The European Proceedings of
Social & Behavioural Sciences
EpSBS

Future Academy

ISSN: 2357-1330

http://dx.doi.org/10.15405/epsbs.2017.10.37

8th ICEEPSY 2017
The International Conference on Education and Educational Psychology

APHASIA AND NONLINGUISTIC COGNITIVE REHABILITATION: CASE STUDY

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Abstract

The language is a prerequisite for a variety of cognitive performance. Its demand for symbolism makes it one of the most challenging cognitive activities. A complete loss of already acquired communication skills is called aphasia. The main objective of this paper is to analyze the effect of cognitive rehabilitation on recovery from aphasia. The research question is: "What is the effect of the rehabilitation of non-linguistic cognitive functions on language recovery in selected patient with mild anomic aphasia?" The aim of the paper is to analyze the effect of non-linguistic cognitive rehabilitation on fluency factor and pragmatic language in person with mild anomic aphasia in chronic stage. Research has a character of a longitudinal case study of one person with mild anomic aphasia after stroke in the chronic stage. A cognitive rehabilitation effect was evaluated with the Addenbrook's cognitive test, a revised version, 2010 (ACE-R). Also, we used Tests of Verbal and Figural Fluency, Clock test and modification of Test of Pragmatic Language. In the context of the case study of the person with mild anomic aphasia, it has been detected and verified that the non-linguistic cognitive rehabilitation affects recovery of aphasia. A highly significant improvement was observed in verbal fluency and quality of life. We would like to highlight that this intervention should be an essential component in aphasia therapy.

Keywords: Aphasia, nonlinguistic, cognitive, rehabilitation, case study.

http://dx.doi.org/10.15405/epsbs.2017.10.37
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Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

Aphasia is a selective disruption of language modalities and functions, which occurs in a focal brain damage, and has a negative impact on the quality of life of people with aphasia, on their relatives and caregivers; it affects social functioning and pragmatic aspects of communication (Cséfalvay & Košťálová, 2012; Papathanasiou, Coppens & Potagas, 2011). Nowadays, it is thought that the language disorder is manifested by impaired cognition (Baldo, Dronkers & Wilkins et al., 2005). These claims are supported by models that specify an integral relationship between the language and other domains of the cognitive function in people with or without the language disorder (Murray, 2012). The history of recovery from aphasia has focused obviously and naturally on language. The recovery from aphasia is necessarily more than recovery language functions alone. Current concept of recovery from aphasia works with term neural multifunctionality focusing on the dynamic development of new neural support systems in the aphasic brain in the service of new functioning. This multifunctionality operates in a multidirectional and reciprocal fashion, such that neural networks engaged in language recovery continuously influence, but at the same time are also reshaped by neural supports of nonlinguistic functions, so as to give rise to new functional neuroanatomies (Cahana-Amitay & Albret 2015). For example, Friderici (2012) proposed a model consisting of two dorsal and ventral streams which presumably mediate spoken language processing and interface with working memory functions. Price (2012) reviewed the neural data for nine major language functions and each function presumably interacts with specific nonlinguistic processes. However, the recovery from aphasia is affected by multiple prognostic factors, including aphasia type, severity, lesion characteristic, sex, age or premorbid intelligence (McClung, Gonzales-Rothi, & Nadeau, 2010). Over 50 % of aphasic persons are ages 70 years or older (Basso & Macis, 2011). From these reason, it is important to point out that the emerging brain-language maps are typically based on neural data collected from young healthy adults, whose functional neuroanatomy is likely distinct from the older adults. Many accounts of age-related language difficulties have proposed considering interactions with other neurocognitive domains. These include reduction in processing speed as well as decreases in cognitive functions, such as working memory, divided attention or inhibitory control (Cahana-Amitay & Albret 2015, Goral et al., 2011, Cotelli et al.,2010). Nevertheless, neuroimaging data from both young and older adults clearly indicate that neural networks subserving language functions also partially mediate nonlinguistic functions, such as working memory, which contribute to certain aspects of language performance (Cahana-Amitay & Albret 2015). Prevalence of non-linguistic cognitive disorders in aphasia after stroke was observed by Hachioui et al. (2014) in their study. Out of the total amount of 147 patients, a cognitive disorder was proven in at least one non-linguistic domain in 107 patients (88 %) three months after stroke and in 91 patients (80 %) one year after stroke. Higher probability of deficiency in cognitive functions is associated with damage to the left hemisphere, cortical lesion and ictus in the medial cerebral artery (Cumming et al., 2013).

