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Assessment of explicit and implicit linguistic impairments in patients with aphasia after resection of tumour of the left cerebral hemisphere. Preliminary results

Ocena zaburzeń językowych na poziomie świadomym i nieświadomym u pacjentów z afazją po usunięciu guza lewej półkuli mózgu. Wyniki wstępne

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Abstract

Background and purpose: Classical definitions of aphasia describe deficits of different language levels (syntactic, semantic, phonologic) hindering the ability to communicate. Recent studies indicate, however, that impairment of particular aspects of linguistic competencies in aphasia differs in severity. Contemporary approach to the aphasic symptoms presents them as disturbed access of linguistic representations to the awareness system. Accordingly, such an approach requires different types of tasks: direct, involving explicit language processes, and indirect, based on implicit language representations. The aim of our study was to examine explicit and implicit language processes in patients with aphasia after resection of the tumour of left cerebral hemisphere along with characterization of relationships between explicit and implicit language processes.
Material and methods: Our cohort included 28 right-handed patients who were divided into four equal groups: two clinical (brain tumours) and two control (lumbar disc disease). Four tasks that assess and compare language processes: lexical decisions (at explicit and implicit levels), sorting of picture captions and word monitoring were implemented.

Streszczenie

Wstęp i cel pracy: W klasycznych opisach afazji występują deficyty różnych poziomów języka (syntaktyczny, semantyczny, fonologiczny), utrudniające komunikację chorych. Nowsze badania wskazują, że zaburzenia poszczególnych aspektów kompetencji językowych w afazji mają różną głębokość. Współcześnie objawy afatyczne traktowane są jako zakłócenia dostępu reprezentacji językowych do systemu świadomości, co wymaga zastosowania odmiennych typów zadań: bezpośrednich, angażujących uświadamiane (jawne, *explicite*) procesy językowe, i pośrednich – bazujących na nieuświadamianych (utajonych, *implicite*) reprezentacjach językowych. Celem pracy jest ocena uświadamianych i nieuświadamianych procesów językowych u pacjentów z afazją po usunięciu guza lewej półkuli mózgu oraz charakterystyka relacji między procesami językowymi typu *explicite* i *implicite.*
Materiał i metody: Badano 28 praworęcznych pacjentów, tworzących cztery równoliczne grupy: dwie kliniczne (nowotwory mózgu) i dwie kontrolne (dyskopatia lędźwiowa). Zastosowano cztery zadania oceniające i porównujące procesy językowe: decyzje leksykalne na poziomie jawnym i utajo-

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Results: In direct tasks, patients with aphasia provided less correct lexical decisions at word level, but did not show deficits in sentence comprehension. In both groups, no priming effect was observed in tasks requiring implicit lexical decisions. The longest time was found in non-primed words, the shortest in pseudowords. The differences between groups regarding word monitoring were also observed. Patients with aphasia obtained longer reaction times in all types of sentences (of different grade of language correctness), with respect to low- and high- frequency words.
Conclusions: Patients with aphasia after brain tumour resection show more pronounced impairments of explicit than implicit linguistic behavior; the same effect was found in studies on forgetting in amnestic syndrome.

Key words: tumours of the left cerebral hemisphere, explicit and implicit language processes, aphasia, priming.

nym, sortowanie podpisów do obrazków oraz monitorowanie słów.
Wyniki: W zadaniach bezpośrednich pacjenci z afazją podawali mniej prawidłowych decyzji leksykalnych na poziomie wyrazu, lecz nie wykazywali deficytów w zakresie rozumienia zdań. W obydwu grupach, w zadaniu wymagającym decyzji leksykalnych na poziomie utajonym nie stwierdzono efektu torowania. Najdłuższy czas notowano przy słowach nietorowanych, najkrótszy przy pseudosłowach. Stwierdzono różnice między grupami w zadaniu monitorowania słów. Osoby z afazją uzyskały dłuższe czasy reakcji we wszystkich rodzajach zdań (o różnej poprawności językowej), dla słów nisko- i wysokofrekwencyjnych.
Wnioski: Pacjenci z afazją po resekcji guza mózgu wykazują w większym stopniu zaburzenia procesów językowych o charakterze świadomym (kontrolowanym) niż nieświadomym (zautomatyzowanym). Taki sam efekt stwierdzono w badaniach nad zapominaniem w zespole amnestycznym.

