Chapter

Neuropsychological Assessment of Children with Learning Disabilities

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Abstract

Learning disabilities are a heterogeneous and common group of disorders that have a relevant impact on children's academic function. The most common learning disorders consist of dyslexia, dyscalculia, dysgraphia or other non-verbal learning disorders. These disorders are commonly associated with neurological or behavioral disorders such as attention-deficit hyperactivity disorders. Understanding of cognitive and mental problems of children with learning disorders is an interesting challenge, and various approaches have been applied for their study, including medical, genetic, educational, epidemiologic and experimental psychologist. Nowadays, clinical neuropsychological approach, which is based on neurocognitive models, is one of the best existing models for description and interpretation of learning disorders. This approach assumes that there is a strong relationship between the various learning deficits and brain functioning. This paper consists of a descriptive review about components of a specialized neuropsychological approach that can be applied for the assessment of children with learning disabilities.

Keywords: learning disabilities, learning deficits, learning disorders, dyslexia, dyscalculia, math disorders, dysgraphia, neuropsychology, neurocognitive model, neuropsychological assessment

1. Introduction

The term Learning Disability means a heterogeneous group of disorders in one or more psychological processes involved in understanding or in using language, do mathematical calculation [1], or deficits in other cognitive functions as attentional or perceptual deficits that can cause particular children learning difficulties [2].

Learning disabilities affect approximately 10% of US children and unfortunately are often unaddressed or incorrectly addressed by schools or family [3].

The most common learning difficulties regard language and consist of an imperfect ability to listen, speak, read, write and spell. Reading and/or spelling disorders are present in 3–11% of children worldwide in particular, combined reading and spelling disorders have a prevalence of 8%, isolated spelling disorders have a prevalence of 7%, while isolated reading disorders have a prevalence of 6% [4].

About 20% of children and adolescents with reading disorders develop emotional disorders, especially anxiety disorders and less frequently depressive or behavioral disorders [5]. Children with reading and spelling disorder, if not

diagnosed and treated, often fail and do not go to school with relevant consequences for professional education and for psychological well-being during adult age [6].

Children with learning problems are generally first identified by teachers for their behavioral disorders, participation behaviors or cognitive difficulties [7].

One of the most common learning disabilities is dyslexia that is a learning disorder characterized by reading problems, a complex cognitive function that requires many abilities that include: letter identification skills, phonological skills (converting letters into sounds), grapheme skills (visual generation of sound on the bases of previous learned sounds), sequencing skills, short-term memory skills to retain information from written material [8].

The evaluation of children with Learning Disorders must consist of a clinical evaluation and a comprehensive assessment of all areas of suspected disability including sensory functions, behavioral and emotional factors, occupational skills, intellectual ability and cognitive functions [9]. A comprehensive evaluation can be conducted by medical doctors, psychologists, social workers, school nurses, speech pathologists, occupational and physical therapists. Child neuro-psychiatrist and developmental-behavioral pediatrician can conduct medical evaluations oriented to identify medical and mental health conditions that could be potentially treated such as primary sensory impairments, primary neuro-psychiatric conditions, or intellectual deficiency. Outside school, it is also important to conduct an evaluation of student's parents for the evaluation of other cultural or socioeconomic conditions that can contribute to learning disorders.

2. General cognitive assessment

It is commonly accepted that neuropsychological assessment is very useful for children with developmental disorders concerning particular learning and attention disorders. According to American Academy of Clinical Neuropsychology, cognitive evaluation helps clinics and therapists to identify how problems with the brain relate to difficulties at school and study neurological and psychiatric disorders. Neuropsychological assessment focuses on identifying if children have a problem with cognitive functions as reading, spelling, or math. Examination of cognitive functions of children with learning disabilities must examine in particular memory, attention, problem-solving functions, math skills and language functions. Cognitive psychologist evaluates these functions using a variety of methods specifically designed to identify why the child has learning or attention problems [10].

Cognitive and neuropsychological evaluations must be as part of a comprehensive assessment of learning disabilities even if only little evidence supports a routine assessment of cognitive functions for children with learning disabilities.

Neuropsychological and modern neuroimaging or neuro-functional studies conducted in particular on individuals with cognitive deficits have demonstrated the existence of neuronal networks so that deficits in specific cognitive functions have characteristic neural substrates [11].