In terms of monitoring the functioning of cognitive functions which can be tested with the use of psychological methods, we can monitor cognitive functioning of speech production as a semantic system as a whole, its word range or the ability to create a concept. It must be mentioned that in terms of a neuroanatomic breakdown of cognitive functions, a verbal production also reflects the quality of the functioning of executive, managerial components which relate to the process of thinking. Impairment at

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this level may result not only in verbal fluency production, but also in coherence and content-fit. In this study the fluency factor is measured. Fluency factor is involved the production of ideas, it depends on the semantic memory capacity but relates to the quality of the working memory and the level of speech functions (verbal alertness, dynamic organization of inner speech, spontaneity, rate and fluency of speech).

1.1. Aphasia therapy and cognitive rehabilitation

Aphasia therapy is a long process, and the most effective results can be achieved not only by applying the evidence-based therapy (Evidence-Based Therapy), but also in teamwork which provides a holistic approach. It was proved that non-linguistic impairments of cognitive functions are a big predictor of the success of aphasia therapy (e.g. Cahana-Amitay & Albret 2015; Vallila-Rother & Kiran, 2013; Brownsett & Warren, Geranmayeh et al. 2014). Negative impact of, especially, disorders of attention and executive functions on the therapy of aphasia is mentioned, among others, in the studies by Brownsett et al. (2014) and Ramsbergera (2005), claiming that the rehabilitation of these cognitive functions, even in people with chronic aphasia, can lead to apparent changes in these abilities. Also, it has been shown to negatively influence aphasic patients' abilities to perform tasks involving new phonological encoding or semantic learning (Freedman & Martin, 2001). Similarly, impaired executive functioning has been shown to adversely affect measures of functional communication in people with aphasia (Ramsberger, 2005). Switching impairment as a symptom of executive function disorder can result in perseveration, typically defined as an involuntary continuation or recurrence of ideas, experiences, or behaviour, in the absence of an appropriate stimulus (Cahana-Amitay & Albret 2015). Functional communication or pragmatic language refers to how language is used socially to achieve some purpose. In essence pragmatic language involves not only what is said but also where, why, and whom a communication is spoken. Because speech take place in a context, it is affected by pertinent factors, such as the audience, topic, or purpose (Phelps-Terasaki, Phelps-Gunn, 2007). Vukovic et al. (2008) draw attention to the condition of memory in people with aphasia which is, according to the results of their research, a significant prognostic factor of aphasia and correlates with revival of the language functions. Thus, it may be assumed that a cognitive improvement using cognitive rehabilitation will improve the area of expressive speech components as a form of brain adaptation to the disease in the context of linking cognitive structures. This assumption is based on long-term memory components, a better ability to respond quickly and flexibly, and an overall effective functioning of cognitive processes as a whole. The aim of our study (Nilius et al.,2016) was to analyse the effect of cognitive rehabilitation on the semantic components in patients with residual expressive aphasia who completed the cognitive rehabilitation program. In a clinical sample of patients with a residual type of aphasia, no statistically significant effect in any of the monitored verbal subtests was found, except of a highly significant improvement in cognitive flexibility and verbal fluency. Nevertheless, this improvement rather reflected a more effective use of executive functions, than the influence of the semantic components improvement. Executive abilities such as set shifting can be used to predict aphasic person's ability to enhance his or her conversational success (Purdy & Koch, 2006). Incorporating nonlinguistic executive components into aphasia therapy could perhaps enhance language

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performance and directly contribute to the neural reorganization of language functions in the course of aphasia recovery (Cahana-Amitay & Albret 2015).