Słowa kluczowe: guzy lewej półkuli mózgu, uświadomione procesy językowe, nieuświadomione procesy językowe, afazja, torowanie.

Introduction

A number of pathological syndromes related to focal brain injuries (i.e. unilateral neglect syndrome, prosopagnosia, amnestic syndromes) shows variable levels of deficits in attention and conscious control processes while automatised, habitual unconscious functions are preserved [1-4]. Descriptions of patients with amnesia provide evidence that explicit and implicit processes should be taken into an account as a part of clinical characteristics not only for theoretical (cognitive) but also for their clinical value. Preserved ability for latent memorizing and learning constitutes a base for cognitive rehabilitation of these patients. Similar diversity of symptoms regarding consciously controlled and automatised language processes might be found in patients with aphasia. Accordingly, a model of dissociation of two categories of knowledge, explicit and implicit with regard to language functions assumes that explicit language processes remain under control of an explicit information processing system, which under normal conditions cooperates with modules that comprise implicit linguistic knowledge. In aphasic patients, individual modules loose their access to the awareness system, which constitutes the essence of neuropsychological deficits [2,5].

Classical studies on aphasia describe impaired and preserved language functions in Broca and Wernicke aphasia. Agrammatic statements and telegraphic style are typical for motor aphasia and arise from syntactic function deficits. On the other hand, comprehension deficits characteristic for sensory aphasia arise from the disruption or loss of representation of the words' meaning. However, observations of patients with aphasia suggest that syntactic and semantic representations in both types of aphasia are preserved while they loose their 'access' to the awareness system. Accordingly, linguistic processes that require explicit control are disrupted while implicit linguistic processes are preserved.

Patients with Broca aphasia retain latent grammatical knowledge while patients with Wernicke aphasia preserve implicit recognition of word's semantic characteristics despite of the fact that explicit recognition is profoundly disturbed [1,5-7].

Classical aphasia definition based on an analysis of explicit linguistic processes has recently been extended with a description of implicit linguistic processes that required the development of novel scientific instruments. Any research on relationships between explicit and implicit linguistic knowledge involves three types of tasks that engage explicit and implicit linguistic processes at various levels:

- indirect tasks that engage implicit linguistic representations with responses to the stimuli so fast that

slower explicit processes do not influence the task performance (i.e. subconscious word association recognition);
- tasks that engage intermediary linguistic representations with minimal involvement of explicit processes (i.e. sentence grammatical accuracy evaluation);
- direct tasks that require considerable participation of explicit linguistic processes (i.e. word to picture matching) [2,5].

Patients with aphasia perform significantly worse in their explicit tasks when compared to implicit tasks. Subjects with motor or sensory aphasia correctly differentiate words in semantic association tasks i.e. they retain concealed semantic knowledge on word meaning. They perform worse in sentence grammatical accuracy evaluation tasks where automatic procedures reflect in a sense that 'something is wrong' without an actual knowledge on the type of mistakes. Finally, they fail in sorting of picture captions for it requires an explicit selection of information from memory storage and activation of end representation [1,5-7].

Literature presents studies on relations between explicit and implicit linguistic processes in patients with aphasia resulting from vascular insults to the left hemisphere (post-stroke aphasia) [5,7,8] or related to neurodegenerative diseases [6,9]. Our study presents a group of patients with relatively isolated (localized) injuries – brain tumours, which might provide a new insight. The report presented here should be considered as a pilot study that attempts to verify previous assumptions and systematize the knowledge on linguistic processes in patients with aphasia related to left hemisphere tumour resection. Accordingly, we aimed at: (1) determination of explicit and implicit linguistic processes in patients with aphasia resulting from left hemisphere tumour dissection, and (2) delineation of relationships between explicit and implicit linguistic processes in patients with aphasia resulting from left hemisphere tumour dissection.

Material and methods

Patients

Our cohort consisted of 28 patients divided into 4 equal, independent, randomly chosen groups: two clinical groups (patients with brain tumours – groups T1 and T2) and two control groups (patients with lumbar disc disease – groups K1 and K2).

Detailed demographics of particular groups with special regard to individual variables are presented in Table 1. Four groups of patients that participated in our study did not differ significantly by age ($F_{3;24} = 1.657$, $p > 0.05$), sex ($\chi^2 = 1.167$, $p > 0.05$), habitation ($\chi^2 = 1.4$, $p > 0.05$) and education ($\chi^2 = 1.274$, $p > 0.05$); moreover, groups T1 and T2 had similar durations of disease ($Z = -0.257$, $p > 0.05$).