Visual processing deficits are typically associated with abnormalities of occipito-parietal areas [12], while auditory deficits are secondary to dysfunction in temporal lobe areas [13].

Attentional and executive functions deficits are usually explainable by a dysfunction in neuroanatomical subsystems of prefrontal cortex of both hemispheres [14].

Word learning deficits are related with left temporal and in particular, hippocampal dysfunctions [15] while spatial learning and visuospatial deficits are usually associated with lesions of right parietal and occipital cerebral areas [16].

Children with math disorders have a prevalent dysfunction of connectivity in temporo-parietal and parietal areas of the right hemisphere [17], but also in connection between frontotemporal and parietal regions of left hemisphere [18].

Language functions are prevalently lateralized in dominant hemisphere (usually the left), while visuospatial functions are prevalently lateralized in non-dominant hemisphere (usually the right).

Consequently, children with verbal learning disabilities such as difficulties in reading or writing have a prevalent involvement in left hemisphere, while children that show nonverbal learning disabilities such as difficulties in perceptual reasoning or understanding math have a prevalent involvement in right hemisphere.

However, language learning reflects activation of complex neuronal networks: for example, frontal cortex and basal ganglia are relevant in learning phonology and grammar of a new language [19] or hippocampus, temporal lobe and putamen have dysfunction in subjects with dyslexia [20]. Specific cerebellar regions also contribute to cognitive functions in particular in reading development, verbal short-term memory and emotional behavior [21].

Studies on cerebral lateralization of motor functions, especially handedness, show that these appear to be related to the lateralization of language functions [22]. In fact left-handedness has been linked to dyslexia, other language learning disorders and autism.

Therefore, different tools have been successfully employed to assess lateral dominance for the eyes, hands and foot across different behavioral domains such as brushing teeth, cutting a paper, throwing a ball, kicking a ball. An example of one of these instruments suitable for adults is the Harris test of Lateral Dominance [23].

Psychometric assessment is essential for identification of correct cognitive treatments, permitting better treatment planning and interventions that match specific cognitive profiles and can be used as follow-up tool [24].

Examples of neuropsychological tests that can be used for a general cognitive assessment are represented by fixed batteries such as Halstead-Retain Neuropsychological battery [25], the Luria-Nebraska Neuropsychological Battery [26], the Boston process approach [27], Kaufman Assessment Battery for Children [28] or by specialized flexible batteries.

However, psychometric measures have many limitations. Neuropsychological tests are less reliable for identifying learning disorders in younger students (students in first or second degree) than in older since in early grades they do not participate in formal education process [29]. Some school teams compare student's performance using national norms, while others use local norms [30]. Student's performance on a psychometric measure cannot reflect the real performance in the classroom. For example, in a test setting, the evaluator is inclined to speak more slowly and gives more time to assure a correct execution of a psychometric task. Standardized measures test scores to determine presence or absence of a disability are chosen somewhat arbitrarily. The most used cut-offs are two standard deviations below mean standard score or a score below the 25th percentile, considering the average performance score as the 50th percentile [31].

Psychometric tasks not always have diagnostic stability that is the validity of the psychometric measure over time. Estimates of diagnostic stability range between 30 and 70% [32].

3. Visual processing assessment

Visual modalities are the primary bases of most academic learning. Consequently, visual processing must be taken in great consideration during the

assessment of learning disorders. The first step of the assessment consists of ruling out peripheral visual problems. Neuropsychological visuospatial tests have the aim to assess integrity of visual system.

Specialized tests of visual processing are now widely used in clinical setting of children with learning disorders. According to Muriel Lezak [33], the examiner must explore six areas critique in visual perception that are: visual scanning, color perception, visual inattention, visual recognition, visual organization and visual interference.

In particular, visual scanning deficits are associated with cerebral lesions and acquired learning disorders causing deficits in reading, writing, performing calculation and telling time [34]. Other learning disorders associated with visual recognition disorders are: spatial dyslexia and dysgraphia with spatial disturbances [35].

4. Auditory processing assessment

As visual processing, also auditory processing is fundamental to learning.

