Neuropsychological rehabilitation of intelectual activity

in a patient with right brain injury

ABSTRACT

Traditionally, the right hemisphere has been considered as non-dominant because of absence of significant alterations in cognitive functioning after lesions. Recent studies have shown that right hemisphere plays an active role in cognitive processes, such as spatial global analysis, recognition and evocation of auditory patterns, motor sequences, recognition of faces and emotions. The objectives of the study consisted in providing qualitative analysis of neuropsychological deficits in a male patient with brain damage in right frontotemporal region due to an automobile accident and to describe the effects of the program of neuropsychological rehabilitation. A pretest-posttest research design was used. The neuropsychological assessment evaluation was carried out through qualitative protocols for Spanish speaking patients. Final assessment pointed out positive changes in the process of intellectual activity on perceptive and verbal levels. The patient managed to return to university studies. Our results show that it is possible to define the mechanisms, which underline the clinical syndrome in cases brain injury in right hemisphere. Predominant difficulties consisted in loss of involuntary regulation and mild difficulties with global perception of information on perceptive and verbal level. These difficulties were reflected in all kinds of complex intellectual activity, which became milder after the work with the program for rehabilitation.

Key words: neuropsychological rehabilitation, brain injury, right hemisphere, intellectual activity, qualitative neuropsychology.

Introduction

It is well known that the syndromes of dysfunction of right hemisphere caused by brain damage are related to acalculia, dysgraphia, pragmatic difficulties, impaired visuospatial and emotional functioning and behavioral disorders. Specific difficulties

with interpersonal and social abilities might also be mentioned (Alonso & Fuentes, 2001; Artigas-Pallares, 2002; Bausela, 2005; Benson, 1988; Brown, 2002; Colome, Sans, Lopez-Sala & Boix, 2009).

Other descriptions have been made only in relation to specific and isolated processes such as language, indicating deficits in prosody, lexical-semantic processing of words and discourse and pragmatic skills and the relationship between language and context (Barroso & Nieto, 1996; Joanette, et al., 2008). No relation between such disturbances or common explanation of their appearance has been established.

It's also known that brain injuries, in dependence of type of lesion and location, can affect the understanding not only of the meaning, but also the sense of information. Such difficulties can be refered in cases of both left and right damages. Alterations in the process of decoding (in alexia syndromes) are frequently assessed by tasks included in the batteries designed for aphasic patients (Cuetos & Gonzalez-Nosti, 2009; Goodglas & Kaplan, 1996). However, the changes in understanding of texts, despite of their greater frequency and ecological importance, have received less attention and very few tools of assessment appear in literature (Garcia & Lopez, 2011; Sampedro, et al., 2013). It's important to stress that evaluation of intellectual activity by tasks for understanding of text together with other complex intellectual tasks has opened new possibilities for understanding of various neuropsychological syndromes (Quintanar & Solovieva, 2000; Solovieva, Chavez & Quintanar, 2001; Tsvetkova, 1977; Tsvetkova, 1985; Solovieva & Quintanar, 2017a). In our opinion, neuropsychological assessment of intellectual activity shouldn't be limited by testing of isolated psychological functions, such as memory, attention, sepach, perception and so on.

Specific modern term of "executive functions" can't be easily related to assessment of intellectual activity. Executive functions are determined in literature as cognitive skills of the prefrontal cortex that allow set goals, design plans, follow sequences, selecting the appropriate behaviors and initiating activities. Executive functions are related to self-regulate the behavior, monitor tasks, select behavior, flexibility in cognitive work and the organization of the task proposal in time and space (Gil,

Romero, Berrio, Hernández, & Lopera, 2103; Luria, 1988; Tirapu-Ustárroz, Cordero-Andrés, Luna-Lario & Hernáez-Goñi, 2017). It seems that executive functions don't conform intellectual activity as a whole, but take part and organize intellectual activity of a subject.

Another important point is that executive functions are related always to frontal orbital lobes functioning. At the same time, intellectual activity can't be related to specific localization in one brain zone. At least, from the point of view of Luria's neuropsychology, it would be better to refer to complex and distributed representation of intellectual activity as functional system. Such functional system includes a variety of brain functioning mechanisms on both cortical and subcortical levels of both brain hemispheres includes a complex structure of psychophysiological mechanisms (Luria, 1988; Solovieva, 2014). The deficit of intellectual activity could be related to different mechanisms or components of functional brain system (Tsvetkova, 1988).

