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NEUROPSYCHOLOGICAL REHABILITATION IN CASE OF ADOLESCENT WITH CEREBROVASCULAR EVENT IN EARLY CHILDHOOD

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ABSTRACT. The objective of this study is to present results of the rehabilitation of an individual case of an adolescent patient with early brain damage in right hemisphere and the cerebellum because of a stroke with an evolution of more than ten years without any formal treatment. The method of the individual case study was used in this research, performing a pre-and-post qualitative assessment before and after of the application of the neuropsychological rehabilitation program. The results obtained in the study allowed to point out an improvement in the functioning of functional systems for practical, ludical, graphic and verbal actions of the patient. Positive changes were obtained in the motor sphere, muscle tone and balance. The patient became more independent in his general behavior, his interests were increased, he showed a higher level of regulation, responsibility, and active participation in his day-to-day life. Neuropsychological assessment should consider the psychophysiological cause of the patient's difficulties together with the guiding activity of psychological age. Results of such assessment lead to elaboration and application of effective programs for rehabilitation even after long periods without formal treatment. Luria's neuropsychological theory together with the theory of psychological development represents a solid background for the assessment and organization of the rehabilitation process in cases of patients with brain damage after several years since the event.

Keywords: Brain injury; right hemisphere; neuropsychological rehabilitation.

REABILITAÇÃO NEUROPSICOLÓGICA EM CASO DE ADOLESCENTE COM EVENTO CEREBROVASCULAR NA PRIMEIRA INFÂNCIA

RESUMO. O objetivo deste estudo foi apresentar os resultados da reabilitação de um adolescente com dano cerebral precoce no hemisfério direito e cerebelo por acidente vascular cerebral com evolução superior a dez anos e sem histórico de tratamento formal. O método utilizado foi o estudo de caso único, com avaliação pré e pós-aplicação de um programa de reabilitação neuropsicológica. Os resultados obtidos evidenciaram a melhora do funcionamento dos sistemas funcionais para as ações práticas, lúdicas, gráficas e verbais do paciente. Mudanças positivas também foram observadas no aspecto motora, no

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tônus muscular e no equilíbrio. O paciente mostrou-se mais independente, houve aumento nos interesses, maior nível de regulação, de responsabilidade e participação ativa em sua vida cotidiana. A avaliação neuropsicológica deve considerar a causa psicofisiológica das dificuldades do paciente, juntamente com a atividade orientadora da idade psicológica. Os resultados deste tipo de avaliação permitem a elaboração e aplicação de programas efetivos de reabilitação, inclusive depois de longos períodos sem um tratamento formal. A teoria neuropsicológica de Luria, juntamente com a teoria do desenvolvimento psicológico, representa uma base sólida para a avaliação e organização do processo de reabilitação em casos de pacientes com dano cerebral, mesmo depois de vários anos após o evento traumático.

Palavras-chave: Dano cerebral; hemisfério direito; reabilitação neuropsicológica.

REHABILITACIÓN NEUROPSICOLÓGICA EN CASO DE ADOLESCENTE CON EVENTO CEREBROVASCULAR EN LA PRIMERA INFANCIA

RESUMEN. El objetivo de este estudio es presentar los resultados de la rehabilitación de un adolescente con daño cerebral temprano en hemisferio derecho y cerebelo por evento cerebrovascular con evolución mayor a diez años y sin historial de tratamiento formal. El método usado fue el estudio de caso único, con una evaluación pre y post aplicación de un programa de rehabilitación neuropsicológica. Los resultados obtenidos evidenciaron la mejoría en el funcionamiento de los sistemas funcionales para las acciones prácticas, lúdicas, gráficas y verbales del paciente. Cambios positivos también fueron observados en la esfera motora, el tono muscular y el balance. El paciente se mostró más independiente, sus intereses se incrementaron, evidenció un mayor nivel de regulación, responsabilidad y participación en su vida cotidiana. La evaluación neuropsicológica debe considerar la causa psicofisiológica de las dificultades del paciente, junto con la actividad rectora de la edad psicológica. Los resultados de este tipo de evaluación permiten la elaboración y aplicación de programas efectivos de rehabilitación, incluso después de largos períodos sin un tratamiento formal. La teoría neuropsicológica de Luria, junto con la teoría del desarrollo psicológico, representa una base sólida para la evaluación y organización del proceso de rehabilitación en casos de pacientes con daño cerebral, aún después de varios años desde el evento.