Non-verbal auditory processing has a possible relationship to non-verbal learning disorders so that it has been described within a framework of non-verbal learning disorder [36]. For example, subjects who have an impairment in interpreting voice intonation or prosody may have non-verbal learning disorders that negatively affect their emotional functioning. Children with socio-emotional processing disorders have been considered by some neuropsychologists as affected by a subtype of learning disorders secondary to right hemisphere dysfunction [37]. Therefore, neuropsychologists must execute a specialized auditory assessment finalized to exclude peripheral and central auditory problems before the general clinical neuropsychological assessment of children with learning disorders.

Examples of neuropsychological instruments that can be used to assess auditory perception in terms of audition acuity, auditory discrimination, auditory inattention, auditory verbal and non-verbal perception are described in Lezak's manual [33].

5. Behavioral and socio-emotional assessment

Learning disorders can have comorbidity with many behavioral, social-emotional and psychiatric conditions. Distinction between cognitive and emotional domain is an unresolved issue in the assessment of children with learning disorders.

There are some evidences that socio-emotional processing deficits related to right hemisphere dysfunction could be considered a subtype of developmental learning disabilities [38].

The assessment of emotional functioning should focus first on psychiatric conditions that could be the primary cause of individual learning problems. During the decision-making process, neuropsychologists should realize an assessment of the mental status of the patient through observation of patient's behavior and use of a clinical interview. In the diagnostic process, neuropsychologist should determine the most relevant diagnosis depending on the background in psychopathology.

Same symptoms, especially behavioral problems, are highly recognizable, while common mental health problems of low mood and anxiety can easily get lost [39].

Psychiatric disorders that must be considered include personality disorders, mood disorders, anxiety disorders, somatoform disorders, thought disorders, dissociative disorders and eating disorders. If there is evidence of presence of a primary psychiatric condition, learning disorder diagnostic process must be delayed until completing a definitive psychiatric diagnostic process.

Antisocial personality disorders and conduct disorder are psychiatric disorders that include aggressive behavior that can causes school dropouts, juvenile delinquents and could be associated with learning disorders. However, different studies conducted on children with learning disorders have not found a clear relationship with antisocial personality disorders [40].

Anxiety, depression and obsessive-compulsive disorders are conditions that can produce behaviors and thoughts disorders; these disorders are often more difficult to recognize and diagnose.

Depression is probably the condition most investigated in children with learning disorders demonstrating that it is rather consistently represented [41].

According to the 'Cerebral Dysfunction Hypothesis' regarding relationship between learning disorders and socio-emotional disorders [42], it asserts that there are the same underlying mechanisms such as constitutional factors, prenatal, perinatal and postnatal factors that can account for both learning development and socio-emotional functioning. This neurobiological hypothesis, based on clinical observation of children, can explain the coexistence of such disorders in many individuals.

Some of the principal assessment approaches commonly used with children consist of investigation of psychiatric symptom severity and relative patterns, analysis of behavioral contingencies affecting behaviors, assessment of ecological interaction between child and outside world and assessment of quality of interaction between child and carers [39].

Psychiatric symptoms and disorders have been embodied in DC-LD (Diagnostic Criteria for psychiatric Disorders for use with adults with learning Disorders) and more recently in DM-ID (Diagnostic Manual of Intellectual Disability), which includes specifically adapted criteria for children and adolescents [43].

There are excellent clinical instruments that can be used for the assessment of emotional disorders, behavioral disorders and for an ecological approach. One of this is the Child and Adolescent Psychiatric Assessment Schedule (ChA-PAS) [44] which consists of a structured interview about children mental health problems. Other general symptom rating scales designed for use in child psychiatry are the Achenbach child behavior checklist [45] and the developmental behavior checklist [46] which is the only behavioral rating scale specifically designed for children with learning disabilities.

6. Intellectual abilities assessment

Intelligence tests are usually part of the assessment of cognitive skills, and the presence of a low Intelligence Quotient (IQ) is commonly a 'red flag' for a possible learning disorder even if IQ scores do not represent the capacity of a child to learn [47].

Neuropsychological assessment of intellectual abilities is useful to document whether there is a discrepancy between IQ and academic achievement and to make a differential diagnosis between learning disorders, mental retardation and other psychiatric conditions.

