0021-7557/04/80-02-Suppl/S111
Jornal de Pediatria

Neuropsychological assessment in children

Danielle I. Costa[1], Luciana S. Azambuja[1], Mirna W. Portuguez[2], Jaderson C. Costa[3]

Abstract

Objective: To describe the methods used for neuropsychological assessment in children, emphasizing aspects of interest to pediatricians, psychologists and neurologists.

Sources of data: Review of the published literature concerning neuropsychological assessment, including textbooks and reference manuals. The experience of the Neuropsychology Unit at Hospital São Lucas, Brazil, is described.

Summary of the findings: Neuropsychological assessment should not be limited to the application of psychometric and neuropsychological tests; it should also correlate test findings with the neurological/behavioral disorder and establish which part of the brain is likely to be involved. In addition, the careful interpretation of result must be associated with an evaluation of the individual's current status and of the context in which she/he lives.

Conclusion: The final result of neuropsychological assessment should be a neuropsychological profile of the patient, which, in combination with the evaluation of neurological/clinical, psychological and social aspects will contribute to diagnosis and provide elements to guide the patient in terms of maximizing his/her potential.

J Pediatr (Rio J). 2004;80(2 Suppl):S111-S116: Neuropsychology, neuropsychological assessment in children, cognitive functions.

Introduction

Neuropsychology studies the relationship between the human brain and behavior. Its development as a specific area of study is relatively recent, although its scientific basis results from several decades of knowledge and investigation.

According to Cunha,[1] neuropsychological screening initially sought to *identify and locate* focal brain lesions. Today, it is based upon the *dynamic location of functions*, with the aim of investigating higher cortical functions, such as attention, memory, language, among others. The participation of the brain is regarded as a whole, where areas are interdependent and correlated, working like an orchestra, which needs the integration of its components to perform a concert.[2] This is called "functional system".

The major focus of this system is the development of a human behavior science based on brain functioning.

This way, by knowing the normal development and functioning of the brain, we may understand cerebral abnormalities, such as cognitive and behavioral disorders that result from injuries, diseases or abnormal brain development.

Child neuropsychology, whose aim is the early identification of cognitive and behavioral disorders, has become one of the key elements of regular well-child visits. In this case, appropriate tools (neuropsychological tests and developmental assessment scales) are necessary.

1. Psychologist, Service of Neurology, Hospital São Lucas, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), Porto Alegre, Brazil.
2. Associate professor, Department of Internal Medicine and Pediatrics, School of Medicine, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), Porto Alegre, Brazil.
3. Professor, Department of Internal Medicine, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), Porto Alegre, Brazil.

The results of these scales and tests show the major gains during development and aim at determining the child's specific level of development. The importance of these tools lies in the prevention and early detection of developmental and learning disabilities, carefully indicating the pace and quality of the process, allowing for a qualitative and quantitative "mapping" of brain areas and their interconnections (functional system), with the aim of early and accurate therapeutic interventions.

Neuropsychological screening in children – indications and contributions

Neuropsychological screening is recommended in any case in which a cognitive or behavioral difficulty of neurological etiology is suspected. This screening can help with the diagnosis and treatment of several neurological diseases, childhood developmental disabilities, psychiatric involvement, conduct disorders, among others.

The contribution of such screening in children also applies to the teaching-learning process, as it allows establishing some relations between higher cortical functions, such as language, attention, memory, symbolic learning (concepts, writing, reading, etc.). The neuropsychological model of learning disabilities seeks to obtain a sample of higher mental functions involved in symbolic learning, which are obviously correlated with the functional organization of the brain. Without that, learning is not processed normally and, in this case, we may have a brain dysfunction or injury.

Neuropsychology can prepare different health professionals (e.g.: physicians, psychologists, speech therapists, etc) by subsidizing the investigation of children's intellectual functions and promoting a more efficient therapeutic intervention.