Palabras clave: Daño cerebral; hemisferio derecho; rehabilitación neuropsicológica.

Introduction

An Optimal state of the central nervous system, from birth, is considered one of the essential conditions for a positive course of psychological development within the historical and cultural paradigm (Vygotsky, 1997). Consequently, brain organic damage in early childhood would be the reason for difficulties in psychological development. Vygotsky (1993) was the one who proposed to study the role not only of the anatomical level of brain damage but also the effects of the social situation of development to understand the causes of retardation of psychological development in different ontogenetic ages. The proper understanding of neuropsychological syndrome requires complex analysis of the physiological/organic, psychophysiological/neuropsychological, and psychological levels. In this case, the negative symptoms and different disabilities shouldn't be understood only

because of immaturity or brain structural damage, but always because of features within each concrete social situation of development. With this term, Vygotsky (1997) minded concrete type of relations existent between the child and close adults (the kinds of activities and communication) who organize his/her psychological development at each period of ontogenetic development.

Few studies report cases with precise descriptions of clinical data about the determination and assessment of difficulties after more than ten years between brain organic damage in early infancy and its consequences in early adolescence. Normally, the studies focused on brain damage, such as cerebrovascular events in children, reports the absence of knowledge about more suitable assessment and interventional procedures, which were always based on studies with adults (Jordan & Hillis, 2007). Cerebrovascular events in children have an average incidence of 13/100,000. Approximately 20% of them die and more than 50% of children presents neurological sequels in the following ages (Giroud et al., 1995 e Lanska et al., 1991 apud Ciccone, Cappella, & Borgna-Pignatti , 2011). Johnson (2009) recognized that children with motor and neurodevelopment disorders are sedentary; manifest reduced balance, poor muscular strength, resistance, and flexibility, leading them to obesity and depression. Hasset et al. (2018) stressed the importance of activities that encourage their independence (besides physical therapy) to enhance the motivation of patients and family participation.

In cases of organic damage in infancy, the importance of early, integral, interdisciplinary, formal, individualized, and intensive rehabilitation is broadly accepted (Pallesen, Buhl, & Roenn-Smidt, 2016; Buhl & Pallesen, 2015). Nevertheless, when practicing, proposals are oriented to physical, behavioral, and cognitive training. Some recent physiological studies claim that the reorganization and brain compensation of the grey matter inside the contralateral hemisphere to the injury, instead of a directly damaged hemisphere, leads to a less effective recovery in patients with brain damage, acquired in the early stages of life (Artzi et al., 2016). These last authors believe that functional reorganization inside the same hemisphere, instead of the contralateral hemisphere, allows them to achieve better results in motor and linguistic recovery within patients with early brain damage. Similar ideas about the primary role of the reorganization of the functional systems inside the damaged hemisphere, and no contralateral, were exposed in Luria's works and his followers.

Neuropsychological Rehabilitation according to Historical-Cultural Paradigm

The neuropsychological conception of assessment and correction in cases of brain damage, based on the model of historical and cultural development of Vygotsky (1997), Luria (1980), and his followers, has shown real possibilities to ensure the acquisition of cultural experience that each child needs according to their psychological age, the rehabilitation of movement, the reorganization of functional systems in children and adults patients as a consequence of brain damage and disturbances in ontogenetic development (Leóntiev & Zaporozhets, 2016; González-Moreno, 2018).

This model of rehabilitation is based on physiological, psychological, and pedagogical principles. On the physiological level, such principles propose the consolidation of new functional systems, according to the psychological age of the patient (Luria & Tsvetkova, 1966). The process of rehabilitation should contemplate the re-organization of the whole activity of the patient instead of training isolated functions and tasks, to stablish a rehabilitation program well-structured and to influence systematically over the central mechanisms of the damage, identified during qualitative neuropsychological assessment

deficits (Tsvetkova, 2016). Such procedures for assessment and rehabilitation considers not only the level of cortical compromise but also the subcortical organization of functional systems at different ages. Recent studies have included assessments combining electrophysiological, anatomical, neuropsychological, and psychological levels of analysis of syndrome in childhood (Ochoa & Quintanar, 2018).