Most useful for the assessment of learning disorders are the performances in Verbal IQ and Performances IQ scores and the subtest score comparisons rather than the Full-scale IQ.

The so-called 'Verbal-Performance Split', consisting of a significant difference between Verbal and Performance IQ scores, suggests a difference in function between language dominant hemisphere (usually the left hemisphere) and non-language hemisphere (usually the right hemisphere).

It is well documented that the Verbal-Performance split can differentiate unilateral left and right brain damage groups of children even if it is not always indicative of a lateralized cerebral dysfunction in children with learning disorders [48].

Furthermore, according to the theory of multiple intelligences, human qualities such as personality, temperament and character are essential ingredients in achievement and cannot be measured with IQ [49].

Examples of tests to assess children intellectual abilities are: Leiter international Performance Scale [50], Standford-Binet Intelligence scale [51] and Wechsler Intelligence scale for children [52].

7. Attention assessment

Attention is a cognitive function on which depend most of cognitive functions. General attention is the ability to maintain a coherent thought, while selective attention is the ability to focus on a single stimulus to the exclusion of others. General attention is usually assessed in terms of mental status, while selective attention is generally assessed psychometrically and is often present as a symptom of Attention Deficit Hyperactivity Disorder (ADHD) in comorbidity with other learning disorders.

Selective attention is considered a necessary condition for most of school learning, ability to complete assignments, performance and even interpersonal relationship.

Some studies found a strong relationship between reading speed and visual, auditory and tactile reaction times in normal children [53]. Reaction times have resulted slower in particular in dyslexic children [54]. Other researchers found no differences between good and poor readers on a scanning task or a reaction time task, but a difference in overall time required to discern whether a word was one of two or three target words [55] so that they interpreted this finding as implicating long-term memory retrieval processes rather than reaction time.

Examples of neuropsychological tests used for an assessment of attention functions in children are: Conners' continuous performance test [56], Gordon diagnostic system [57], Children paced auditory serial addition test, [58] and test of everyday attention for children [59].

Many computerized tools have also been prepared to assess attention such as the test of variables of attention (TOVA) that is available to assess in particular sustained selective attention [60].

8. Executive functions assessment

Children with learning disabilities have frequent deficits in working memory and processing speed, which are basic cognitive process for executive functions.

Executive functions consist of ability to organize, plan, problem-solve, initiate or inhibit response, be flexible in relation to feedback and self-monitor mental control.

Deficits in executive functions are rather heterogeneous in nature and usually lead to difficulties with time management, organization of activities or losing things.

Children with ADHD have difficulties with some of these mental control functions such as organizational skills, complex problem-solving and self-monitoring [61].

Evaluation of executive functions is an essential moment of neuropsychological assessment to predict how well an individual will perform in a traditional environment.

Examples of tests generally employed to assess prefrontal functioning are: Children's category test [62], Delis-Kaplan executive functioning system [63], go-no go inhibition tasks [64], Stroop color-word interference task [65], Tower of London [66], trail making test part B [25], verbal fluency test [67], Wisconsin card sorting test [68] and controlled oral word test [69]. These measures, in combination with behavioral history and observation of behavior during the execution of the tasks, typically comprise assessment in this cognitive area.

9. Memory assessment

In the history of scientific thinking about memory, for a long time there was the assumption that memory was a unitary and monolithic entity [70].

In the 1960s and 1970s, it started to spread the notion of the existence of two distinct systems called short-term and long-term memory systems. Subsequently, in the 1970s, researchers started to explore multiple long-term memory systems regarding episodic and semantic memory [71].

From 1990s, also short-term memory was considered a multicomponent system consisting of a phonological loop, a visuospatial sketchpad and a central executive system [72].

In groups of children with learning disorders, researchers have often found short-term memory deficits [73] as well as long-term memory deficits [74]. Other researchers argued that children with learning disorders have more difficulties than non-disabled children in acquiring information, but once they have learned it, they do not differ in retaining the information [75].

Traditional memory assessment consists of what is now considered to be the hippocampal declarative memory such as episodes and facts [76] and typically consists of administration of memory testing that assess short-term (e.g., immediate recall of words), long-term (e.g. delayed recall of words or delayed execution of geometric figures) across auditory/verbal and visual/visuospatial modalities. In the assessment of long-term memory, neuropsychologists commonly use subtests of free recall and subtests of recognition with cues.