Clinical groups encompassed patients older than 18, who underwent surgery (craniotomy or craniectomy and tumour dissection) for a brain tumour without any quantitative or qualitative consciousness disturbances. Patients with any central nervous system (CNS) comorbidities (hydrocephalus, stroke, arterio-venous malformation, abscess etc.), psychiatric disorders, dementia or epilepsy (posttraumatic, alcoholic or juvenile) diagnosed prior to brain tumour diagnosis were excluded from the study. Finally, 14 patients aged 24-75 (mean = 49.6, standard deviation [SD] = 13.8) who were diagnosed with left hemisphere tumour based on imaging studies and clinical signs were selected for the study. All of them underwent surgical treatment at the Clinical Department of Neurosurgery of the Silesian Medical University in Sosnowiec. Patients with depression, hallucinations or delusions during examination or immediately prior to were also excluded from the study. Disease duration varied from 4 to 36 months (mean = 10.3; SD = 8.1). All the patients in clinical groups were right-handed. Unfortunately, clinical group was heterogeneous based on tumour characteristics (see Table 2), which in com-

Table 1. Demographics of the study cohort: groups of patients with brain tumours (T1 and T2) and control groups (K1 and K2)

Variable	T1 group, *n* = 7	T2 group, *n* = 7	K1 group, *n* = 7	K2 group, *n* = 7
Age [years]; mean (SD)	43.3 (13.9)	55.9 (11.4)	43.6 (10.9)	43.0 (15.1)
Sex (men/women)	4/3	5/2	5/2	5/2
Education [years]; mean (SD)	12.9 (2.3)	12.3 (1.8)	11.4 (2.2)	12.6 (2.5)
Residence (urban/rural)	4/3	5/2	5/2	6/1
Duration of symptoms [months]; mean (SD)	9.1 (3.6)	11.4 (11.3)	–	–

SD – standard deviation

Table 2. Histological classification of the tumour and its location within the left hemisphere in patients from clinical groups

	Patients with tumours (T1 group) (n = 7)	Patients with tumours (T2 group) (n = 7)
Tumour type		
Glioblastoma multiforme (grade IV)	3	3
Atypical meningioma (grade II)	1	–
Fibrous meningioma (grade I)	–	2
Anaplastic astrocytoma (grade III)	1	–
Fibrillary astrocytoma (grade II)	1	–
Ependymoma (grade II)	1	–
Isomorphic oligodendroglioma (grade II)	–	1
Metastatic gatrointestinal tract adenocarcinoma (grade III)	–	1
Tumour location		
Frontal region	1	1
Temporal region	–	1
Parietal region	–	1
Fronto-temporal region	2	–
PTO region	1	–
Temporo-parietal region	1	–
Temporo-occipital region	–	1
Parieto-occipital region	–	1
Lateral ventricle	1	1
Thalamus	1	–
Insula	–	1

PTO – parietal-temporal-occipital

bination with a low number of patients render impossible to perform any correlational analysis and limited the ability for any generalizations. Tumour resection was performed under general anesthesia with thiopental. After surgery, 11 patients were in good condition and 3 others were in moderate condition. Postoperative complications involved haematomas in post-operative cavity in 2 patients and single cases of right-sided hemiparesis, grand-mal epileptic seizure or paroxysmal supraventricular tachycardia. Based on their linguistic deficits, 4 patients in group T1 presented motor aphasia, 2 – amnestic aphasia and one had subcortical, sensory aphasia. Linguistic symptoms were mild in 3 cases, in another 3 – moderate, while one patient presented severe aphasia. Two patients in group T2 were diagnosed with motor aphasia, 3 with mixed aphasia and another 2 with amnestic aphasia. Again, in 3 cases linguistic disturbances were mild, in another 2 – discrete and severe in the remaining two cases. On top of linguistic deficits, these patients presented with memory deficits, psychomotor retardation, dyscalculia, motor apraxia and tumour-related epileptic seizures in three patients.