Our study was carried out on the basis of neuropsychological conception developed by Luria (1988) and cultural historical paradigm. According to Luria (2005), neuropsychological diagnosis should be based on identification of predominant mechanism (or mechanisms), which underline clinic picture as a total unity. Such mechanisms can affect different levels: neuroanatomic, psychophysiologica, psychological, verbal and linguistic (Quintanar, Solovieva & León-Carrión, 2011). All kinds of different sympthoms and difficulties should be resumed into the same clinic picture with unique underlining mechanism. According to this conception, neuropsychological rehabilitation should represent harmonious continuation of assessment, which can provide better analysis the syndrome (Quintanar, 2002; Tsvetkova, 1988).

According to traditional or cognitive perspective, the syndrome is understood as a combination of symptoms or difficulties with no common base or relation between them. According to Luria's perspective, neuropsychological syndrome is always disturbance of some cognitive processes with preservation of the others. Altered processess include same specific brain mechanism, which might be understood as neuropsychological reason or cause of the defects. Preserved processess don't

include this altered neuropsychological mechanism or factor. The classical syndrome in Luria's theory is aphasia as a complex alteration of verbal actions caused by brain damage (Luria, 1988; Tsvetkova, 1988; Quintanar, Solovieva & León-Carrión, 2011). The clinical picture should include analysis at neuroanatomical, psychophisiological, psychological and linguistic levels.

Luria himself and his collegues and pupils have fulfilled precise analyses of neuropsychological syndrmes caused by damage in left brain hemisphere (Akhutina, 1989; Glozman, 2004; Luria, 1979). The precise analysis of types of syndromes caused by right hemisphere damage is still missing.

The analysis of the structure of intellectual activity permits to detect conserved and disturbed elements of such operations. According to activity theory, such elements are: object of activity, goal of activity, orientation base and executive operations (Leontiev, 1981; Leontiev, 1983). For example, it is possible to suppose that in some cases of brain damage, the object of activity or motive might suffer. In other cases it is possible to detect alteration of orientation base of action or of executive functional part of action (Solovieva & Quintanar, 2017b).

It is quiet often that, in cases of brain injury, orientation base of action suffers on the basis of diverse brain functional mechanisms in different lesions. In our previous study with rehabilitation of a patient with semantic aphasia (left posterior cortical brain damage) specific alteration of orientation and execution of all operations, which include spatial analysis and synthesis was observed (Vargas, Solovieva, Sánchez, González & Rojas, 2011). External orientation proposed by a therapist could help the patient to reorganize gradually appropriate execution of intellectual actions on perceptive and verbal level inclusion spatial analysis and synthesis (Solovieva & Quintanar, 2017a).

According to our opinion, the goal of neuropsychological assessment should facilitate and provide functional analysis of brain mechanisms within functional systems of psychological actions. Intellectual activity consists of diverse kinds of intellectual actions as well (Solovieva, 2014). The goal of psychological analysis of the structure of intellectual activity is to precise the components of intellectual activity in order to propose proper tasks and orientation during neuropsychological

rehabilitation, so that the program for neuropsychological correction should emerge as a final result of neuropsychological assessment.

In cases of adult patients with local brain damage the success of rehabilitation depends on adequate detection of conserved and disturbed structural components of intellectual activity and of specific brain mechanisms, which guarantee fulfillment of such activity. We stress again that such mechanisms are known much better in cases of lesions of left hemisphere in previous studies of Luria's neuropsychological school. In case of right hemisphere such mechanisms have to be concretized and studied with details in future.

The aim of the present study is to show the effects of implementation of the program for rehabilitation of intellectual activity in case of right brain damage.

Method

The study was carried out as pre and post assessment and application of the program of neuropsychological rehabilitation in between. Neuropsychological assessment was of qualitative clinic manner according to Luria's and his school proposals. Neuropsychological assessment was performed with the help of qualitative tests. The rehabilitation was based on previous neuropsychological assessment of the patient according to Luria's methodology of syndromic analysis and on analyses of structure of intellectual activity following proposals of main representatives of activity theory such as Leontiev (1983), Galperin (2000), Talizina (2009). Their proposals were adapted to clinic procedures of assessment and rehabilitation in our previous publications (Solovieva, Chávez & Quintanar, 2001; Solovieva & Quintanar, 2017 a, b), which will be described in the part of the program of neuropsychological correction.