The objective of this study is to present the results of a clinical qualitative assessment based on the theory of functional brain organization together with the content and results of rehabilitation. The Assessment was provided on psychological, neuropsychological, and electrophysiological levels. The data from the assessment served as the basis for the creation of the program for neuropsychological rehabilitation.

Neuropsychological assessment was performed individually during five sessions of fifty minutes each. The assessment was conducted according to Luria's neuropsychological general scheme, modified, and adapted for Spanish-speaking patients. The assessment included tasks with concrete actions, symbolic tasks, and dialogues, to evaluate functional components of psychological activities and the zone of proximate development for the practical and cognitive actions of the patients.

Method

The method comprehended the study of an individual clinical case by performing a pre-and-post evaluation with an intra-subject comparison before and after the application of an interventional program. The method of qualitative neuropsychological assessment was accomplished followed by the analysis of the neuropsychological syndrome, stressing strong aspects of the patient's development together with discovering weak aspects and the central mechanisms of the syndrome. The method also included the analysis of the actual psychological age, zone of actual and proximate development, and the levels of accessible practical and intellectual actions. Such information served as the background for the creation, organization, and fulfillment of the program for neuropsychological rehabilitation together with the tasks for individual work and joint tasks with the parents.

Case

A 12-year-old patient, who suffered a brain stroke whose age was one year old, was included in the study. Magnetic resonance pointed to an epidural hematoma in the frontotemporal and parietal right hemisphere and focal alterations on the bridge as the consequence of an ischemic event together with a lesion on the right cerebellum hemisphere. The patient showed strong communicative difficulties and an absence of day-to-day habits such as washing hands and using a spoon. The patient couldn't walk independently, presented severe difficulties with balance and motor sphere, and used a stroller. The patient presented obesity, clubfoot, and spastic diplegia. His school record wasn't constant, and he never assisted to specific measures of rehabilitation.

At first neuropsychological assessment, the patient's had no contact with his family members or friends of his age, showing difficulties in communication with strangers. He used to spend his evenings watching television.

Stages of Study and Procedure

The initial neuropsychological assessment was performed individually during five sessions of fifty minutes each. After the initial neuropsychological assessment, the program for neuropsychological rehabilitation was created and applied. Recommendations were

given for home as orientation for re-organization of home tasks including playing activities and practical actions with concrete objects for an increment of independency in day-to-day life.

At the end of the program, a final neuropsychological assessment was applied to evaluate the progress after working with the proposed program. Due to clinical validity purposes, the post-evaluation was performed by another neuropsychologist.

Clinical Assessment

Neuropsychological qualitative assessment, before and after the work with the program of rehabilitation was carried on with the help of the following instruments, created according to principals of historical and cultural neuropsychology (Luria, 1980; Vygotsky, 1997):

- Brief Neuropsychological Assessment for Children – Puebla (Solovieva & Quintanar, 2017).
- Neuropsychological Assessment of Pre-schooler Child (Quintanar & Solovieva 2010).
- Neuropsychological Assessment of School Learning (Quintanar & Solovieva, 2012).
- Complementary tasks for assessment of production and comprehension of oral speech.
- Electrophysiological Assessment included electroencephalographic register followed by visual qualitative analysis to evaluate the functional conditions and maturity grade of cortical and subcortical brain levels.

Results of Initial Clinical Assessment

During the clinical evaluation, important difficulties with self-balance, low muscle tone on all limbs, weak strength in both hands, difficulty to grab a pencil, and the absence of hand preference was noticed. The patient presented limited eye contact with psychologists and an absence of motivation for the presented tasks.

The neuropsychological evaluation allowed to discover the following positive aspects of functional systems: ‘activation of the cortical tone, phonemic analysis and synthesis, kinesthetic tactile analysis and synthesis, and visual and audio-verbal informational retention’.