Control group included patients who were treated for lumbar disc herniation at the Clinical Department of Neurosurgery of the Silesian Medical University in Sosnowiec. They were qualified for the study based on their medical documentation and clinical anamnesis. Five patients presented with disc herniation at L4/5 level, 8 patients had discopathy at L5/S1 while one patient had two-level discopathy at L4/5 and L5/S1. Surgery was performed under general anesthesia with thiopental. After surgery, all patients were in a good condition without any complications. Fourteen patients aged 25-70 (mean = 43.3, SD = 12.7) were included in the study. All of them were right-handed and showed no signs of cognitive decline and reported no CNS comorbidities on anamnesis. None of the patients showed any signs of linguistic disturbances or dementia; no psychiatric treatment or intellectual deficits were reported.

Methods

We implemented neuropsychological methodology in order to assess various aspects of explicit and implicit linguistic processes. Preliminary evaluation entailed neurological and neuropsychological examination. Neurological evaluation was performed a day after surgery in all of the groups (in 2 cases due to the general condition of the patients it was performed 3 or 6 days after surgery) while neuropsychological assessment was performed as soon as cognitive functions of the patient allowed examination, which happened usually 5 days after surgery (in 2 cases – 9 and 10 days). Control groups underwent neuropsychological evaluation 4 days after surgery. Mini Mental State Examination (MMSE) and short version of Boston Diagnostic Aphasia Examination (BDAE) [10,11] were implemented accordingly.

On the second, experimental stage of the study that was performed six days after surgery in groups T1 and T2 (in 2 patients 10 or 11 days after surgery) and four days after surgery in groups K1 and K2, we evaluated the linguistic function at the explicit and implicit levels of linguistic behaviors. Implemented tasks comprised linguistic material with diverse structure (single words and complex statements – sentences) that required various degrees of attention and voluntary control during execution. Accordingly, we developed a computer program that comprised four experimental-clinical tasks: lexical decision on explicit and implicit levels, sentence-picture matching and word monitoring run on a Toshiba Satellite A 300-146 computer.

I. *Naming and reading* (explicit task)

A patient was to name an object presented on the picture and subsequently to identify the name of an object out of five presented captions: 1) a correct caption of the object, 2) caption of the object written incorrectly, 3) a name of an object from the same semantic category, 4) object attribute and 5) pseudoword [5,12]. During examination data on the number of correctly named pictures and words read as well as numbers and types of errors was collected.

II. *Lexical decision* (implicit task)

During this task we exploited priming effect that reveals subconscious results of previous experiences (i.e. picture presentation) on actual performance of errands (i.e. word differentiation) [3,4,13]. Patients were initially presented with a single picture followed by words from three categories, featured in various order: 1) words strongly correlated semantically with the name of the object on a proceeding picture (primed words), 2) words from different semantic category than the picture name (non-primed words) and 3) pseudowords. The subject was to recognize whether a series of letters that follow the picture are words [5,14,15]. Execution indices included: number of correct lexical decisions and reaction times for three categories of words provided.

III. *Sentence-picture matching* (explicit task)

Subject was to match a sentence to the presented pictures based on provided three sentences with various degrees of linguistic correctness on semantic, syntactic, phonologic and pragmatic levels [5]. Task performance was evaluated based on the number of correct answers and types of committed errors.

IV. *Word monitoring* (implicit task)

Experimental set-up exploited 15 low- and high-frequency words (based on Polish language lexicon) presented in series of 4 sentences with various degrees of linguistic accuracy. A key word occurred in the sentences in various positions i.e. in different grammatical forms. A subject was to press the key whenever he heard previously provided word that occurred in the sentence [5]. The basic assumption for the task was that measured reaction times vary relative to the degree of sentence correctness and the frequency of a given word.

Study procedure

The study was performed in four randomly selected groups – two clinical (T1 and T2) and two control (K1 and K2). Groups T1 and K1 performed tasks I and II while groups T2 and K2 tasks III and IV. The established selection of patients into two clinical groups and matched control groups raised from clinical condition of the patients and concern for their psychophysical efficiency. Tasks implemented comprised the number of tests therefore the performance of all of the tasks could severely burden a single group. Moreover, implementation of linguistic material of diverse structure (words/sentences) facilitated more profound analysis of linguistic processes. All the tests were individualized and duration times were adjusted based on current condition of the patient. All tests were performed based on a previous informed consent.