The group of instruments used allows us to have a global assessment of children's abilities, as well as of their difficulties regarding their daily performance. We are not "labeling" children as "problematic," but we are preventing such difficulties from affecting their healthy development.

Some aspects should also be considered, such as the fact that brain development has characteristics that are peculiar to each age group. Therefore, according to this brain functioning pattern, it is important to devise tests that are based on the maturational process of the brain. For instance, "immaturity in childhood should not be understood solely as deficiency,"[3] due to peculiarities of brain development in childhood. Differently from adults, a child's brain is still in the process of developing, with its own characteristics that warrant differentiation and specificity of functions.

According to Antunha,[3] the batteries of neuropsychological tests for children are not many, as they must include:

- the organization and development of the child's nervous system;
- the variability of development parameters between same-aged children;
- the narrow relationship between physical development, neurological development, and progressive emergency of higher cortical functions.

Tests used

Some of the neuropsychological tests are listed next. Their potentialities also are briefly described.

Intelligence

Intelligence tests for children basically evaluate skills that are essential to school performance.

The Stanford-Binet[4] test was the first to be used in the United States. Adapted from Binet-Simon original scales, it is extensively based on verbal performance and covers the ages of two years to 23 years (adulthood), providing a mental age and intelligence quotient (IQ).

Wechsler intelligence scales, subdivided according to age, are the international gold standard for the quantification of intellectual capacities. These scales consist of a series of standardized questions and answers that determine an individual's potential in different intellectual areas, such as level of information on general topics, interaction with the environment and capacity to solve every-day problems.

Wechsler preschool and primary scale of intelligence[5] (WPPSI) is a version of Wechsler scales for younger children that allows assessing the intelligence of children aged between four and six and a half years. It consists of six verbal and five performance subtests. Usually, the application of five subtests of each of the (verbal and performance) subscales is enough for a reliable analysis of that scale. This scale also allows gathering some information on how child's behavior is organized.

Wechsler Intelligence Scale for Children-III (WISC-III)[6] is the scale most widely used to assess the intelligence of children aged between six and 16 years, 11 months and 30 days. It provides scores for verbal and performance scales, as well as a full scale IQ score. It includes different types of tasks, allowing the observation of the child's strengths and weaknesses. It should be underscored that children with motor difficulty often are penalized on this test, and therefore it should not be used when such deficiency is observed. WISC-III block design subtest (Figure 1) aims at checking the capacity of analysis, synthesis and planning of visuospatial coordinates and constructive praxis. Individuals are asked to reproduce drawings shown to them using multi-colored blocks. A limit time is established for each model.

Although IQ is used to detect brain dysfunctions, the IQ score can give further information on the patient's general level of functioning and thus serve as reference for more specific functions, such as memory, language, etc. Both Stanford-Binet and WISC-III and WIPPSI are administered individually.

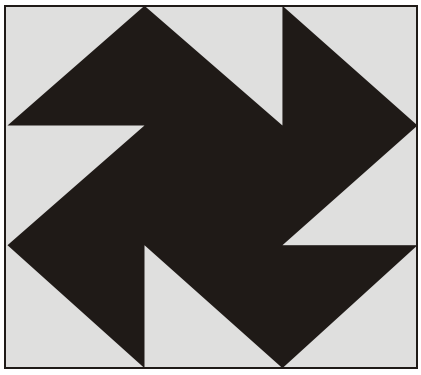

Figure 1 - Example of WISC-III "cubes" subtest

When patients cannot express themselves verbally, Raven's progressive matrices[7] and Columbia mental maturity scale[8] are used. These tests assess general intelligence and estimate a child's general ability to reason independent of language. The aim of Raven's progressive matrices (Figure 2) is to find out the relations between the figures and imagine which of them (total of eight) completes the system.