Case report

The participant of our study was a young male patient, 23 years old, university student of third semester of Law Faculty, who suffered traumatic brain injury as a result of car accident. The aunt of the patient refers to the fact that before his accident her nephew was too serious and, sometimes, even angry. After the

accident, the patient started to show more affective and communicative behavior. At the same time, the patient became more emotionally vulnerable.

Neurological analysis detected adequate functioning of motor, visual and kinesthetic primary and secondary zones. Tomography showed hypodensity in the fronto-temporal region of the right cerebral hemisphere. EEG data obtained by bipolar and monopolar montage and visual qualitative analyses has shown local abnormal patterns of groups of theta oscillations (4-7 Hz) in frontal, central and temporal sectors of the right hemisphere, indicating dysfunctional stage of cortical zone of right hemisphere (Morán-Paz, Solovieva, Quintanar & Machinskaya, 2013).

Analysis of results of neuropsychological assessment concluded conservation of phonemic integration, kinesthetic integration, perceptive visual images and kinetic melody. At the same time, analysis of the results of neuropsychological assessment together with assessment of intellectual activity pointed out severe disturbance of global perception and involuntary retention of diverse types of information. Mild difficulties with regulation and direction of actions to objectives with conservation of selective control of activity were identified. The patient was always critical and orientated in time and person. He could understand that he had committed mistakes, but was unable to correct them independently.

Program of rehabilitation

The patient was included into the program of neuropsychological rehabilitation divided into two periods. Neuropsycological assessment was provided by the Service of Neuropsychology of Master Program in Neuropsychological Diagnosis and Rehabilitation of the Faculty of Psychology of Autonomous University of Puebla (Mexico). This service is free of charge for patients and the whole procedures of assessment and rehabilitation always take place according to an agreement of the patients and their families. The patient agreed to take part in the program and accepted to use clinical information for the study. The duration of the first period was of four months. Each individual session dured one hour, the frequency of the sessions was three sessions per weak.

The sessions of the first period of rehabilitation were divided in three stages (Table 1).

Table 1. First period of neuropsychological rehabilitation (Juárez, Solovieva & Machinskaya, 2013)

Stage	Preliminary stage	First stage	Second stage
Number of Sessions	2	13	21
Goals of stages	Establishment of contact with the patient and explication of goals of rehabilitation, necessity of independence and variety of activities at home	Strengthening of organization and planning of intellectual activity. Introduction of strategies for organization of remembering.	Work with written production.
Tasks	Introduction of rules for table games.	Complex table games with rules Verbal description of artistic pictures with observation and analysis of features, actions and characters Work with strategies for understanding of read texts. Solving of arithmetic problems with one operation. Creation of words using external letters.	Retention of series of images and artistic pictures. Elaboration of plans for artistic texts. Solving arithmetic problems with multiple operations. Work with grammar structures in written sentences.

After six months, the second period of rehabilitation of the same duration took place (four months).

The sessions of the second period of rehabilitation were divided into two parts: 1) intellectual activity at perceptual level and 2) intellectual activity at logic-verbal level (Table 2).

Table 2. Second period of neuropsychological rehabilitation.

Stage	Perceptual stage	Logic-verbal stage
Sessions	15.	16.

Objective	To guarantee analysis and synthesis relationships of cause-consequence between elements of texts and artistic drawings in order to achieve understanding of the profound meaning of complex information.	To optimize identification of essential verbal elements according to their meaning. Identification and differentiation of essential elements of verbal information and facilitating of access to the understanding of the whole meaning of the text.
Tasks	Observation of paintings and oral comments of all details. Analysis of all actions and characters and writing of correspondent sentences. Writing of short texts according of the content of paintings.	Oral reading of texts. Elaboration of plans using key phrases. Writing of plans for texts; elaboration of scheme for texts.
Instruments and materials	Therapist Instructions. Orientation cards with the order for analysis of paintings. Artistic paintings.	Therapist Instructions. Orientation cards with key words for texts. Descriptive, narrative and artistic texts.

Some examples of orientation cards for the order of analysis of paintings are shown below. The patient had to observe the picture, comment all features, characters, colors, actions and so on. Examples of questions used during orientation in tasks of analysis of pictures:

1) Find the main character or characters of the picture.

2) What are they doing (what is happening to them)?

3) Where are they?

4) What is the whole situation?

5) Which are the elements (objects) of the painting?