Statistical analysis

Statistical analysis was performed with SPSS 17.0 for Windows software. Variable distribution was analyzed with Shapiro-Wilk test (for $n < 100$). Intergroup comparisons were performed with Student t-test or non-parametric Mann-Whitney U-test for independent variables (based on variable distribution). For within-group analysis, a non-parametric Friedman rank ANOVA for k dependent groups or Wilcoxon rank test for two depended samples were implemented. A p-level < 0.05 was considered statistically significant.

Results

Lexical decision on explicit and implicit level

Comparisons of results of lexical decisions' tasks on explicit and implicit levels between patients from clinical (T1) and control (K1) groups are summarized in the Table 3. Patients with aphasia gave out significantly less picture names in comparison to control group. Moreover, they pointed out significantly less correct picture names. No significant differences in frequencies of particular errors were found.

Priming task analysis revealed no significant differences between groups in the numbers of correct lexical decision in all categories of stimuli (in both groups we found the highest numbers of correct lexical decisions for pseudowords and lowest for non-primed words). Still, a statistically significant differences in reaction times for primed and non-primed words occurred. Patients with

Table 3. Comparison of results on lexical decisions at explicit and implicit levels in patients with and without aphasia (tasks I and II); means and standard deviations for numbers of particular answer categories, errors and reaction times (in milliseconds)

Answer category	Patients with tumours (T1 group) (*n* = 7)	Controls (K1 group) (*n* = 7)	*P*-value
Task I – Naming and reading			
Proper name	25.43 (2)	28.14 (2)	0.035*
Name	29.43 (1)	29.86 (0.3)	0.917**
Category	3.14 (3)	2.00 (1)	0.897**
Error in the name	1.86 (2)	1.14 (0.9)	0.412*
Attribute	1.71 (2)	2.57 (2)	0.469*
Pseudoword	0.57 (1)	0.43 (1)	0.593**
Sum of errors	3.86 (2)	1.14 (1)	0.034*
Task II – Lexical decision			
Primed words	27.43 (5)	28.28 (4)	0.157**
Non-primed words	25.86 (6)	26.86 (6)	0.593**
Pseudowords	29.00 (1)	29.86 (0.3)	0.173**
Time – primed	2605.83 (766)	1279.76 (406)	0.002*
Time – non-primed	2971.47 (1155)	1477.15 (565)	0.010*
Time – pseudoword	2187.49 (985)	1757.47 (891)	0.406**

**Student t-test*
***Mann-Whitney U-test*

aphasia showed significantly longer times in both cases when compared to the control group. Initial assumption was that reaction time is based on whether a picture is accompanied by a strongly or weakly associated word or pseudoword. Friedman rank ANOVA analysis proved that reaction times for primed, non-primed and pseudowords in patients with aphasia differed significantly ($\chi^2 = 8.0, p = 0.018$) but these differences existed only between non-primed words and pseudowords ($Z = -2.366, p = 0.018$) with longest reaction times for non-primed words' decisions and shortest for pseudowords. Healthy subjects (K1 group) showed no significant differences in reaction times ($\chi^2 = 3.429, p = 0.180$).

Sentence comprehension and word monitoring

Comparisons of results of picture captions' sorting and word monitoring tasks between patients from clinical (T2) and control (K2) groups are summarized in the Table 4. No significant differences in the selection of captions for situational pictures from sentences with various degrees of linguistic accuracy were found.

Nonetheless, we found differences in a word monitoring task, which predominantly engages implicit linguistic processes. Patients with aphasia showed significantly longer reaction times for all categories of sentences, similarly for low and high frequency words.

Friedman rank ANOVA in clinical group K2 revealed no significant differences for reaction times in low frequency ($\chi^2 = 3.0, p = 0.392$) and high-frequency ($\chi^2 = 4.543, p = 0.208$) word monitoring in sentences with various degrees of linguistic accuracy. An ability to identify a word in a sentence for patients with aphasia apparently did not depend on the degree of the sentence linguistic accuracy. Nevertheless, while comparing reaction times for low and high frequency words we found that patients with aphasia respond to low frequency words in linguistically accurate sentences faster than to high frequency words ($Z = -2.366, p < 0.05$).