Assessment of ‘sequential organization of movements and actions’ showed a total impossibility for reciprocal coordination of hands, for the making of a dynamic change of finger’s position, and for completing a sequence of manual movements (motor fluency test). It was necessary to present fragmentation of the stimuli for the repetition of a series of words, syllables, and sounds. Simplification of sequences in concrete levels (real objects), together with perseveration of elements, were observed in all tasks, including an exercise for semantic fluency.

The deficit of functioning of ‘the mechanism of programming and control of voluntary actions’ was also observed in all tasks, which regarded planning and selective organization of action. The patient showed the incapacity to accomplish the execution of a verbal associative and conflictive task. Constant collateral associations were presented in his responses before the presentation of a stimulus (word). In addition to intrusions and verbal contamination, strong preservation appeared in all complex intellectual tasks. The same answer was obtained for diverse verbal questions.

The assessment showed that the patient didn’t understand the meaning and sense of texts, metaphorical and figurative language, proverbs, and jokes at all. The patient presented multiple collateral associations, semantic intrusions, and substitutions in all tasks and daily dialogues communication. The content of his expressions was concrete and

incoherent. Speech understanding was reduced to the level of concrete words and sentences with direct simple grammar.

The patient couldn't correct his own mistakes committed in a wide range of activities, despite the constant help and guidance of the neuropsychologist. The assessment detected the absence of organization and planning to perform formulated tasks, which were clearly on canceling tasks. The patient didn't accept the helping strategies given by the neuropsychologist, showing constant impulsive and distractive behavior.

Assessment of 'psychological age' showed an absence of motivation for intellectual activity and verbal communication directed to the goals, proper to adolescence age. The tasks that introduced playing activities were much more accessible for the patient. The patient's motivation increased always according to active participation in recreational tasks with the use of concrete objects. At the same time, the patient couldn't propose any kind of table game or concrete task by his initiative, but he accepted the rules and steps of the games after the suggestion of the psychologist, always according to the presence of external concrete objects. The cultural use of toys and objects on a concrete level was known and accepted by the patient.

As for the functions of language, limited development of 'communicative' function was detected. The oral expressions were full of the constant appearance of collateral associations, and concrete answers. The patient showed impossibility in maintaining a coherent dialogue together with difficulties in the clear expression of ideas. The function of 'regulation of language showed poor development', as corporal regulation given by the psychologist was necessary for all tasks. 'The function of the mediatization of language' showed a low level of acquisition as it wasn't possible to use an object as a tool to remember information. The patient couldn't use the words as a tool of substitution for an object or an action. Lastly, the patient presented poor knowledge of empirical concepts and a complete absence of scientific concepts. Acquisition of school actions such as writing, reading, and calculation wasn't accessible at all.

Regarding the 'voluntary sphere', appropriate and voluntary movements were achieved only in situations with playful content. In graphic activities, the executions were reduced to senseless doodles; the patient didn't recognize global forms of objects in perceptive space.

According to all exposed data, initial neuropsychological assessment permitted to achieve to the conclusion of a severe functional deficit in the mechanism of programming and control, functional weakness in spatial synthesis, and the sequential organization of movements and actions.

From a psychological point of view, it was concluded that the psychological age of the patient corresponded to the first stage of preschool age, due to the poor development of different functions on language, low level of symbolic functions, absence of graphic activity, and predominant motivation for playing tasks with concrete support.

From an electrophysiological point of view, the visual qualitative analysis allowed to prove an incongruence of the functional state of the cortex that links with the chronological age. In the central and temporal-parietal sections, long (up to 5 s.) periods of slow (6-7 Hz) oscillation are recorded. These focal EEG deviations testify to a decreased excitability of the somatosensory and motor cortical zones. Another characteristic feature of the patient's EEG is the presence of alpha spindles predominantly in the frontal leads of the right hemisphere. According to the MEG study, the source of frontal alpha-like EEG patterns is the anterior cingulate cortex (Connemann et al., 2005). This prefrontal zone on the medial surface of the

right hemisphere is an important part of the brain system providing executive control and sustained attention (Posner & Fan, 2008).

