Nonverbal learning difficulties in children from a clinical neuropsychological perspective.

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Abstract This study aims to understand non-verbal learning difficulties from the perspective of clinical neuropsychology, where people with this disorder suffer from impaired visual-spatial skills, motor coordination, and social interaction, although their verbal abilities remain intact. Clinical neurological evidence suggests insufficiency of the right parietal lobe, cerebellum and associated neural pathways, affecting visual-spatial processing and nonverbal communication. Neuroimaging studies have supported these hypotheses. The study relied on the descriptive analytical approach toreview the methodology of modern neuropsychological research, where the results of studies that used neuroimaging techniques and neuropsychological tests were analyzed to clarify the neurological foundations of the disorder. The most important findings are the ability to develop more accurate diagnostic and intervention strategies such as improved visual-spatial perception, executive functions, social interaction through neurological training, academic adaptations and effective application of behavioral therapy.

Keywords: Non-verbal learning difficulties, right parietal lobe, visual-spatial perception, neuroimaging, psychotherapeutic management.

1 – Introduction

Nonverbal Learning Disabilities (NVLD) are developmental disorders that affect many cognitive and behavioral aspects of individuals, despite having good or even superior verbal abilities. This disorder is characterized by a clear gap between verbal and nonverbal skills, leading to problems with visual-spatial perception, motor coordination, social interaction, and adaptation to educational and professional environments (Mammarella & Cornoldi, 2014). Although NVLD is not officially listed in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) or the International Classification of Diseases (ICD-11), several neuropsychological studies confirm its existence as a syndrome with distinct patterns of cognitive and behavioral deficiencies. (Cornoldi et al., 2016).

The academic interest in nonverbal learning disabilities is due to research by Byron P. Rourke, who provided a theoretical framework that illustrates the relationship between this disorder and the neural functions of the right lobe of the brain, noting that dysfunction in the processing of nonverbal information significantly affects sensory perception, information regulation, and social interaction (Rourke, 1989). Thus, children with NVLD may have difficulties understanding facial expressions, interpreting vocal tone, reading maps and charts, and may have difficulty learning fine motor skills such as handwriting and tying shoes (Whitaker & Smith, 2018).

Given the importance of this disorder and its impact on academic and social functioning, there is an increasing need for accurate diagnosis and effective intervention strategies aimed at enhancing nonverbal skills and compensating deficiencies in the areas of visual-spatial perception and social interaction. Therefore, this article aims to provide a comprehensive review of non-verbal learning difficulties, starting from their definition and causes, through diagnostic criteria and clinical manifestations, to the most prominent intervention and treatment strategies, based on the latest scientific literature in this field.

2 – Definition of Non-Verbal Learning Disabilities (NVLD)

Nonverbal Learning Disabilities (NVLD) refers to a neurological disorder that mainly affects nonverbal skills such as visual-spatial perception, motor coordination,

executive functions, and social interaction, while verbal skills remain preserved or superior (Cornoldi et al., 2016). Individuals with NVLD show a marked discrepancy between verbal and nonverbal performance, having a good ability to express language and understand written information, but having difficulties interpreting visual cues, grasping social context, and dealing with activities that require complex motor coordination (Whitaker & Smith, 2018).

The first systematic description of this disorder dates back to research by Byron P. Rourke, who developed a neurocognitive model that associates NVLD with dysfunction in the right hemisphere of the brain, leading to difficulties with visual processing, sensory integration, and abstract thinking (Rourke, 1989). According to this model, individuals with NVLD rely primarily on their verbal skills to learn and adapt to their environment, but face difficulties with tasks that require interpreting spatial relationships, understanding facial expressions, or dealing with complex social situations (Mammarella & Cornoldi, 2014).

3 – Basic criteria for NVLD definition

Recent research relies on a set of basic criteria for determining NVLD, including:

- **Gap between verbal and non-verbal skills**: where verbal intelligence is higher than nonverbal intelligence, as shown by the results of intelligence tests such as WISC-V (Wechsler Intelligence Scale for Children) (Peterson et al., 2021).
- **Difficulties with visual-spatial perception**: Individuals experience impaired interpretation of visual shapes, images, and patterns, which affects the ability to read maps, understand charts, and spatial planning (Cornoldi et al., 2016).
- **Social interaction disorders**: People with NVLD find it difficult to understand tone of voice, nonverbal cues, making them appear insensitive to social context or unable to read the emotions of others (Whitaker & Smith, 2018).
- **Poor motor and coordination skills**: These difficulties include poor handwriting, and difficulty learning fine motor skills such as using scissors or tying shoes (Mammarella & Pazzaglia, 2010).

- **Problems with executive functions**: Individuals experience challenges in planning, organization, and time management, which affect academic and professional performance (Semrud-Clikeman et al., 2010).

3.1 – Distinguish between NVLD and other disorders

NVLD may be confused with other disorders such as autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD), due to the overlap of symptoms such as social interaction difficulties and impaired executive organization. However, children with NVLD have normal or superior language ability, while having underlying difficulties with visual processing and abstract thinking, unlike children with autism who show language delays and repetition in stereotypical behaviors. (Peterson et al., 2021).