Most used tests to assess these aspects of memory include: the Wechsler memory scale [77], the California verbal learning test for children [78], children's memory scale [79], test of memory and learning [80], the wide range assessment of memory and learning [81], Rey auditory verbal learning test consisting of immediate and delayed recall of 15 words [82] and the memory condition of the Rey-Osterrieth complex figure drawing test [83]. Each of these tests has age norms and standard scores.

The interpretation of memory tasks in individuals with learning disabilities can be very complex since this function has many relationships with other neuropsychological functions and since memory performance may require language and auditory processing, visual/visuospatial processing and motor abilities. Memory performance is also more difficult to assess in children with associated behavioral disorders or psychiatric conditions.

10. Visuospatial assessment

Visuospatial function involves the ability to discriminate the position of objects in space and is a fundamental ability related in particular to reading function. An

inadequate visual-spatial function can cause difficulties in many cognitive domains such as reading (involving spatial components of some letters such as b, d or p), math abilities (such as misaligning numbers) or handwriting (for example, in putting spaces between words). Deficits in visuospatial functioning can cause impairments in reading (spatial dyslexia) or in using math (spatial dyscalculia).

A deficit in this cognitive domain can cause other problems in school such as difficulties in reading a map, difficulties in assembling tridimensional objects as models or puzzles.

Visuospatial abilities often require integrity of other cognitive functions; for example, a drawing task usually used to assess visuospatial function requires integrity of motor skills than results in activation of both right and left hemispheres. In the years, learning disorders associated with visuospatial disorders have been labeled as non-verbal learning disorders [84], non-verbal perceptual-organization-output disability [85] and right hemisphere deficit syndrome [86]. More recently, these types of non-verbal learning disorders have been shown to be associated with symptoms of ADHD, depression [87] or other socio-emotional disorders [37].

In past years, performances in visual-perception have been extensively studied by using the Bender Gestalt test [88] or the Frosting developmental test of visual perception used to assess visual perceptual performances in children with developmental learning disorders [89].

More recent neuropsychological assessment of visuospatial functioning includes test that explores visual organization such as Hooper visual organization test [90], sensory-perceptual examination [91], test of copying simple or complex geometric figures such as Rey-Osterrieth complex figure test [83], free drawing objects as a clock, tasks of block assembling in two or three dimensions, tasks of puzzles assembling as the ones proposed in Wechsler intelligence scale for children [92].

11. Math abilities assessment

Math disabilities are less understood, and there are only few studies of individuals with math disorders if compared with those with dyslexia. The general terms 'acalculia' and 'discalculia' have been used to describe developmental and learning math disorders in children [93].

Different researchers have suggested the existence of two distinctive subtypes of math disorders in children with learning disabilities that regards children having only math disorders and children having both math, reading and spelling disorders [94]. Some authors hypothesized that children with isolated math disorders had only right hemisphere dysfunction while the combined group had a prevalent left hemisphere dysfunction [94], while a subsequent study replicated only some of these findings since it was not replicated in girls having math only disorders [95].

Errors most frequently found in children with math learning disorders consist of spatial error (such as difficulties in placing numbers in columns), visual errors (such as difficulties in reading arithmetic signs), procedural errors (such as omission or addition of a step of the arithmetical procedure, or application of a learned rule for a procedure to a different one), graph motor errors (as difficulty in forming the appropriate numbers), judgment errors (errors that imply impossible results, such as one in which the result of subtracting is bigger than the numbers being subtracted), memory errors (such as problems in the recall of multiplication tables or arithmetical procedures) and perseverations (such as difficulty in changing from one task to another one) [94].

Batteries used to explore math abilities commonly include some basic psychological and neuropsychological tests directed to assess not only calculation abilities, but

also language, memory, perceptual abilities, concept formation and praxis abilities. Examples of arithmetical tests used are tasks that explore in general abilities to do written or mental arithmetical operations (additions, subtractions, multiplications and divisions) and to solve arithmetical problems.

