). This might be interpreted in a similar way as the number of repetitions: the assumed self-control processes are present in favor of a higher accuracy. In this context, the self-control processes might indicate sufficient attentional resources of a patient to recognize that the previous result from linguistic processing needs an amendment.

Limitations

The small sample size of twelve patients in the acute phase and nine patients in the post-acute phase could result in an under- or overestimation of effects. In addition, the severity of aphasic symptoms was very heterogeneous in this study, which could have an impact on the study results. Furthermore, nine out of twelve aphasic patients were older than 70 years. According to Hochstenbach et al. [28], degenerative processes beginning with 70 years and might cause cognitive impairments. Thus, the observed cognitive deficits might not be caused by the stroke alone, but also by an age-related decline of mental function.

Both attentional assessments have to be performed under time pressure, which might have a negative impact on the performance of the patients [32]. Time pressure may influence the arousal of the patient, which in turn might result in a less efficient attention allocation to specific task demands. Regarding the screening of the ACL, it turned out that the copy template was too small. In addition, there was a considerable overload caused by the task demands. Such an overload should be avoided when testing patients in the acute phase after stroke. Further, it has to be mentioned that the patients had no long adaption phase for using the left (non-dominant) hand in case of hemiparesis of the dominant hand. In summary, the operationalization of the attentional performance of patients after stroke was limited in this study.

Despite the adaptation of the R-SDT for the acute phase, the task might still have been too difficult. Only few patients were able to accomplish the task during the acute phase after stroke. Thus, the test might be more appropriate in the post-acute phase. In general, it has to be noted that the given instructions of an assessment of nonverbal attentional performance are still verbal (spoken or written). So, language is still part of the assessment. Thus, when testing aphasic patients, there is a risk that patients do not completely understand the demands of the task (depending on comprehension skills). Taken together, both chosen attentional assessments are challenging patients, in particular during the acute phase. For future research, more appropriate attentional assessments for testing both phases should be used.

Regarding the behavioral responses, it should be noted that they were counting measures (as defined in the manual of BiAS). For future research, a relationship between the number of behavioral responses and the number of correctly edited items of the BiAS might be used for a more appropriate analysis of attention deficits among aphasic stroke patients.

Conclusion

The study confirmed that attentional deficits are common among aphasic patients after stroke since there was a high prevalence in this study sample. Further, there was a strong correlation between the attentional deficits and the assessed linguistic skills. Since attentional deficits are frequently accompanied by aphasic symptoms, their possible impact on the recovery of linguistic skills should be considered. However, screening and diagnosis of attentional deficits in the early phases after stroke is limited, yet.

In this study, the behavioral responses in the BiAS were evaluated as potential indicators for attentional deficits. The analyzed correlations revealed that behavioral responses are not only a sign of attentional deficits but also of remaining attentional resources in patients with acquired attentional deficits. These findings might be interesting for future research focusing on behavioral responses.