Interestingly, significant differences in reaction times for low frequency words in sentences with various degrees of linguistic accuracy were found in control group K2 ($\chi^2 = 14.04, p = 0.003$). Longest reaction times involved identification of words in linguistically accurate sentences that were not correct pragmatically while shortest ones occurred during identification of words in sentences that were incorrect pragmatically and semantically (Table 5). Similarly, significant differences in reaction times for high frequency words in sentences with various degrees of linguistic accuracy were found

Table 4. Comparison of results on sentence comprehension and word monitoring in patients with and without aphasia (task III and IV); means and standard deviations for numbers of particular answer categories, errors and reaction times (in milliseconds)

Task category	Tumours T2 (*n* = 7)	Control K2 (*n* = 7)	*P*-value
Task III – Sorting of picture captions			
Adequate	25.71 (3)	27.86 (1)	0.178*
Non-adequate	7.57 (6)	5.14 (4)	0.458*
Error 1	3.71 (6)	1.71 (3)	0.419**
Error 2	11.28 (12)	6.86 (7)	0.440**
Task IV – Word monitoring			
lf_0	2035.19 (523)	1370.76 (91)	0.020*
lf_1	2246.47 (689)	1387.4 (88)	0.028**
lf_2	1962.96 (889)	993.91 (91)	0.038*
lf_3	2555.15 (1290)	1297.48 (90)	0.058*
hf_0	2235.93 (664)	1550.51 (393)	0.042**
hf_1	2395.68 (931)	1363.65 (122)	0.036*
hf_2	2126.16 (1026)	1054.68 (137)	0.045*
hf_3	3394.83 (3703)	1253.84 (206)	0.028**

**Student t-test*
***Mann-Whitney U-test*
lf – low-frequency word; hf – high-frequency word; 0 – correct sentence; 1 – pragmatically erroneous sentence; 2 – pragmatically and semantically erroneous sentence; 3 – pragmatically, semantically and grammatically erroneous sentence

Table 5. Comparisons of reaction times for word monitoring task, separately for low- and high-frequency words dependent on the linguistic correctness of the sentence in control group K2 (Wilcoxon test)

	Z-value	*P*-value
lf_1 – lf_0	–1.214	0.225
lf_2 – lf_0	–2.023	0.043
lf_3 – lf_0	–2.023	0.043
lf_2 – lf_1	–2.023	0.043
lf_3 – lf_1	–2.023	0.043
lf_3 – lf_2	–2.023	0.043
hf_1 – hf_0	–1.753	0.080
hf_2 – hf_0	–2.023	0.043
hf_3 – hf_0	–2.023	0.043
hf_2 – hf_1	–2.023	0.043
hf_3 – hf_1	–1.483	0.138
hf_3 – hf_2	–2.023	0.043

lf – low-frequency word; hf – high-frequency word; 0 – correct sentence; 1 – pragmatically erroneous sentence; 2 – pragmatically and semantically erroneous sentence; 3 – pragmatically, semantically and grammatically erroneous sentence

($\chi^2 = 12.84, p = 0.005$). Identification of words in linguistically accurate sentences that were not correct pragmatically necessitated longest reaction times while the shortest ones occurred during identification of words in sentences that were incorrect pragmatically, semantically and gramatically (Table 5).

Comparisons of reaction times for low- and high-frequency words in healthy subjects revealed faster reactions to low-frequency words in comparison to high-frequency ones in linguistically accurate sentences ($Z = –2.023, p < 0.05$) and sentences that were pragmatically and grammatically incorrect ($Z = –2.03$, $p < 0.05$).

Discussion

The principal aim of our study was to assess explicit and implicit linguistic processes in patients with aphasia subsequent to left hemisphere brain tumour dissection. We assumed that people with aphasia show deficits in explicit linguistic behaviors while simultaneously do not differ from subjects in the control group on the implicit linguistic processes level.

Analysis of attributes that characterize explicit and implicit linguistic activities in patients from clinical group allowed us to formulate following suggestions:

1. Patients with aphasia show deficits at various levels of explicit linguistic processes. They show difficulties

in proper object naming when showed on the picture along with proper picture-caption matching, which confirms previous descriptions of this group. Despite of the fact that patients with aphasia make more errors than subjects without linguistic deficits the types of errors are similar to the examined from control group. Particularly interesting are the results of task III, where patients with aphasia showed no difficulties with sentence matching in relation to situational pictures. Our data support the notion that patients with aphasic disorders secondary to the left hemisphere tumour dissection show greater deficits in linguistic material processing on word level rather than sentence level. Situations that require significant participation of explicit linguistic representations (i.e. sorting of picture captions) proved that patients with aphasia after tumour resection have only slightly lower access to explicit linguistic representations when compared to healthy subjects. This suggests that tumour cytoreduction with subsequent decrease of increased intracranial pressure results in neural pathways release from tumour mass compression, which in turn facilitates the return of normal conductivity of information in access to linguistic and contextual knowledge.The ability of explicit control for the patient conditions the participation of consciousness in speech understanding.