After the work with the orientation card and answering to all questions, the patient had to identify the general meaning of the whole situation represented in the painting.

External orientation proposed by therapist consisted in directed questions, which helped the patient to detect the features of the images. Examples of questions were used during orientation for identification of the meaning of pictures:

1) What do you think about this picture?

2) What is represented in the picture?

2) What is the general meaning of the picture?

3) Why did the author draw this painting and what did he wanted to show?

Finally, the patient was encouraged to try to realize independent drawing of the most important details or impressions of the painting. The Figures 1 and 2 show examples of the paintings and the drawings of the patient during the work with the program of rehabilitation.

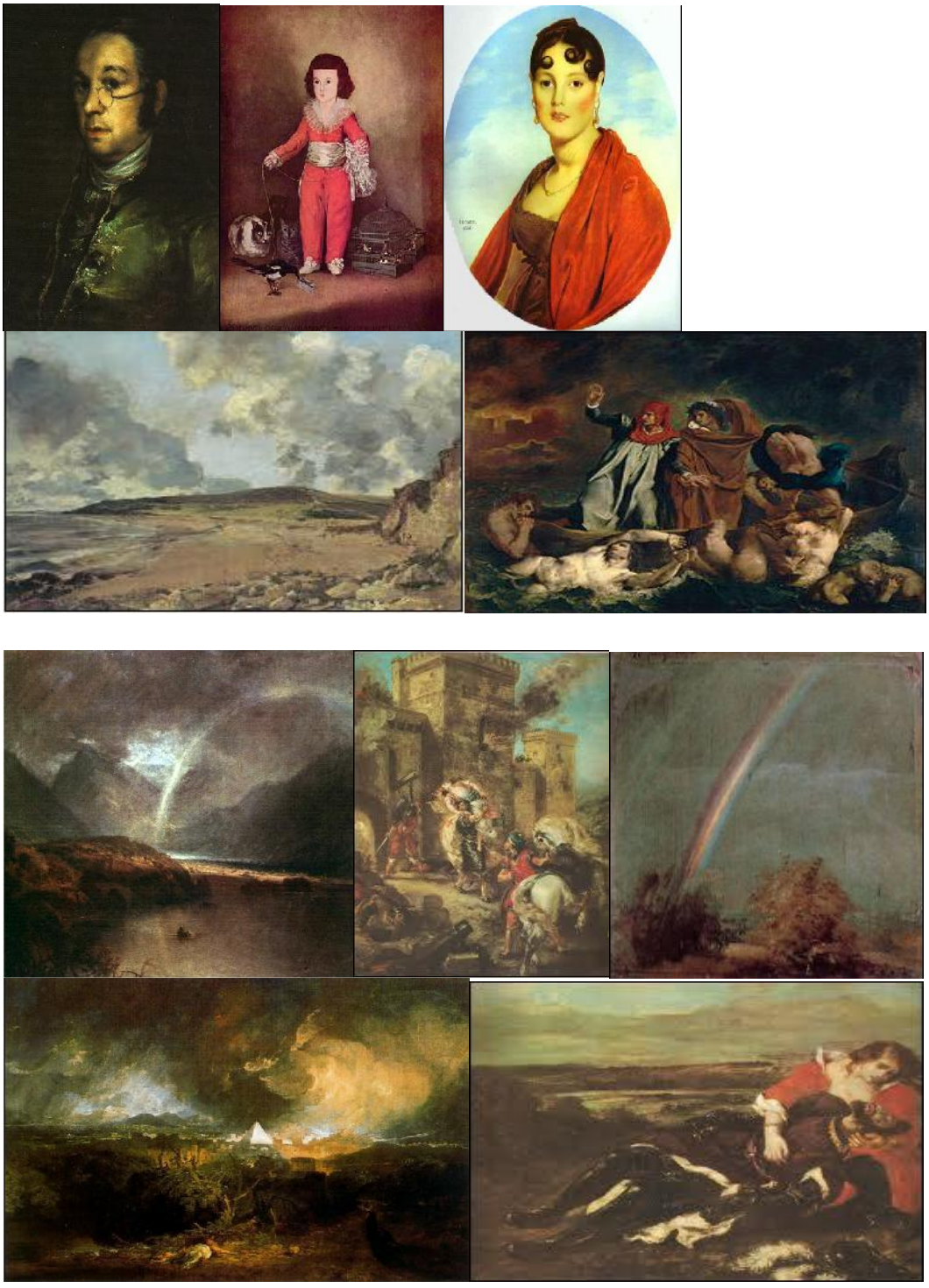

Figure 1. Examples of artistic paintings used during rehabilitation by Goya, Turner, Constable, Ingres, and Delacroix.