2. Problem Statement

It was proved that non-linguistic impairments of cognitive functions are a big predictor of the success of aphasia therapy (e.g. Cahana-Amitay & Albret 2015; Vallila-Rother & Kiran, 2013; Brownsett & Warren, Geranmayeh et al. 2014). Deficits in some non-linguistic cognitive areas may disrupt not only the recovery process of language skills, but also the process of coping with the disability (Seniów, Litwin & Lesniak, 2009). Negative impact of, especially, disorders of attention and executive functions on the therapy of aphasia is mentioned, among others, in the studies by Brownsett et al. (2014) and Ramsbergera (2005), claiming that the rehabilitation of these cognitive functions, even in people with chronic aphasia, can lead to apparent changes in these abilities. Also, it has been shown to negatively influence aphasic patients' abilities to perform tasks involving new phonological encoding or semantic learning (Freedman & Martin, 2001). Similarly, impaired executive functioning has been shown to adversely affect measures of functional communication (pragmatic language) in people with aphasia (Ramsberger, 2005). Vukovic et al. (2008) draw attention to the condition of memory in people with aphasia which is, according to the results of their research, a significant prognostic factor of aphasia and correlates with revival of the language functions.

Thus, it may be assumed that a cognitive improvement using cognitive rehabilitation will improve the area of expressive speech components and pragmatic language as a form of brain adaptation to the disease in the context of linking cognitive structures. This assumption is based on long-term memory components, a better ability to respond quickly and flexibly, and an overall effective functioning of cognitive processes.

The main purpose of the paper is to analyze the effect of six months nonlinguistic cognitive rehabilitation on fluency factor and pragmatic language in person with mild anomic aphasia in chronic stage.

3. Research Questions

"What is the effect of the rehabilitation of non-linguistic cognitive functions on language recovery in selected patient with mild anomic aphasia?" This would be analyzed by comparing test results at the beginning of therapy and after 6 months of intensive therapy. Test results are compared with each other and with cut-off scores for specific tests. Inferential statistics (t-test) it can't be used to statistically determine whether the difference between the two measurements is statistically significant.

3.1. Research Hypotheses

H_0: There is no significant difference between the test results at the beginning and at the end of the therapy.

H_A: The test results are different from the start of therapy

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4. Purpose of the Study

The overall purpose of this study is to examine the effect of non-linguistic cognitive rehabilitation on language recovery in person with mild anomic aphasia in chronic stage after 6 months' therapy. The following specific variables were measured: word fluency (WF), semantic fluency (SF), ideational fluency (IF), associational fluency (AF), expressional fluency (EF), figural fluency (FF) and pragmatic language. Also, the Addenbrook's cognitive test score was measured. Specific purposes for the research study include:

- Determine the effect of non-linguistic cognitive rehabilitation on the fluency factor.
- Determine the effect of non-linguistic cognitive rehabilitation on pragmatic language.
- Determine the effect of non-linguistic cognitive rehabilitation on Addenbrook's cognitive test score.

5. Research Methods

Research has a character of a longitudinal case study of one person with mild anomic aphasia after stroke in the chronic stage. A cognitive rehabilitation effect was evaluated with the Addenbrook's Cognitive Test, a Czech revised version, 2010 (ACE-R). Also, we used tests of:

- Word Fluency (WF), the ability to rapidly produce words that share a nonsemantic features. This test is used to diagnose deficits of the frontal area of the brain. An example of test is name as many words as possible that begin with the letters K, L, M in 1 minute. Based on the Dystest test (Cimlerová et al., 2014).
- Semantic Fluency (SF), the ability to rapidly produce words that share semantic features.) Name as many animals as possible in 1 minute (Nikolai et al., 2015). From the neurophysiology point of view, the temporal area of the left hemisphere is important for this test (Lečbych, 2014).
- Ideational Fluency (IF), the ability to rapidly produce a series of ideas, words or phrases related to a specific condition or object. An example of test is think of as many uses of key and bag as possible in 1 minute.
- Associational Fluency (AF), the ability to produce a series of ideas related to a particular concept. We used We used a subtest of similarities from Czech version WAISS III (Černochová et al., 2010).
- Expressional fluency (EF), the ability to rapidly think of different ways of expressing of idea. An example of test if how many ways can you say that the person is drunk in 1 minute?
- Figural Fluency (FF), the ability to rapidly draw as many things as possible in 1 minute when presented with a nonmeaningful visual stimulus (a set of unique visual elements). Based on the Olomouc test of figural fluency (Lečbych, 2014). Test material consists of 6 sheets. Two sheets are used for instruction and task training. Set A contains 24 squares in a matrix of 4 x 6 squares. Set B contains the same number and square spacing, but combines three squares and three points in their content. In the evaluation of the test, we operate with variables of the total number of completed figures regardless of the error rate (TNF), overall performance (OP, the