Program for Neuropsychological Rehabilitation

The program was designed and applied after the initial assessment. The parents of the patient signed an agreement for participation in the program during forty sessions organized in four months. Each session was individual with a one-hour duration. The program was applied by a neuropsychologist formed under the fundamentals of historical-cultural model, in the University's Hospital of Puebla, Mexico. The study was approved by the Comity of Ethics of the Autonomous University of Puebla and the procedures was followed to guarantee the compliance of the principles and norms of the Helsinki Declaration.

The program was based on essential principles of neuropsychological rehabilitation, which lead to psychological development. This means organizing the tasks, which include weak components of functional systems by including them in actions directed to the goals. All tasks were presented in the zone of proximate development, which means that the patient could achieve the tasks with the external help of the adult (Akhutina & Pylayeva, 2012). The actions were included in the playing activity, which was significant for the patient. Gradually, a perceptive level of actions was introduced, according to Galperin´s theory of interiorization (Galperin, 1992). Simple intellectual actions were introduced on material and materialized levels. Detailed orientation was presented by the psychologist for all tasks, as the central element of the structure of psychological action.

The general objective of the program consisted of promoting the functioning of programming and control, spatial simultaneous synthesis, and sequential motor organization as well to facilitate the increase of the muscle tone in hands and balance. The complementary objective was the introduction of graphic activity, forming an independence in practical day-to-day concrete actions, and strengthening of communicative and cognitive motivation.

The program consisted of two stages, which were organized according to the following principles: from simple to complex, from material to verbal, and from guided to independent (Tsvetkova, 2016).

The first stage had as an objective the gradual improvement of planning, organization, and verification in playing tasks and constructive; preparation for the introduction of drawing by identification of global shapes; supporting of muscle tone in hands and aspects of balance in sitting position. The employed tasks were: identification of model shapes in real objects while walking in the yard, finding objects correspondent to a presented shape model, elaboration of shapes models with clay, arming and disarming real practical objects using pressure such as coffee (juice) makers, etc., symbolic representation of actions and gestures in games; listening to stories followed by analysis and reproduction of short sentences according to the content and action of the tales with the help of dolls and other toys, sequential motor games with the usage of big size balls.

The objective of the second stage was the practice of expressive productive language, the organization, planning, and verification through playing tasks, the symbolic representation of an object by figures in graphic perceptive space; the inclusion of complex constructive activities; the continuity in the work with muscle tone balance in standing position.

Results of the Final Clinical Assessment

The final neuropsychological assessment allowed to observe significant qualitative changes in the patient's activity and personality. Firstly, the patient became able to keep positive eye contact and communication with the adults. Differently from the initial assessment, he showed high interest and motivation for the realization of all proposed tasks. The patient's parents have noticed greater willingness and organization to perform activities at home and school, an increment of coherence in the dialogues, less dispersion, and more conversational topics. The patient asked for homework at school and was eager to perform the tasks; he demonstrated more cognitive motivation and he started to show a sociable and cheerful mood with other people. The Table 1 shows the qualitative changes seen in muscular tone, equilibrium and in graphic tasks.