Based on the above, NVLD can be considered as an independent disorder that requires specialized diagnostic and interventional strategies, due to its significant impact on the academic and social functioning of individuals.

4 – Causes and neural mechanisms of non-verbal learning difficulties (NVLD)

Nonverbal learning disabilities (NVLD) are a complex developmental disorder associated with dysfunction in specific areas of the brain, affecting visual-spatial processing, social interaction, and executive functions. Recent research is based on neuroimaging studies and clinical tests showing how neurogenetic factors contribute to the onset of this disorder (Cornoldi et al., 2016; Peterson et al., 2021).

4.1 – Neural mechanisms of non-verbal learning difficulties

a. Defect in the right hemisphere of the brain

Studies have indicated that individuals with NVLD have impaired functions in the right hemisphere of the brain, which is responsible for visual-spatial processing, sensory integration, and social skills (Rourke, 1989). Functional magnetic resonance imaging (fMRI) results show decreased activity in the right parietal lobe, affecting the ability to interpret visual information, estimate distances, and understand spatial relationships (Whitaker & Smith, 2018).

b. Poor communication between brain regions

Studies show that NVLD may be associated with a communication defect between the right parietal cortex, limbic system and cerebellum, which explains difficulties in social adaptation and emotional regulation (Semrud-Clikeman et al., 2010). In addition, it has been found that there is a deficiency in the white matter connecting these areas, leading to poor integration between sensory and cognitive functions (Mammarella & Pazzaglia, 2010).

c. Weak executive functions

Neurological evidence suggests that Dorsolateral Prefrontal Cortex may be less active in individuals with NVLD, affecting executive functions such as planning, problem solving, and time management (Peterson et al., 2021). This explains why these individuals have difficulty coping with multi-step tasks and in the cognitive flexibility needed to solve new problems.

4.2 – Possible causes of non-verbal learning disabilities

a. Genetic and formative factors

Research suggests that NVLD may have a genetic basis, as children with a family history of learning disorders or executive function problems have been found to be more likely to develop it (Peterson et al., 2021). Genetic factors may also play a role in influencing the development of white matter in the brain, impairing communication between the brain lobes.

b. Neurodevelopmental Factors

- **Early brain injury**: Children with injuries to the right hemisphere of the brain, either before birth, during childbirth or in the early stages of childhood, are more likely to develop NVLD (Rourke, 1989).
- **Exposure to hypoxia**: Lack of oxygen at birth may affect the development of white matter in the brain, leading to impairment in neural connections essential to nonverbal skills (Whitaker & Smith, 2018).

- **Disorders of neurodevelopment**: Some neurological disorders, such as cortical dysplasia, have a negative effect on the right parietal lobe, affecting visual perception and motor coordination (Mammarella & Cornoldi, 2014).

c. Environmental factors

- **Exposure to early environmental** stressors: such as severe stress in childhood or living in an environment that lacks sensory and cognitive stimulation, may affect the development of neural pathways associated with nonverbal cognition (Cornoldi et al., 2016).
- **Exposure to neurotoxins**, such as lead and mercury, may affect brain function, increasing the risk of nonverbal learning disorders (Semrud-Clikeman et al., 2010).

4.3 –The relationship between NVLD and other disorders

NVLD is confused with other disorders such as:

- **Autism Spectrum Disorder** (**ASD**): Both share difficulties in social interaction, but people with NVLD do not exhibit the repetitive and stereotypical behaviors that characterize autism disorder (Peterson et al., 2021).
- **Attention Deficit Hyperactivity Disorder** (**ADHD**): Some people with NVLD show problems with concentration and attention, but the underlying cause is poor visual-spatial processing and not neuroregulatory deficits as in ADHD (Mammarella & Pazzaglia, 2010).

Scientific evidence suggests that nonverbal learning disabilities are caused by a complex interaction between neurological, genetic, and environmental factors. This disorder is associated with dysfunction in the right hemisphere of the brain, which affects visual-spatial skills, motor coordination, and executive functions. Therefore, early diagnosis and therapeutic intervention based on an understanding of these neural mechanisms are essential to help individuals with NVLD adapt and improve their academic and social performance.

5 – Diagnostic criteria for non-verbal learning difficulties

Although NVLD is not formally included in major diagnostic classifications such as the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) or the International Classification of Diseases (ICD-11), researchers have developed criteria based on cognitive neuroscience studies and psychological assessments (Whitaker & Smith, 2018).

a. Basic criteria for diagnosis

According to recent research, NVLD can be determined based on the following criteria (Peterson et al., 2021):

- **Visual-spatial skills deficiencies**
- Difficulty interpreting visual information such as figures, maps, and diagrams.
- Poor estimation of distances and spatial relationships between objects.
- **Impairment in fine motor skills and motor coordination**
- Problems with handwriting, linking letters or shapes.
- Difficulty with tasks that require careful coordination such as tying shoes or using precision instruments.
- **Deficiencies in executive functions and attention**
- Poor planning, task organization, and time management.
- Problems changing strategies according to the situation (poor cognitive flexibility).
- **Difficulties with non-verbal social and communication skills**
- Poor understanding of social cues such as facial expressions and body language.
- Difficulty interpreting the tone of voice and the social context of conversations.
- **Lack of major verbal problems**
- Relatively good performance in reading and writing at the level of words and vocabulary, compared to significant difficulties in visual, spatial and social skills.