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basic criterion of success in the test), errors corrected (Err-C), errors uncorrected (ERR-UC) and perseveration (PSV). The design fluency test is sensitive to right-hand frontal damage.

- Clock Test
- Modification of Test of Pragmatic Language (TOPL-2), which proposed the Situational-Discourse-Semantic model of language. Situational context represents the physical environment in which discourse takes place and characteristics of audience to which conversation is directed. Discourse context concerns the function of language an individual use in a communication. Discourse context consists of two subcomponents, topic and purpose. Semantic refers to the meaning of a communication and to the aspects of language that are used to convey the concepts and ideas. Semantic context has three subcomponents, visual-gestural cues, abstractions, pragmatic evaluation. Pragmatic evaluation ability is associated with executive control and metacognitive processing, allowing self-reflection, verbal mediation, response inhibition, and behavioural direction (Phelsps-Terasaki, Phelps-Gunn, 2007). The TOPL-2 is a 43-item test, but we used only 10 item:
    - The Doctor's Office – physical context, purpose, visual-gestural
    - Painting a Picture – topic, purpose
    - The Restaurant – physical context, purpose, visual-gestural
    - Going to the Movies – audience, purpose, pragmatic evaluation
    - The Scary Movie – audience, topic, purpose
    - Picking Up Kate – topic, purpose, pragmatic evaluation
    - The Store – physical context, purpose, visual-gestural
    - The Friends – audience, purpose, pragmatic evaluation
    - Talking to the Teacher – audience, topic, purpose, pragmatic evaluation
      Playing and Wrestling – audience, topic, purpose, visual-gestural, pragmatic evaluation

The research was conducted from August 2016 to February 2017. Cognitive rehabilitation, focused on attention, components of short-term memory, and executive functions were done once every 14 days in the speech therapy practice. Home-based training was done in the form of pencil-paper and computer applications by Mentem. Verbal fluency or naming was not trained. The results of research were evaluated by statistical analysis and verified by Paired t-test. The calculation was carried out with the Excel 2016.

5.1. Research Sample

The research sample consists of a woman aged 69 years, high school educated, after stroke in 12/2015. According to fMRI and CT, it is subacute ischemia parietal and parieto-occipital sin, lower blood flow in the ACI sin and occlusion ACM sin. The woman comes up with speech problems, subjectively has difficulty in word retrieval, completing a sentence and short-term memory. Objectively, speech is fluent, naming failure and word descriptions present to remember the word. Repetition and understanding speech is preserved. Differential diagnostics excluded cognitive communication disorder (Mini-Mental State Examination - MMSE = 28 points). According WAISS III, the neuropsychological

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eISSN: 2357-1330

test, the input IQ scores correspond to the below- average zone with (IQ 85), VIQ = 77, PIQ = 97. Working memory and divided attention are markedly below average. Short-term memory capacity is below average. From the conclusion of a psychological examination, the woman has the greatest difficulty in verbal expression, but vocabulary, speech comprehension and verbal conceptualization are preserved at an average level. Disorder of executive functions and divided attention was diagnosed.