Traditionally, intelligence is related to academic skills, but there are other types of intelligence (e.g.: capacity to relate complex ideas, form abstract concepts, derive logical implications through general rules), which sometimes cannot be measured by conventional tests. In this regard, Primi[9,10] underscores that two types of intelligence are considered fundamental: crystallized intelligence (which prioritizes knowledge) and fluid intelligence (which prioritizes reasoning). The former one refers to the depth of information acquired through formal schooling, and is often used to solve problems similar to those learned through past experience (as in conventional intelligence tests). The latter one refers to the capacity of cognitive processing, that is, general capacity to process information, or to mental operations performed when relative new problems are solved.

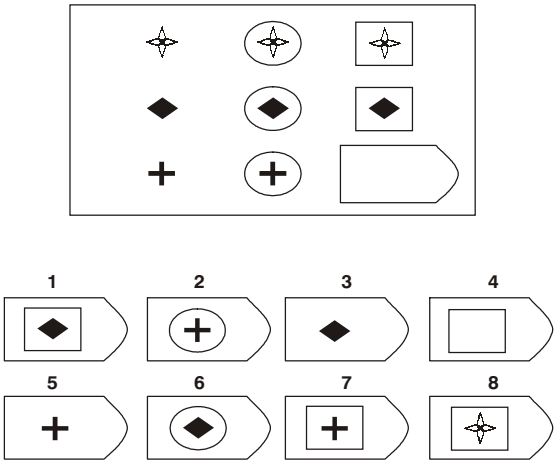

Figure 2 - Raven's progressive matrices

A battery of reasoning tests (BPR-5)[11] for assessing intelligence on a global basis has been standardized to be used in the Brazilian population. These tests estimate the general cognitive functioning and skills in five specific areas: abstract, verbal, spatial, numerical and mechanic reasoning. They help examiners to take decisions based on the assessment of aptitudes and general reasoning, as in the assessment of learning disabilities. The tests are applied to: A) elementary school students (6th to 8th grades) and B) high school students (1st to 3rd grades).

Memory

Here, tests that assess memory functioning are used, such as Rey Auditory Verbal Learning Test (RAVLT) and Rey Visual Design Learning Test (RVDLT).[12] The tests that involve learning, that is, the repeated exposure to the material to be recalled, are more sensitive in detecting memory impairment than tests that are presented only once. The RAVLT (Figure 3) consists in reading a 15-word list to the examinee at a slow pace five times in a row. After each turn, the examinee has to recall the words, without having to follow the same order of presentation.

Wide range assessment of memory and learning – Short form (WRAML)[13] is a psychometric instrument used to evaluate the ability to learn and memorize several types of information (visual memory, verbal learning, story memory) in patients aged between five and 17 years.

Language

The Boston naming test[14] is one of the most widely used tests to assess language. It is designed to measure object naming from line drawings. It is applied to children aged six years or older with difficulty understanding or producing words or written verbal material. Other tests are used, such as the verbal fluency test (FAS), comprehension tests (e.g.: Token test),[15] and text, written and reading comprehension. Assessment also includes the following topics: speech organs, oral habits, and language development.

Some peculiarities have to be respected and taken into consideration when assessing children with brain injuries. It is the health professional's duty to be aware of the aims, skills, and adequacy of techniques and investigative tools to be used, and to know about the possible alterations and restraints that result from brain injury, so that mistakes are not made during neuropsychological screening.

The formal channels of expression and communication with the environment are impaired in many children with

REY AUDITORY VERBAL LEARNING TEST (RAVLT) ***Phase I***

Patient: _____

Age: _____

LIST A	1	2	3	4	5	LIST B	1	LIST A	6	7
DRUM						DESK		DRUM		
CURTAIN						RANGER		CURTAIN		
BELL						BIRD		BELL		
COFFEE						SHOE		COFFEE		
SCHOOL						STOVE		SCHOOL		
PARENT						MOUNTAIN		PARENT		
MOON						GLASSES		MOON		
GARDEN						TOWEL		GARDEN		
HAT						CLOUD		HAT		
FARMER						BOAT		FARMER		
NOSE						LAMB		NOSE		
TURKEY						GUN		TURKEY		
COLOR						PENCIL		COLOR		
HOUSE						CHURCH		HOUSE		
RIVER						FISH		RIVER		
SCORE										

Figure 3 - Rey Auditory Verbal Learning Test (RAVLT)

brain injury. Therefore, the health professional has to create strategies so that the child can communicate, interact, and have a better understanding about what is going on with him/her.