Table 1 Qualitative observations pre and post intervention

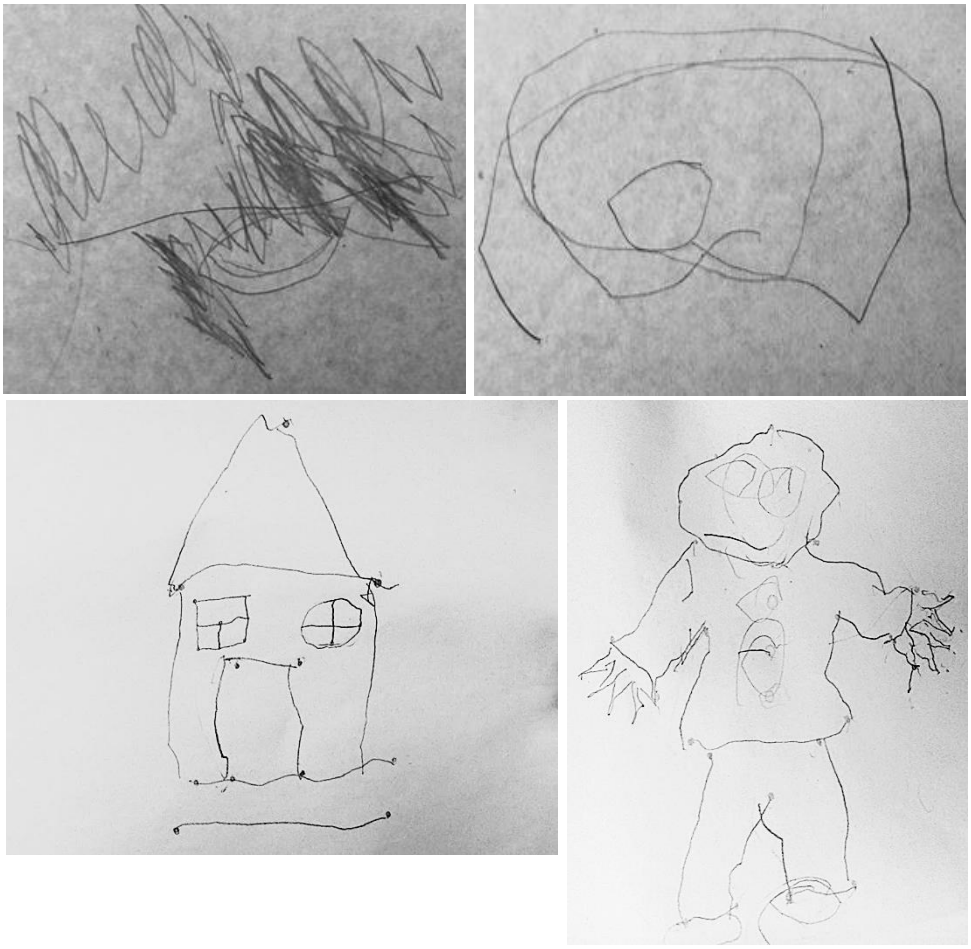
Area	Initial assessment	Final assessment
Equilibrium and muscular tone	Hypotonia in both hands. Impossibility to grab with the fingers any objects with precision. Important difficulty to maintain equilibrium, requiring to be carried all the time.	Possibility to hold a pencil independently (Figure 1), and build/unbuild toys, as well as making high towers with small cubes using only the index and thumb. He worked in a standing position and moved just by holding an arm.
Graphical activity and spatial organization	Scribbles, even with verbal regulation by the evaluator and guiding points using A4 papers. Impossibility to stablish global forms of objects. In verbal, perceptive, and materialized levels, he showed impossibility to comprehend spatial prepositions. In material level, he showed difficulties with the left and right identification.	Patient able to draw the global shapes of objects and join dots following guiding points (Figure 2). Better depiction of simple objects. Shows improvement in graphic activity with better muscle tone in hands. All made in A4. The patient executed satisfactorily commands with spatial prepositions, including left-right at a materialized level.
Verification and planification in perceptive level	In cancelation task, impossibility to recognize errors, showing aleatory execution and presence of perseverative scuffs.	Improved awareness about his mistakes and tried to correct them. Correct planning in cancelation tasks (Figure 3).

Figure 1
Equilibrium and Muscular Tone in Hands

Note. Example of graphic task achieved. Executions were made while standing up with the support of the neuropsychologist to hold him. The patient is holding the marker during realization of graphic tasks.