6. Findings

With regard to the level of education achieved, the cut-off score for the 2nd percentile for the age group 66-89 years is ≥74 points. Attention and Concentration ≥ 15 points, Memory ≥ 11 points, Verbal Fluency ≥ 7 points, Language ≥20 points, Visuospatial Skills ≥10 points and MMSE ≥27 points (Beránková et al., 2015). To differentiate the normal level of cognitive functions and dementia, the limit of 88 points from the ACE-R total score can be used for the Czech population, the test sensitivity is 100% (Hummelová-Fanfrdlová, 2009). The results of the case are presented in the table 01. According to stricter criteria, Acer score results indicate a decline in cognitive function. The biggest difficulties are observed in verbal fluency.

Table 01. ACER scores and MMSE

	8/2016	**2/2017**
ACER	82/100	88/100
Attention-Concentration	17/18	18/18
Memory	19/26	19/26
Verbal fluency	5/14	9/14
Language	25/26	26/26
Visuospatial Skills	16/16	16/16
MMSE	28/30	29/30

Table 02 shows the results in the verbal fluency test. The results are presented in raw scores. Standards for WF – K, L, M (Budíková et al., 2014). The cut-off score for the WF test is 44. The results in this test are deeply subnormal in the first and second tests, although there has been significant improvement.

Table 02. Word fluency

	8/2016	**2/2017**	**Cut-off**
Word Fluency	7	24	44
K	2	11	-
L	2	8	-
M	3	5	-

Standards for semantic fluency were taken from Nikolai et al. (2015). The results of semantic fluency for the age group of 60-75 years are presented in the T-scores and raw scores in Table 03. We evaluate the results of the first testing as subnormal. In the second test, the results are within the norm.

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eISSN: 2357-1330

Table 03. Semantic fluency

	8/2016	T-score	2/2017	T-score
Semantic Fluency	10	30	14	50

The results of further verbal fluency tests are shown in Table 04 in raw scores. Standards for these exams are not yet available. For this reason, we only compare the difference between first and second testing at the level of improved / not improved.

Table 04. Fluency factor

	8/2016	2/2017	Difference
Ideational Fluency	6	10	+4
Key	4	5	+1
Bag	2	5	+3
Expressional fluency	4	5	+1
Associational Fluency	19	21	+3

Table 05 shows the results of the Olomouc test of figural fluency. For persons with problems in the area of executive functions and cognition, we can expect total low performance compared to standard in OP and P/N index. For the preliminary cut-off score we can consider the OP ≦ 16 value, which as a criterion detects 97% of patients with dementia. There is no tendency to correct errors and there is tendency to perseveration. Average performance for the 51-70 age group in the OP index = 26.51 and in the P/N index = 0.81. The results of the case are slightly below the age group, even though we find the difference between the first and second tests.

Table 05. Figural Fluency

Figural Fluency	**8/2016**	**z-score**	**T-score**	**2/2017**	**z-score**	**T-score**
OP-T	25	-0.17	48	25	-0.17	48
P/N	25/35	-0.43	46	25/32	0	50

OP-T overall performance whole test, P/N overall performance whole test/total number of figure whole test

Switching impairment in aphasia can result in perseveration. In addition to the overall lower test performance in the OP variable, it seems to take into account the amount of perseveration and the ability to correct the errors (see table 06). The value of PSV> = 2 is characteristic for 61% of people in the risk set. The results are presented in rough scores. We observe perseveration only during the first test.

Table 06. Figural Fluency

	8/2016	2/2017
OP-A	16	14
OP-B	9	11
PSV-T	3	0
ERR-UC-T	8	3
ERR-C-T	2	3

OP-A overall performance part A, OP-B overall performance part B,
PSV-T perseveration whole test, ERR-UC-T errors uncorrected, ERR-C-T errors corrected

Table 07 presents the results of the modification of Test of Pragmatic Language in raw scores. Standards for the entire test could not be used. Test values range from 0 to 1. We only compare the