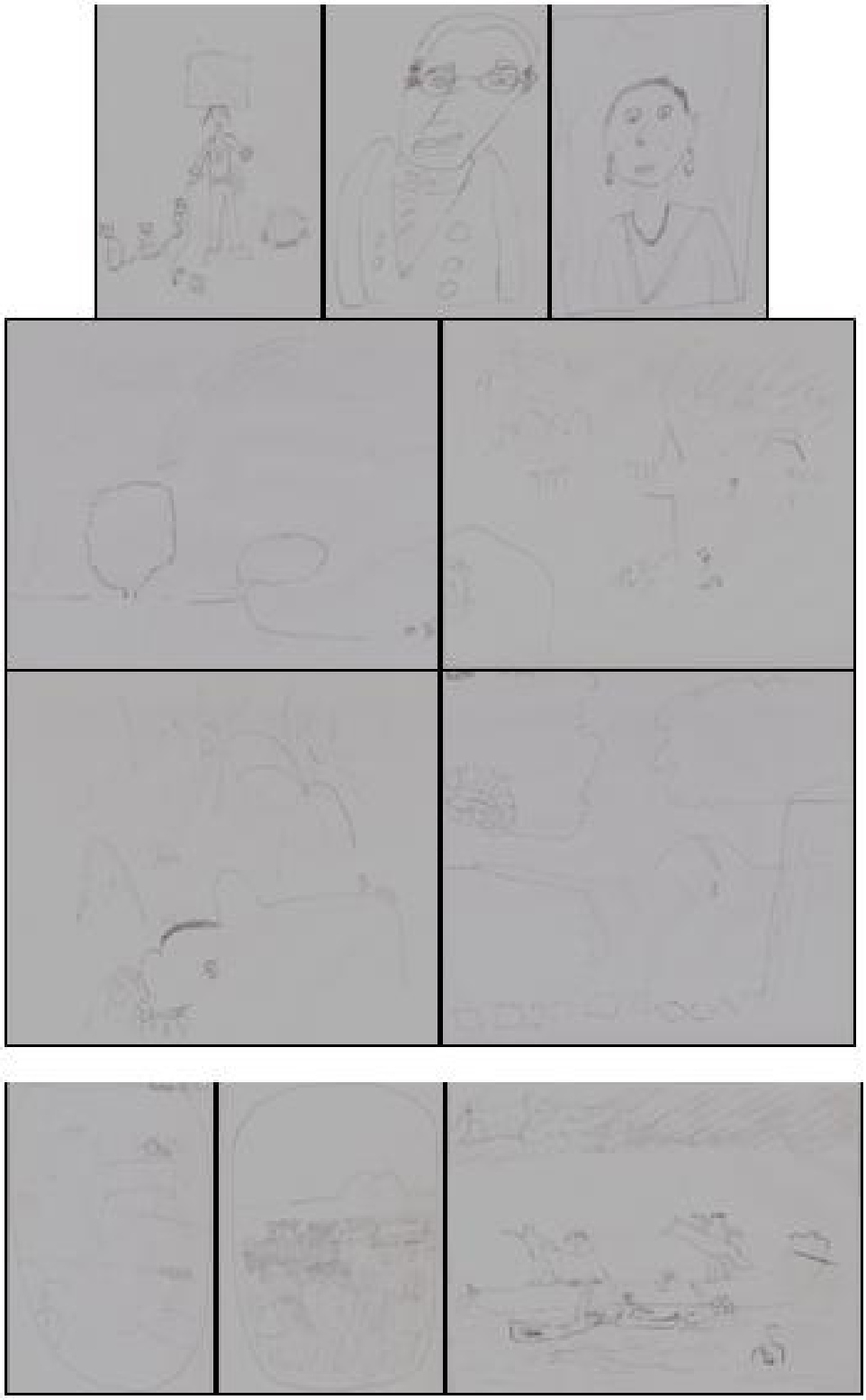

Figure 2. Examples of the executions (drawings) of the patient.

During the work with the reading and understanding of the texts, orientation card was also used in order to achieve elaboration of the written plan for the texts.

Example of the questions used for orientation card:

1) Divide the text into parts according to their meaning.