We should help children to show us their potential and communicate using resources that allow them to understand what they are being asked, and to represent (through gestures, mimicry, speech, written expression, or action) what they understand and/or want to do.

Frontal lobes

The interest in frontal lobe functions has been aroused in the last few years. It is in this brain region that most differences between humans and their ancestors are found. Frontal lobes constitute one of the largest brain regions, whose functions remain poorly known, although remarkable data on their activity have been gathered in the last few years. It is now known that the most complex human skills are located in the frontal lobe, such as planning of sequential actions, standardization of social and motor behaviors, part of automatic emotional behavior and memory.

For proper assessment of "frontal" functions (executive functions), it is necessary to know the developmental stages of this structure, that is, its process of maturation, which is particularly important when assessing children. Evaluation of the frontal lobe is usually difficult, since it involves complex and poorly investigated functions. Among the several functions of the frontal lobe are: plasticity, judgment capacity, ability to produce different ideas, organization of information, capacity to give proper responses to stimuli, to establish and change strategies and to plan an action. These abilities may be assessed by the verbal fluency test, drawing fluency, Wisconsin card sort test,[16] trail making test,[17] Stroop test,[18] which evaluate the capacity to keep one's attention focused and not be influenced by answers that are not expected at the moment. On the trail making test, the task in part A (Figure 4) is to link, with a pencil, consecutively numbered circles randomly distributed in a sheet of paper; in part B (Figure 5), besides numbers, there are also printed letters on the answer sheet and the sequence to be linked should alternate between the two series, numbers and letters (1-A, 2-B, 3-C). This task has to be performed as quickly as possible.

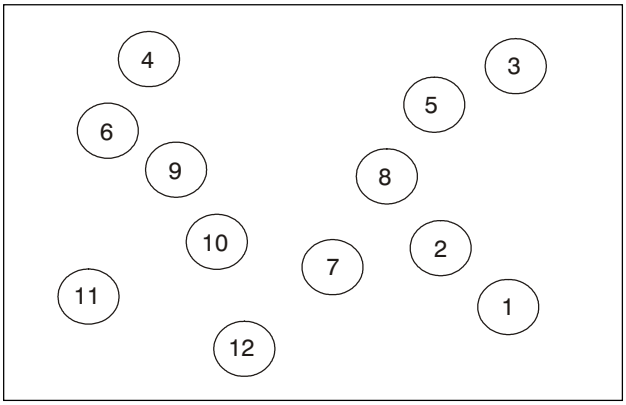

Figure 4 - Trail Part A

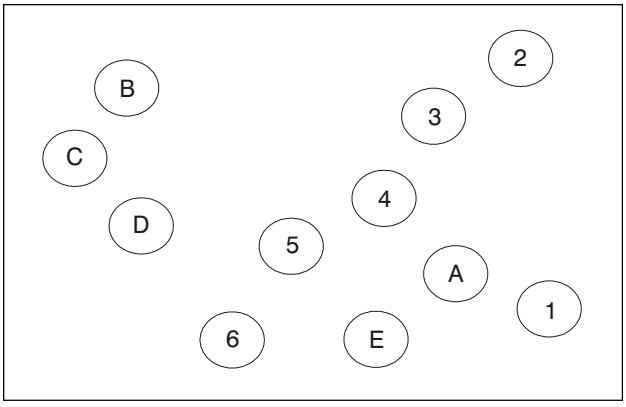

Figure 5 - Trail Part B

The Wisconsin card sorting test (WCST) assesses the executive function of the frontal lobe. It measures the modulation of impulsive answers, direction of behavior, the abilities to develop and maintain a strategy to solve a problem despite changes in contingencies, flexibility, planning, organization, inefficiency of initial conceptualization, and difficulty in finding solutions to every-day problems, as the level of perseveration, which is the continuation/repetition of a topic and the inability to modify it after some time, or repetition of a motor behavior. It may be applied to children aged six years or older.