The WAIS arithmetic subtest [96] is probably the most widely used instrument when testing for calculation abilities in neuropsychology even if it assesses just single aspects of numerical processing and is very difficult to administer to patients with language and memory disorders.

One of the best standardized neuropsychological batteries used to explore math abilities developed by a group of European neuropsychologists is known as EC 301 [97] and consists of subtests that explore: counting abilities, dot enumeration, numbers transcoding, use of arithmetical signs, magnitude comparison, mental calculation, calculation approximations, placing numbers on an analogue line, writing down an operation, written calculation, perceptual quantity estimation, contextual magnitude judgment, numerical knowledge.

Other tests have been proposed as model for testing calculation abilities, as an extension of the EC301 [98].

12. Language assessment

One of the most common learning disorders is dyslexia, which is the term sometimes used interchangeably with reading disorder and is considered a learning disorder related to reading, recognition of words and interpretation of what is seen visually or heard auditory [99].

Neuropsychological studies have shown that there is not a single reading disorder but many different subtypes.

According to Border, there are three subtypes of dyslexia: dysphonetic, dyseidetic and dysphonetic-dyseidetic [100]. The subgroup of individuals with dysphonetic dyslexia is the largest (>60%) and is characterized by disability in developing phonic and word-analysis skills; in fact, they are unable to decode written words or to write them using phonic or sound principles. These individuals recognize the words on the bases of visual patterns but confuse words with similar visual patterns or meanings. The subgroup of individuals with dyseidetic dyslexia is characterized by disability in recognizing words by their visual configuration, but they are able to use phonic skills to read or do a correct spelling. These individuals have difficulty in developing a correct vocabulary and have misreading that involves phonic renditions, or they do misspellings. Finally, the subgroup of individuals with dysphonetic-dyseidetic dyslexia is characterized by individuals that combine both types of deficits and are unable to develop a sight and phonic dictionary; consequently, they are alexic.

Border classification is similar to other classifications, in particular that of Johnson and Myklebust, who divided dyslexic individuals in two subgroups: dyslexic with primary impairment in visual processing and dyslexic with primary impairment in auditory processing [84].

Researchers can discern the subgroup of dyslexia deficit by using screening tests that assess their ability to discriminate between known and unknown words and their ability to recognize words by sight and to recognize words by sound.

Bradley and Bryant have developed an interesting approach initially reading independent that consisted of testing children's ability in sound categorization before they started to read. The task consisted of giving the children three or four words and asking them to pick out the word that did not share a phoneme in common with the others. By using this task, they found that children who were poor

at sound categorization they start lately to read and become backward in reading and spelling [101]. They hypothesized that reading deficiency would be caused by deficiency in phonological awareness. They argued that the initial insensitivity to rhyme and alliterations caused a subsequent reading impairment; in fact, if children initially impaired were given a special training, their reading ability was less impaired. Rutter and Yule highlighted how dyslexia in associated with other cognitive deficits such as disorders in temporal orientation, difficulties in perception of spatial relations, directional confusion, right-left confusion, difficulties in naming colors, difficulties in recognizing the meaning of pictures, inadequate cerebral dominance, bizarre spellings, but it is not clear if these correlations are casual [102]. Vellutino proposed that only a deficit in verbal processing is related to dyslexia, and when verbal components of the tests are removed, there is an improvement in cognitive performances [103].

When studying patients with dyslexia, examiner must study in particular performance on specific *test of left hemisphere function* such as verbal memory, verbal fluency, spelling, reading and arithmetic skills. Neuropsychological assessment of children with learning disorders should offer insight into the abilities sensitive to all areas of brain function. In fact, usually these children are not dyslexic or dyscalculic alone, but have different associated cognitive disorders. Tests should also be able to distinguish individuals with central reading impairments and those who have problems caused by emotional or environmental causes.