2) Identify the first part according to its meaning.

3) Think of a subtitle for this part of the text.

5) Write the first subtitle.

6) Check if you like this subtitle and change it if you don't.

7) Identify the second part of the text and so on.

8) Write down the whole plan for the text.

9) Write sentences explaining each point of the plan.

10) Review the sentences and try to obtain the complete text.

During rehabilitation the texts by Myriam Laurini, Rolo Diez, Tomás Borges, Alfonso Lara, Nicolas Machiavelli, Edgar Allan Poe where used together with didactic texts on different topics, interesting and attractive for the patient.

The Figure 3 shows examples of executions of the patient.

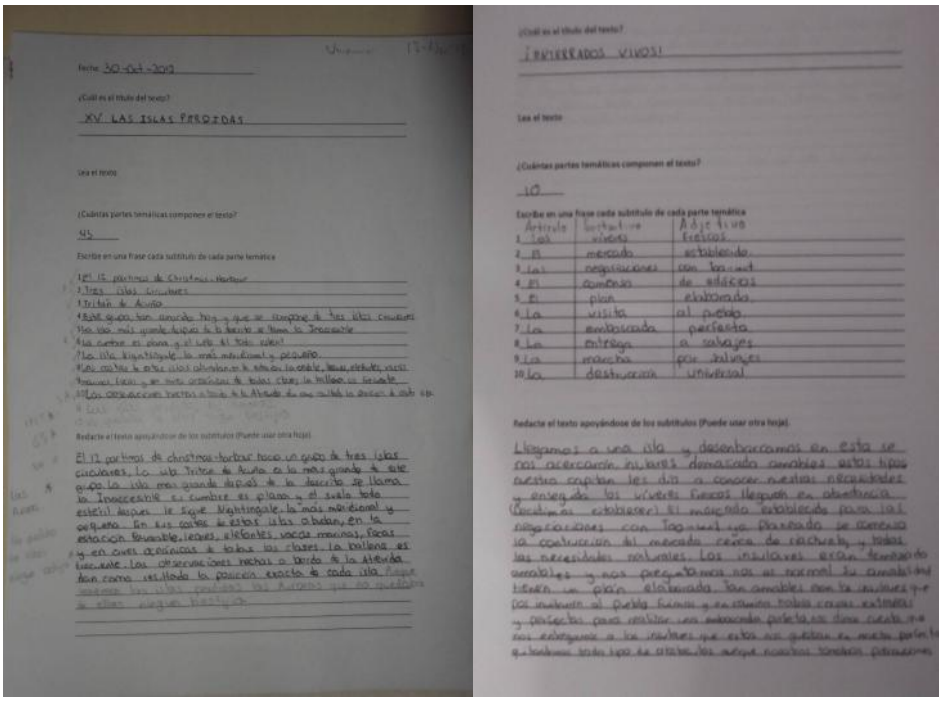

Figure 3. Examples of a plan for the text created by the patient.

Results of rehabilitation

After the work with two periods of rehabilitation, final neuropsychological assessment was carried out. The second assessment has shown the disappearance of systematic errors such as impulsivity, lack of order, difficulties with verification, disinhibiting, collateral associations, pathological inertia, omission of essential features of perceptive and verbal information. During the final evaluation, mechanisms of involuntary regulation and global perception of information showed better functioning, which was reflected in significant improvement in tasks of intellectual activity.

The tables 3, 4 and 5 show types of errors detected during the initial evaluation.

Table 3. Tasks of the neuropsychological evaluation for adults (Quintanar and Solovieva, 2013)

Neuropsychological Mechanism	Task	Type of error
Kinesthetic integration	Reproduction of finger positions.	No difficulties.
	Object recognition.	No difficulties.
	Reproduction of articulator phone positions.	No difficulties.

	Repetition of syllables with similar sounds per point or mode.	No difficulties.
	Determination of the number of sounds in words.	No difficulties.
Kinetic melody	Motor coordination test.	No difficulties
	Copy and sequence continuation.	No difficulties
	Repeat word pairs.	No difficulties
Phonemic integration.	Repetition of syllables.	No difficulties
	Identification of phonemes.	No difficulties
	Identification of sounds in words	No difficulties
Retention of information.	Playing finger positions in opposite hands.	No difficulties
	Involuntary audio-verbal retention.	Contaminations. Changes of order of words.
	Voluntary audio-verbal retention.	No difficulties.
Spatial integration	Spatial visuomotor retention	Changes of order.
	Audio-verbal retention with heterogeneous interference	Distortions and difficulties with proportions of the elements.
	Copy of a house	No difficulties
	Understanding of orders.	No difficulties
	Body scheme.	No difficulties
	Comprehension of sentences.	No dificulties
	Perception of numbers and letters	No difficulties
Object images	Drawing of an animal.	Omission of essential features in the drawings.
	Drawing of a cat.	
	Drawing of a mouse.	