Various subtests of the Wechsler intelligence scale (WISC III and WPPSI) also help to investigate frontal lobe dysfunctions, such as analogies, comprehension, coding, etc.

Parieto-occipital lobes

Functions related to visuospatial skills, visuospatial organization (perception) and planning are assessed by Rey-Osterrieth complex figure test[19] and perceptual and visuospatial skills on Hooper visual organization test.[20] Rey's figures (Figure 6) aim at evaluating perception and memory, verifying how individuals recognize perceptual data that are shown to them and what has been spontaneously stored in memory. The tests are comprised of two stages: the first one consists in copying the figure, and the second one consists in recalling it after 30 minutes. It may also be assessed through the block design subtest of Wechsler intelligence scale.

Bayley scales of infant development (Bayley II- Bsid-II)

Bayley II[21] is a test to assess the development of children aged between 1 and 42 months. The test is divided into three scales: motor, mental and behavioral, with a performance score for each area. The three areas are considered complementary, each of which has its importance in assessing children.

The mental scale assesses aspects related to cognitive development and communication skills (ability to distinguish shapes, attention, fine motor ability, understanding of instructions, naming, problem solving, social skills).

The motor scale assesses the level of coordination of large muscles (activities such as sitting, standing, walking, climbing up and going down stairs) and fine motor skills (more delicate manipulations with fingers and hands.

The behavioral scale allows assessing qualitative aspects of children's behavior during the testing session, such as attention, understanding instructions, engagement in tasks, emotional control, among others.

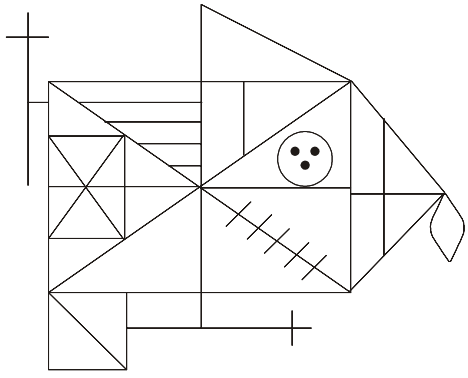

Figure 6 - Rey's Figure

The test material is attractive and easy to be used. There also is the Bayley infant neurodevelopment screener (BINS), which is a simpler version used to evaluate the development of children between three and 24 months, as with Denver II[22].

Result analysis

We have mentioned some of the tests used to evaluate children. We suggest that more than one test be used to assess each function, thus allowing for more reliable neuropsychological conclusions.

It is also important to analyze the patient's whole performance throughout the process in combination with other tests. The contribution of the findings of neurological, neuroimaging, neurophysiological and neuropsychological tests should be interpreted by a multidisciplinary team.

In conclusion, neuropsychologists choose the most suitable evaluation methods based on their experience and specific training, but they should be aware that the tests are not categorical. The interpretation of results requires knowledge about cognitive and affective aspects, as well as about factors that might interfere with a task.

Psychologists interested in this area should be aware of the complexity of each function and of the ways they could be assessed by these tests. This way they can improve their knowledge about brain functions and various central nervous system pathologies. After a quantitative analysis, it is necessary to analyze results qualitatively and investigate the intellectual functions implicated in each of the items of each test, thus establishing a relationship between function or dysfunction and brain area. Only after such detailed analysis it will be possible to contribute recommendations and guidelines to these children's rehabilitation program, corroborating them with clinical investigation.