Studies conducted using *intelligence quotient test* in dyslexic children show low scores on four tests: arithmetic, coding, information and digit span [104]. This profile was confirmed in many studies and is referred as the ACID profile. Dyslexic children typically have a mean IQ score of about 100 and a mean full-scale IQ that averages about seven points lower than that of control children. ACID profile is typical for dyslexic children over 8, whereas children younger than 8 may often not show deficit in arithmetic and information subscales. This finding suggests that cognitive deficits in older children and adults could be secondary to the underlying impairment that produces dyslexia [105]. Deficits in digit span and coding could be more directly related to underlying impairment that produces dyslexia. Other researchers did not find emerging deficits in arithmetic and information but the impairments they did find were not pronounced, and the groups studied were quite young [106]. Study on dyslexic individuals by using Wechsler intelligence scale for children (WISC) demonstrated that WISC patterns are not useful for the diagnosis of very young children. IQ of dyslexic children is average even if very high scores are not found.

Using the *test of left-right differentiation,* there was not significant differentiation between normal controls and dyslexic children if they were both younger than 8 years. On the contrary, the control children performed better than dyslexic children did after the age of 8 years [105]. Word fluency tests demonstrated that differences between dyslexic and control children did not occur at an age younger than 8 years, too [105]. These results suggest that control health children have increasingly improved fluency performances, while dyslexic children remain almost static. In a neuropsychological study by using composite test batteries using tests sensitive to left and right function and functions of different cerebral lobes, dyslexic children have performance below standard deviation except in test sensitive to frontal lobe (Wisconsin card sorting test) and right parietal function (the Mooney Faces Test) [105]. In the same study, largest differences occurred on tests of verbal IQ, performance IQ, memory quotient, left-right discrimination and word fluency that are test sensitive to the function of parietal lobes and in particular left parietal lobe [105].

Language learning disorders can be associated with attention deficits as happens in ADHD syndrome. Children with ADHD commonly have dyslexia, and children with dyslexia have twice ADHD, so that it is difficult to establish the primarily condition. If ADHD precedes dyslexia, it can accentuate reading difficulty. For this reason, *psychological assessment* should be performed before cognitive assessment.

Examples of neuropsychological tests that can be used for a general language assessment of children are: Boston naming test [107], the comprehensive test of phonological processing [108], expressive vocabulary test [109], Peabody picture vocabulary test [110] and token test for children [111].

Neuropsychological assessment of children with dyslexia or other language learning disorders must also include specific language measures such as word recognition, reading comprehension, reading rate, writing and spelling patterns.

Word recognition consists of the ability to decode words either within a text or inn isolation. An example of a task that explores word recognition of isolated words is word recognition subtest of the wide range achievement test [112].

Reading comprehension consists of the ability to derive a meaning from a printed page. This process requires adequate word recognition, knowledge of semantic and syntactic rules, as well as attentional abilities, memory and motivational states [113]. An example of task to explore children's reading comprehension is the test of word reading efficiency [114].

Reading rate consists of time required for word recognition and reading comprehension. In fact, dyslexic children have been found to be slower than normal riders [115]. Reading comprehension rates can be assessed with instruments as the Reating rate subtest of SDRT [116] and the Nelson Denny reading test [117].

Writing assessment is clinically useful to distinguish writing problems that are language-based from writing problems that are motorically based. Assessment of writing consists of production of writing samples approximately of one or two pages. The analysis of these samples can give information about many functions such as language organization (grammar, semantics and syntax), organization of thinking and other psychological factors (as tangential thoughts, mood disorders, lack of insight).

Finally, combination of *spelling tasks* with words recognition tasks is useful to classify dyslexics in dysphonetic (unable to do a correct spelling, blend letters and syllables), dyseidetic (with a poor vocabulary probably due to problems with word gestalt) or with mixed dyslexia (with both dysphonetic and dyseidetic disorders). Assessment of spelling can be done with specific spelling tests designed to be used for children [118].

13. Conclusions

Learning disabilities cause cognitive difficulties in children that lead to less academic results than expected for individual potentials.

Cognitive assessment of children with learning disabilities and behavioral problems is very complex, but useful procedures have been planned to determine a correct diagnosis and provide modifications and interventions for optimize learning.

Identification of risk factors for learning disabilities, multifactorial evaluations with examination of potential neurologic or genetic conditions associated with learning disorders and correct diagnosing using appropriate neuropsychological tools are useful to formulate an individualized education plan that can prevent dropping out of school, enhance their life and support their families.

Further studies are needed regarding the study of neurocognitive framework and neuropsychological tools for the assessment and definition of neuropsychological profiles of children with learning disorders.

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