Table 4. Tasks of the Protocol of Assessment of the Sphere of Affects and Emotions in patients with brain damage (Solovieva & Quintanar, 2017 a)

Task	Types of error
Recognition of emotions in artistic paintings.	Problems with exact meaning and collateral associations.
	Difficulties in the representation of emotions.
Evocation of emotions in own facial and corporal expressions	Difficulties of finding for appropriate title according to the picture.
Choice of a title for artistic painting.	Problems with exact meaning and collateral associations
Identification of emotions in verses.	Problems with exact meaning and collateral associations.

Identification of emotions in texts written in prose.	Problems with exact meaning and collateral associations.

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Table 5. Tasks of the Protocol of Assessment of Intellectual Activity in patients with brain damage (Solovieva & Quintanar, 2017 a).

Task	Types of error
Identification of emotional expressions in artistic drawing by comparison of similitudes and differences.	Difficulty in understanding of the meaning and poor analysis of visual information.
	Problems with exact meaning and collateral associations.
Identification of meaning in texts	Impossibility
Elaboration of the plan (scheme) for the text.	Problems with exact meaning and collateral associations.
Production of text title	Difficulty in understanding of the meaning and poor analysis of verbal information.
Identification of emotions of the characters of the text.	Impossibility. Pathological inertia and verification difficulties. Collateral associations.
Written composition according to selected topic, according to previously created own plan.	Impossibility.
Understanding of proverbs	Pathological inertia and verification difficulties

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272 The table 6 shows important changes observed after applying of the second
273 period of the program of rehabilitation of intellectual activity.

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275 **Table 6. Improvements in intellectual activity as result of rehabilitation.**

Task	Before the second rehabilitation cycle	After the second rehabilitation cycle
1. Copy of the house.	Distortion of the elements of the house.	Correct fulfillment, no distortions in the elements.
2. Drawings by of objects by		Presence of essential features in the drawings.

instructions.	Luck of essential features in the drawings.	
3. Reproduction and evocation of figures.	Difficulties with reproduction of proper order, distortions, omissions and contaminations.	Correct execution.
4. Elaboration of a plan for the text.	Presence of pathological inertia. Omission of essential details.	Elaboration of the coherent plan.
5. Interpretation of emotions in artistic drawings.	Difficulties and impossibility of identification of general sense, difficulties to identify similitudes and differences.	No difficulties in identification of emotional expression in paintings.
6. Representation of emotional expressions by the patients.	Difficulties of expressions.	No difficulties in identification of emotional expression.
7. Reading and understanding of poems.	Total impossibility and confusion.	Better understanding of the sense of poems.
8. Identification of emotion in texts.	Difficulties of understanding.	No difficulties in understanding.
9. Problems solution.	Difficulty in understanding of the meaning of the text of the problems and confusion with operations. Impulsive answers with no reflection.	Proper understanding and verification of mistakes during solution.
10. Oral expressions.	Presence of elements unrelated to the situation.	Disappearance of elements collateral associations. Adequate conversation.

Examples of executions of the tasks with improvement achieved after the second period of neuropsychological rehabilitation are presented below. The Figure 4 shows adequate representation of details and proportions in the task of the copy of the house after rehabilitation. The perspective isn't clearly expressed in the copy before rehabilitation.

Figure 4. The task of the copy of the house before and after rehabilitation.