References

1. Cunha JA, org. Psicodiagnóstico. 4th ed. Porto Alegre: Artes Médicas; 1993.
2. Luria AR. Fundamentos de neuropsicologia. São Paulo: Editora da Universidade de São Paulo; 1981.
3. Antunha EL. Investigação neuropsicológica na infância. Boletim de Psicologia da Sociedade de Psicologia de São Paulo. 1987;37(87):80-102.
4. Thorndike RL, Hagen EP, Sattler JM. The Stanford-Binet Intelligence Scale. 4th ed. Technical Manual. Chicago: Riverside Wechsler; 1986.
5. Wechsler D. Wechsler Preschool and Primary Scale of Intelligence. San Antonio, TX: The Psychological Corporation; 1989.
6. Wechsler D. WISC-III: Escala de Inteligência Wechsler para Crianças - adaptação brasileira da 3ª ed.. São Paulo: Casa do Psicólogo; 2002.
7. Raven JC. Matrizes Progressivas. Escala Geral. Rio de Janeiro: CEPA; 2000.
8. Rodrigues A, Rocha. JMP. Escala Colúmbia de Maturidade Intelectual. Rio de Janeiro: CEPA; 1994.
9. Primi RO, Santos AAA, Vendramini CM, et al. Cognitive abilities and competencies: distinct terms for the same constructs. Psic Teor Pesq. 2001;17(2):151-9.
10. Primi R, Almeida LS. Validity of a battery of reasoning tests (BPR-5). Psic Teor Pesq. 2000;16(2):165-73.
11. Primi R, Almeida LS. Estudo de validação da bateria de provas de raciocínio (BPR-5). Psic Teor Pesq. 2000;16(2):165-73.
12. Wiens A, McMinn MR, Crossen JR. Rey Auditory Verbal Learning Test: development of norms for healthy young adults. Clin Neuropsychol. 1982:67-87.
13. Adams W, Sheslom D. WRAML Manual. Wilmington, DE: Jastak Associates; 1990.
14. Kaplan E, Goodglass H, Weintraub S, editors. Boston Naming Test. Philadelphia: Lee & Febiger; 1983.
15. De Renzi E, Vignolo LA. The Token Test: a sensitive test to detect disturbances in aphasic. Brain. 1962;85:665-78.
16. Heaton RK, Chelune GJ, Talley JL, Kay GG, Curtiss G. Wisconsin Card Sorting test manual: revised and expanded. Odessa: Psychological Assessment Resources; 1993.
17. D'Elia LF, Satz P, Uchiyama CL, White T. Color trail test: professional manual. Odessa: Psychological Assessment Resources; 1996.
18. Trenerry MR, Crosson B, DeBoe J, Leber WR. Stroop Neuropsychological Screening Test Psychological Assessment. Odessa: Psychological Assessment Resources; 1989.
19. Oliveira M, org. Figuras Complexas de Rey - Teste de Cópia e Reprodução de Memória de Figuras Geométricas Complexas - Adaptação Brasileira. São Paulo: Casa do Psicólogo; 1999.
20. Hooper HE. The Hooper Visual Organization test. Beverly Hills, CA: Western Psychological Services; 1958.
21. Bayley N. Bayley Scales of Infant Development. 2nd ed. San Antonio: Psychological Corporation; 1993.
22. Frankenurg WK, et al. Denver II. Denver (CO): Denver Developmental Materials, Inc.; 1996.

Corresponding author:
Mirna Wetters Portuguez
Serviço de Neurologia, Unidade de Neuropsicologia,
Hospital São Lucas da PUCRS
Av. Ipiranga, 6690
CEP 90610-000 - Porto Alegre, RS, Brazil
Tel./Fax: +55 (51) 3339.4936
E-mail: mirna@pucrs.br