Figure 2

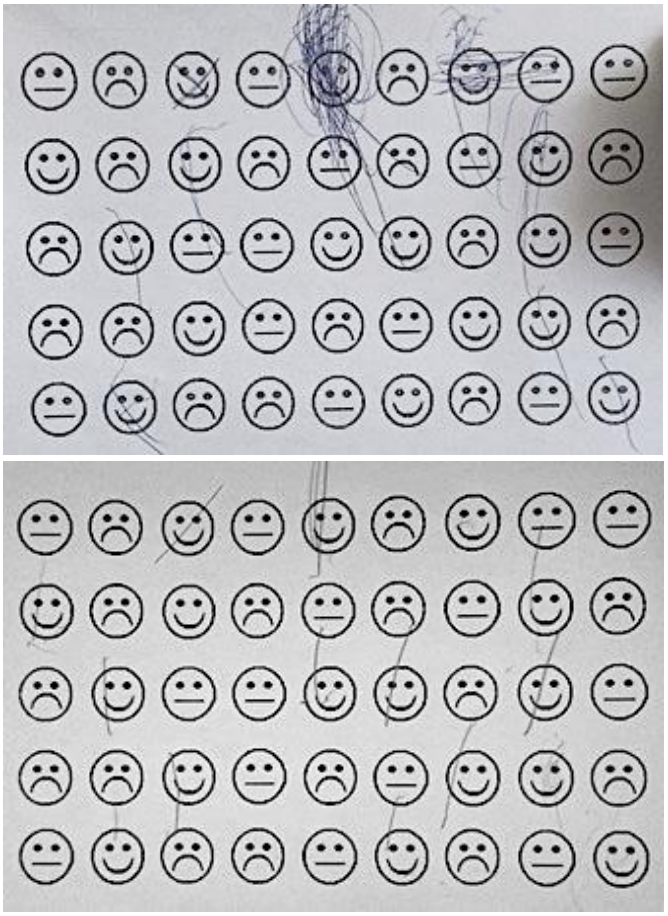
Graphical Activity



Note. Graphic tasks of “copy of a house” and “picture of a child” during the initial (above) and final (below) assessment.

Figure 3

Verification and Planification in Perceptive Level



Note. Fulfillment of cancelation task during initial (above) and final (below) assessment.

One of the most remarkable progresses of the treatment was related to changes in the patient's oral speech. In the first assessment it was reported the presence of verbal contamination, perseverations on the intellectual level, incoherent speech, with poor temporal sequence, and frequent appearance of collateral associations when there was a stimulus presentation (word). In the final assessment it was evident the absence of thought perseverations, collateral associations, intrusions, verbal contaminations, and impulsive responses during the repetition of words, direct questions, and dialogue. It was observed coherence and temporal sequence in his speech, evidencing the possibility of verifying his verbalizations and being possible to start and maintain brief conversations. The Table 2 presents representative examples of the speech pre and post evaluation.

Table 2 Clinical characteristics of speech

Initial assessment	Final assessment
Evaluator (E): when are people afraid? Patient (P): fear, the birds have years, and they get scared. It came out, my what? Do you want to go to my house? Dialog example: E: tell me, what will you do tomorrow? P: oh! I'm not going anywhere tomorrow, huh! Yes, I'm going out with my parents, but you're going to take care of it, huh? E: what am I going to take care of? P: of my business (the patient has no business), of selling juices, of selling ice pops. E: and what do you do in that business? P: I take care of my patients, mine, I understand them very well, when, ah! When I go, well you, I'm going to eat and you take care of that, ah! E: and what else will you do tomorrow? P: yesterday we went to the beach (the patient hasn't been to the beach in many years).	E: tell me, do you know when people are afraid? P: when they get scared, when there are witches, on Halloween (the evaluation was carried out close to the festivity date). Dialog example (patient-initiated): P: hey, what do you want the three wise kings to bring you? E: I want a cart that I can assemble. P: like a puzzle, but bigger? E: Exactly, one like that. And to you, what do you want the kings to bring you? P: an airplane, one like Paw Patrol, but bigger, it transforms, it has wheels, barracks, and a bike. E: but aren't you asking too much of the three kings? are they going to bring you all of that? P: Yes, I put them a letter and that's it. E: and the bike, how are you asking for it? P: too big, so that I can learn to ride it and teach my sister because she goes backward and falls. E: and in what color do you want your bike? P: I want it red.

Discussion

According to the literature, patients with brain damage at early ages show different symptomatology. Cases of right hemisphere injury usually represent a diversified group due to the location and extension of injuries, the presence of linguistic difficulties, and factors such as age and laterality of the patient (Mackenzie & Brady, 2008). In some cases, the symptomatology includes disruptions in pragmatic language, comprehension, and prosody production (Barnes et al., 2019) and executive disorders (Blake, 2018). At the same time, the symptomatology of cerebellum damage might conduct in ataxia, muscular hypotonia, postural tremor, alterations in balance and fine motor skills (Manto, 2018), executive, visual, linguistic, and affective disruptions (Provasi et al., 2014; Smet De, Paquier, Verhoeven, & Mariën, 2013).