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difference between first and second testing at the level of improved / not improved. It is important to note that the qualitative analysis of TOPL2 subcomponents is important when evaluating this test We see the biggest difficulty at the beginning of therapy in the area of purpose (ability to requesting, asking, informing, explaining, describing, stating an opinion or judgment), audience (ability of tailoring messages to different audiences, adjusting to the mood, point of view of audience, being aware of what the listener knows, remembers and adjusting communication accordingly), topic (ability of shift from one topic to another, keep the topic logical, pertinent, and relevant) and pragmatic evaluation (ability of monitoring, evaluating, and appraising how effective pragmatic language is, with an emphasis on evaluating and predicting how much success a message will achieve). Subcomponents of physical context (attending to event, situational, and context characteristic that shape or direct the social language) and visual-gestural cues (monitoring facial expression, body language, and gestures) are preserved. In the Test of Pragmatic Language, we see a significant improvement based on qualitative and quantitative level. In contrast to the first test, pragmatic language is effective. We evaluate the communication as functional. The patient is satisfied with her condition. Compared to peers, she notices that she completes the words for them, she is able to conducting a conversation ad completes the sentences adequately.

Table 07. Pragmatic language

	8/2016	**2/2017**
Pragmatic language	4/10	9/10
The Doctor's Office - physical context, purpose, visual-gestural	1	1
Painting a Picture - topic, purpose	1	1
The Restaurant - physical context, purpose, visual-gestural	0	1
Going to the Movies - audience, purpose, pragmatic evaluation	0	0
The Scary Movie - audience, topic, purpose	0	1
Picking Up Kate - topic, purpose, pragmatic evaluation	1	1
The Store - physical context, purpose, visual-gestural	1	1
The Friends - audience, purpose, pragmatic evaluation	0	1
Talking to the Teacher - audience, topic, purpose, pragmatic evaluation	0	1
Playing and Wrestling - audience, topic, purpose, visual-gestural, pragmatic evaluation	0	1

0 wrong answer, 1 correct answer

7. Conclusion

Methods of aphasia recovery vary considerably in the spectrum of patients, and the recovery process depends on the level of activation of neuroplasticity processes of the cerebral cortex. According to Nilius et al., 2016, a bigger blood flow to the brain can give rise to at least a partial recovery of the neurological deficit. Increase in the blood flow to the brain can be caused by a pharmacological intervention but also by the activation of the organism with neurorehabilitation, including activation of cognitive and language function. The overall purpose of this study is to examine the effect of non-linguistic cognitive rehabilitation on language recovery in person with mild anomic aphasia in chronic stage after 6 months' therapy. The results show that in the investigated case, there was a significant improvement in all areas surveyed (ACER, verbal and figural fluency and pragmatic language). An

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alternative hypothesis "H_A: The test results are different from the start of therapy" was confirmed. An effect in an area of cognitive flexibility (fluency) was found in the whole tests. Due to such effective functioning other cognitive functions are used more effectively. ACER score increased from 82 points to 88 points. The results in Word Fluency Test are deeply subnormal in the first and second tests, although there has been significant improvement (RS + 17 points). Semantic fluency test is evaluated in the first testing as subnormal (T-score 30). In the second test, the results are within the norm (T-score 50). In the figural fluency test, lower performance can be observed at the beginning and end of therapy, which indicates a deficit in an area of executive functions (T score 48, z-score -0.17 in both measurement) However, the ability to correct mistakes has improved (T-score 46, z-score -0.43/ T-score 50, z-score 0). Tendency to correct your own errors is a preview of your own error rate, preserved self-control, monitoring of your own performance and working memory. This improvement reflected a more effective use of executive functions as evidenced by the results of the Test of Pragmatic Language. In the Test of Pragmatic Language, we see a significant improvement based on qualitative (4/10 points and 9/10 points) and quantitative level. In contrast to the first test, pragmatic language is effective. We evaluate the communication as functional. The patient is satisfied with her condition. Compared to peers, she notices that she completes the words for them, she can conduct a conversation and completes the sentences adequately. Topic content is logical, appropriate and relevant. Topic change concerns a smooth shift from one topic to another. Word search problems are not observed. Limitations of the study may be influenced by the overall small number of patients in the study (longitudinal case study of one person), and by impossibility of statistical evaluation of results.

Acknowledgments

The research results constitute partial results of the specific research "The research on impairment and deviations of communication ability and orofacial system in a speech and language therapy perspective" IGA_PDF_2017_026, principal researcher: Assoc. Prof. Kateřina Vitásková.

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