2. Implicit tasks proved higher level of independence of implicit linguistic processes from the brain status when compared to explicit linguistic processes. Patients with aphasia retain the ability to recognize words (discrimination 'word/not word') similar to the patients without linguistic disturbances but they require significantly longer periods of time for correct lexical decisions. Moreover, patients with aphasia show no priming effect. Reaction times for words semantically connected to the previously presented picture (i.e. primed words) and not connected (i.e. non-primed words) were similar in these patients and significantly longer when compared to people without linguistic disturbances. Our results do not concur with other reports, however [9,16,17]. This difference might arise from a small size of studied groups or their heterogeneity with regard to the linguistic deficits (type of aphasia) as well as tumour type and its location. Previously published data mainly describe patients with Broca or Wernicke aphasia that results from stroke, cerebro-cranial injury or neurodegenerative disorders – primary progressive aphasia and semantic dementia. A different type of material used for aforementioned study is also of importance.

The assumption that reaction time depends on the fact that a picture is followed by a word strongly or weakly related to it or a pseudoword proved to be true only in clinical group. Furthermore, we collected the data that suggest a different nature of these relationships when compared to previous reports [9,15,16]. Patients with aphasia required longest periods of time for association whether a presented sequence of letters forms a word not associated with the name of the picture in contrast to pseudowords that required shortest times, which again is in contrast with literature data. Based on our own results analysis we can conclude that shortest reaction times achieved on pseudowords results from the lack of the need for semantic decoding after visual letter analysis of a pseudoword. Decision time is also reduced owing to the learning effect (along with patient's experiment accomplishment) and utilization of automatised processes that determine consciousness participation in speech understanding, which suggests participation of intermediary linguistic representations.

Subjects without any linguistic disturbances achieved similar word recognition times independent of word's association to the previously presented picture or the fact that it was a pseudoword. One can conclude that patients without CNS dysfunction have an equal access to the implicit and explicit linguistic representations and show no priming effect.

Word monitoring task results point out that patients with aphasia might identify a word in the sentence independent of the sentence linguistic accuracy. Still, it is easier for them to identify low frequency words in comparison to high frequency ones in linguistically correct sentences.

Based on acquired results one might conclude that access to the implicit linguistic representations is hindered by impaired priming effect in intermediary linguistic representations rendering slowing of automatic procedures that barely engage conscious processes.

The ability to identify a word in a sentence in population without any linguistic disturbances depends on the level of linguistic accuracy of the sentence. Identification of words in sentences that are correct linguistically and incorrect pragmatically takes longest periods of the time; conversely, shortest times are necessary for identification of low frequency words in pragmatically and semantically erroneous sentences and high frequency words in pragmatically, semantically and grammatically incorrect sentences. The differences in reaction times necessary for identification of words in the sentences with various linguistic accuracy find a confirmation in literature, yet they show slightly different profile [5]. Tyler reports [5,6] that in subjects without any speech disturbances reaction times to the target word increase in sentences with linguistic errors while are the shortest for words identified in the correct sentences.

Conclusions

Based on presented analysis of the results of preliminary studies one might conclude that patients with aphasia secondary to brain tumour resection present a partial deficit of explicit linguistic behaviors that arises from the blockade of a process that determines participation of consciousness in speech comprehension. Simultaneously, these patients do not differ from healthy control patients with regard to the implicit linguistic behaviors. The main difference in patients with aphasic disturbances pertains to the range of access to intermediary linguistic representations and the ability to utilize automatised processes.

It is of particular importance that the difficulties in the ability to access implicit linguistic representations directly correlate with deficits in the range of access to explicit and intermediary linguistic representations, which reflects itself in the strength of the perceptive priming effect. Nevertheless, these patients still show the ability to access linguistic knowledge' storage through the activation of implicit linguistic processes via various priming stimuli implementation.

Disclosure

Authors report no conflict of interest.

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