Frequently, after many years of brain damage, the measures of rehabilitation don't achieve any positive progress, because of the lack of detailed functional analysis of the nature of difficulties, to the absence of a relation between the diagnostic and the corrective proposal, as well as a poor analysis in the psychological age of the patients. Our study proves that even after more than a decade of brain damage, the programs of neuropsychological rehabilitation might conduct to positive effects. Different principles should be considered to defend this position. Firstly, functional qualitative diagnosis is much more effective than a description of symptoms according to anatomic localization of the

damage or psychometric measure of isolated cognitive functions. From an anatomic point of view, the patient included in our study presented brain damage at frontal cortical and right cerebellum levels. According to this data, only a clinical diagnosis in each case might reveal a concrete neuropsychological syndrome. Secondly, our data suggest the consideration of complementary psychological principles for the creation of the content of the program. Such proposal is related to the analysis of psychological age and not only to the formation of weak brain mechanisms over strong ones (Akhutina & Pylaeva, 2012). The program of correction must be led not to the symptoms but to the underlying mechanisms (Tsvetkova, 2016). The mediatization and gradual interiorization of the actions, which include weak functional mechanisms represent a proper strategy for rehabilitation (Galperin, 1992). Our results claim the necessity of the assessment of psychological age (pre-school age with motivation for paying tasks) of the patients instead of paying attention only to chronological age (12 years). According to our findings, such consideration means proper usage of the concept of the zone of proximate development in the context of clinical rehabilitation. The starting level of introduction of practical and intellectual actions should always be considered instead of the rigid repetition of the same kind of tasks only as verbal instructions. Complexity, variety, and emotional significance of materials for the participant are also essential principles of our program (Elkonin, 1999).

Our results show that disadvantageous situations in the development of children with brain damage can be modified through the implementation of interventional programs under the qualitative neuropsychological model as its proposed on the historical and cultural neuropsychology. Such model suggests an active role of an adult to provide joint productive tasks within the zone or proximate development. The reorganization of functional systems and the creation of new functional systems, which underline the patient's psychological activity is an important psychophysiological principle in this model of rehabilitation. We may agree with Leóntiev and Zaporozhets (2016) who considered the relevance of practical actions for the functional reorganization of the system of movements. Motivated and directed joint actions conform an opposition to mechanic repetition and treatment of common tasks presented as instructions to the patients without any kind of explanation, help, and proper order of presentation.

In the case of our study, such systems were introduced for practical actions with objects, playful tasks, the construction of models, graphic tasks, and oral speech exercises at the level of dialogues. All these actions didn't exist before our rehabilitation. Considering that more than ten years have passed after the brain injury without any formal or successful intervention for the child, our program proved to be effective after four months. Achievements in the functional state of the psychophysiological mechanisms and the psychological development show the coherence of the content of the program with the psychological and neuropsychological needs of the patient.

We emphasize the importance of the detection and rehabilitation of early development difficulties, nonetheless, with this case study we evidence that when there's coherence between the diagnostic and the intervention, highly significative results can be obtained, even after prolonged periods without treatment. The importance of neuropsychological rehabilitation directed to the cause and not the symptom or the aisled psychological functions, is that it allows to have a systematic effect in the whole psychiatric sphere of the patient, allowing, for example, in the case study presented, besides of a better level in the functionality of the functional systems for practical, playful, graphic and verbal actions, an increase in the independency level, confidence in oneself, in their interests, as well as the desire of having more participation and responsibilities in everyday life.

Final considerations

Children diagnosed with brain damage represent a population with unique clinical expressions in each case, which requires a personal evaluation to know their psychological and psychophysiological development, as well as the level of cortical maturity to establish an adequate interventional program that presents an effect to the detected deficits. Neuropsychological assessment should consider the psychophysiological cause of the patient's difficulties together with the guiding activity of psychological age. Results of such assessment lead to the elaboration and application of effective programs for rehabilitation even after long periods without formal treatment.

The results of this research might be interesting for fields such as physical and rehabilitation medicine, psychology, special education, and different lines of neuroscience that have interest in clinical and treatment evaluation.

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