Before **After**

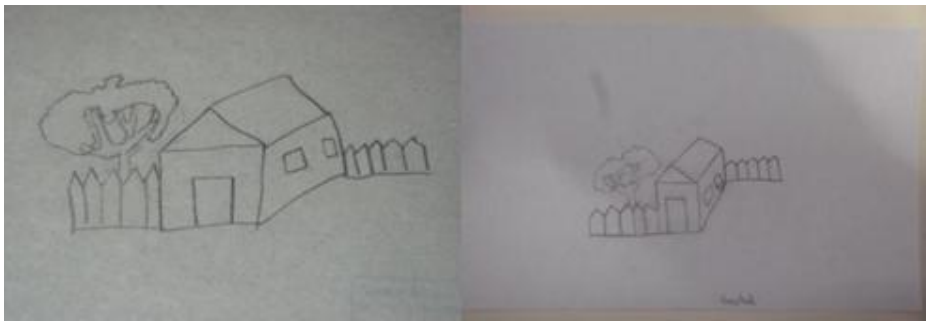

Figure 4. Back home

The figure 5 shows examples of independent drawing of objects by instruction before and after rehabilitation. It is possible to notice the presence of essential features of the drawn animals in the examples after rehabilitation in the contrast with the drawing made before rehabilitation. In the drawings after rehabilitation it is possible to recognize the dog, the cat and the mouse. The animals drawn before rehabilitation aren't clear and are difficult to identify.

Figure 5. The task of drawing of the animals before and after rehabilitation.

Before

After

Figure 5. Drawing of a dog, a cat and a mouse before and after rehabilitation.

The Figure 6 shows the task of copying, evocation and posterior reproduction of figures before and after the second period of rehabilitation. There are no mistakes in conditions of heterogeneous interference were detected after rehabilitation.

Figure 6. The task of copy and evocation of figures before and after rehabilitation.

Before **After**

First series of images.

Before **After**

Second series of images.

Figure 6. Task of copying, evocation and reproduction of two series of figures before and after rehabilitation.

Positive results were also noticed in day-to-day life of the patient after the second period of rehabilitation. The general organization of intellectual activity improved considerably, the patient became able to complete his homework independently as well as other tasks of academic and domestic life.

All cognitive actions of the patient improved considerably thanks to the development of his planning. In addition, voluntary memory strategies of the patient were also favorably improved. As for personal behavior in general, it's important to

mention that no irrelevant comments and collateral associations were noticed as important result of neuropsychological rehabilitation. The patient became able to tell stories and to express correctly events of his life with more extensive and more coherent content. The patient managed to express emotions and emotional behavior of characters of stories he read at the sessions. The relatives have reported improvements in emotional control in their interpersonal relationships. The achievements, which were reflected in the final assessment, represent the possibility of rehabilitating intellectual activity at the high levels of complexity of perceptual and verbal intellectual tasks. In addition, the achievements have allowed the subject to establish better communication in his family, with friends and mates. The patient became able to drive and supervise his own automobile, which is a kind of activity of high personal significance for a young adult.

Finally, it should be mentioned that the patient, who was 24 years of age at the end of the program, was able to return to successfully to his university studies in law.

Discussion and conclusions

A classic approach to cases of brain damage in frontal region of right hemisphere is frequently focused on isolated functions of memory, spatial deficits and difficulties in the relationship between language and context or impossibility to automatize new actions (Barroso & Nieto, 1996; Maestú, Martin, Sola & Ortiz, 1999; Xomskaya, 2002). Some authors relate such difficulties to deficits in executive functions (Schoenemann, Seehan & Glotzer, 2005; Thoma & Daum, 2006). In our opinion, executive functions cannot be understood as synonym of intellectual activity. The integrative analysis of intellectual activity of patients with right brain damage according to Luria's neuropsychological approach is still missing in modern neuropsychology.

Our results have shown that it's possible to define the mechanisms, which underline the clinical syndrome of the patient could be described as loss of involuntary regulation (Xomskaya, 1987) and mild difficulties with global perception of information on perceptive and verbal level. These difficulties were reflected in all kind of intellectual activity, but didn't affected simple operations such as

reproduction, repetition, direct naming, copying, simple arithmetic operations and so on. We had already previous experience with other patients with right brain damage who presented similar difficulties (Solovieva, Pelayo, & Quintanar, 2002). We also stress that the methods of neuropsychological rehabilitation of young adults of high educational level should include creative intellectual tasks with consideration of the interests and cognition of the patients.

Our results could be summarized as follows:

- Neuropsychological mechanisms (factors) of frontal cortical subcortical damage could be expressed with terms of lack of involuntary regulation and global perception.
- Both mechanisms were significantly improved after two periods of neuropsychological rehabilitation.
- Neuropsychological assessment and syndrome diagnosis according to Luria's approach is useful in cases of right brain damage.
- Qualitative analyses of neuropsychological syndrome and psychological structure of activity are essential methodological elements for elaboration and application of programs of rehabilitation in adult patients.

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