Competing Interests

The authors declare that they have no competing interests

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References

1. Hacke W (2010) 13th ed. Neurologie, Heidelberg: Springer.
2. Huber W, Poeck K, Weniger D Aphasie. pp. 93–173.
3. Nasios G, Dardiotis E, Messinis L (2019) From Broca and Wernicke to the neuromodulation era: Insights of brain language networks for neurorehabilitation. Behav Neurol 2019: 9894571.
4. Stapleton T, Ashburn A, Stack E (2001) A pilot study of attention deficits, balance control and falls in the subacute stage following stroke. Clin Rehabil 15: 437–444.
5. Helm-Estabrooks N (2002) Cognition and aphasia: a discussion and a study. J Commun Disord 35: 171–186.
6. Heidler M (2008) Aufmerksamkeit und Sprachverarbeitung. Sprache-Stimme-Gehör 32: 74–85.
7. Bonini MV, Radanovic M (2015) Cognitive deficits in post-stroke aphasia. Arq Neuropsiquiatr 73: 840–847.
8. Nobis-Bosch R, Rubi-Fessen I, Biniek R, Springer L (2012) Diagnostik und Therapie der akuten Aphasie. Stuttgart: Thieme.
9. Petry MC, Crosson B, Gonzalez Rothi, LJ, Bauer RM, Schauer CA (1994) Selective attention and aphasia in adults: preliminary findings. Neuropsychologia 32: 1397–1408.
10. Murray LL (2002) Attention deficits in aphasia: presence, nature, assessment, and treatment. Semin Speech Lang 23:107–116.
11. Murray LL (2012) Attention and other cognitive deficits in aphasia: presence and relation to language and communication measures. Am J Speech Lang Pathol 21: S51-64.
12. Collo S B, Feigin V, Lawes C, Senior H, Parag V (2010) Natural history of attention deficits and their influence on functional recovery from acute stages to 6 months after stroke. Neuroepidemiology 35: 255–262.
13. Hula WD, McNeil MR (2008) Models of attention and dual-task performance as explanatory constructs in aphasia. Semin Speech Lang 29: 169-187.
14. Guendouzi J, Loncke F, Williams MJ (2011) The handboock of psycholinguistic and cognitive processes: Perspectives in communication disorders. New York: Psychology Press.
15. Murray LL (2000) The effects of varying attentional demands on the word retrieval skills of adults with aphasia, right hemisphere brain damage, or no brain damage. Brain Lang 72: 40–72.
16. Villard S, Kiran S (2015) Between-session intra-individual variability in sustained, selective, and integrational non-linguistic attention in aphasia. Neuropsychologia 66: 204–212.
17. Barker-Collo SL, Feigin VL, Lawes Carlene MM, Parag V, Senior H (2010) Attention deficits after incident stroke in the acute period: frequency across types of attention and relationships to patient characteristics and functional outcomes. Top Stroke Rehabil 17: 463–476.
18. Hyndman D, Pickering RM, Ashburn A (2008) The influence of attention deficits on functional recovery post stroke during the first 12 months after discharge from hospital. J Neurol Neurosurg Psychiatry 79: 656–663.
19. Richter K, Wittler M, Hielscher-Fastabend M (2006) BIAS: Bielefelder Aphasie Screening: NAT-Verlag.
20. Richter K, Hielscher-Fastabend M (2018, BIAS AR 2nd edition).
21. Kalbe E, Reinhold N, Ender U, Kessler J (2002) Aphasie-Check-Liste: ACL. Köln: ProLog Therapie- und Lernmittel GmbH.
22. Huber W, Poeck K, Springer L (2006) Klinik und Rehabilitation der Aphasie. Stuttgart: Thieme.
23. Bley M, Wagner A, Berrouschot J (2002) Aphasiediagnostik auf der Stroke Unit. Der Nervenarzt 73: 336–341.
24. Smith A (1982) Symbol Digit Modalities Test. Los Angeles: Western Psychological Services.
25. Sohlberg MM, Mateer CA (2001) Improving attention and managing attentional problems. Adapting rehabilitation techniques to adults with ADD. Ann N Y Acad Sci 931: 359–75.
26. Peschke V (2004) Burgauer-Bedside-Screening: PSYDAT.
27. Pinter D, Enzinger C, Gattringer T, Eppinger S, Niederkorn K, et al. (2019) Prevalence and short-term changes of cognitive dysfunction in young ischaemic stroke patients. Eur J Neuro 26: 727–732.
28. Hochstenbach JB, den Otter R, Mulder TW (2003) Cognitive recovery after stroke: a 2-year follow-up. Arch Phys Med Rehabil 84: 1499–1504.
29. Mirman D, Kraft AE, Harvey DY, Brecher AR, Schwartz MF (2019) Mapping articulatory and grammatical subcomponents of fluency deficits in post-stroke aphasia. Cogn Affect Behav Neurosci 19: 1286–1298.
30. Awh E, Vogel EK, Oh S (2006) Interactions between attention and working memory. Neuroscience 139: 201–208.
31. Souza AS, Rerko L, Lin H, Oberauer K (2014) Focused attention improves working memory: implications for flexible-resource and discrete-capacity models. Atten Percept Psychophys 76: 2080–2102.
32. Kahneman D (1973) Attention and effort. Prentice-Hall: Englewood Cliffs.