5.1 – Assessment tools and psychological tests

A set of standardized tools are used to assess NVLDs, including tests of cognitive abilities, executive functions, visual-spatial skills, and social interaction (Mammarella & Cornoldi, 2014).

a. IQ Tests and Cognitive Measures

- **Wechsler Child Intelligence Scale (WISC-V)**
- Assess the contrast between verbal and nonverbal intelligence.
- People with NVLD often show a significant discrepancy between verbal (high) and nonverbal (low) performance.
- **(Raven's Progressive Matrices)**
- A test that measures visual-spatial reasoning and a child's ability to solve nonverbal problems.

b. Visual-Spatial Perception Tests

- **(Bender Visual-Motor Gestalt Test)**
- Measures the ability to reproduce visual patterns, revealing poor visual-spatial processing.
- **Rey-Osterrieth Complex Figure Test**
- Evaluation of the ability to analyze and reproduce complex forms, which is impaired in people with NVLD.

C. Executive Function and Attention Tests

- **(Tower of London Test)**
- Measures planning, organization, and problem-solving skills.
- **Stroop Test**
- Assess an individual's ability to control automatic responses and switch between different tasks.

d. Social and communication skills tests

- **Social Responsiveness Scale (SRS)**
- Used to distinguish difficulties understanding social cues, which are evident in NVLD but less severe than autism.
- **Vineland Adaptive Behavior Scales (VABS)**

- Assess daily living and social skills.

5.2 – Differential diagnosis of non-verbal learning difficulties

NVLD diagnosis is a multidimensional process that requires careful assessment of visual-spatial abilities, executive functions, and social skills. Although NVLD is not formally listed in DSM-5 or ICD-11, research suggests that there are specific criteria that can be relied upon to distinguish it from similar disorders. Early assessment using tests of intelligence, executive functions, and social skills is essential to develop appropriate treatment strategies that help individuals. Sufferers better adapt to their academic and social environment.

6 – Intervention and treatment strategies for non-verbal learning disabilities (NVLD)

Nonverbal learning difficulties (NVLD) are a major challenge for individuals with NVLD, affecting their visual-spatial skills, executive functions, and social communication. Since NVLD is not officially classified in major diagnostic guides such as DSM-5 and ICD-11, intervention strategies rely on a multidimensional model that combines behavioral-cognitive therapy, educational support programs, social skills training, and enhanced executive functions. (Cornoldi & Mammarella, 2016; Peterson et al., 2021).

6.1 – Educational and academic interventions

Academic interventions aim to improve educational performance and enhance students' ability to deal with visual-spatial, planning and organizational challenges (Mammarella & Cornoldi, 2014). These interventions include :

a. Curriculum Adaptation

- Use verbal and written means instead of graphs and mind maps to compensate for poor visual processing.
- Break down information into small steps while providing clear and sequential instructions.
- Use written timelines to organize daily tasks.

b. Specialized Learning Strategies

- **Verbal-based teaching techniques**: Reinforce learning using verbal explanations, rather than relying on visual cues alone.
- **Motor support-based education**: The use of motor activities to enhance visual-spatial perception, such as drawing or sensory activities.
- **Repetition and structured practice**: Repeating activities to help the child develop nonverbal problem-solving strategies.

c. Use of assistive technology

- Organizational apps like Google Calendar and Notion to help students manage time.
- Text reading software such as Read&Write to improve reading comprehension skills.
- Interactive programs to train spatial skills such as Tetris and pattern analysis.

6.2 – Psychological and behavioral interventions

a. Cognitive Behavioral Therapy (CBT)

Cognitive behavioral therapy (**CBT**) is used to help individuals develop strategies to address the challenges associated with social interaction and self-regulation (Whitaker & Smith, 2018). Treatment focuses on :

- Promote self-awareness and analyze factors that influence behaviors.
- Develop strategies for dealing with social anxiety and difficulty understanding nonverbal cues.
- Improve the ability to plan and make decisions through cognitive restructuring techniques.

b. Play therapy and social interaction therapy

- Play therapy helps improve fine motor skills and develop the ability to deal with spatial problems.
- Social interaction therapy enhances the ability to understand social cues and nonverbal communication.

c. Support to executive functions

Executive training is an essential part of therapy and includes:

- **Working memory exercises** to improve planning and organization.
- **Training in solving problems** using real-life scenarios.
- **Time management exercises** using techniques such as dividing tasks into smaller parts.

6.3 – Social skills training

a. Social Skills Development Programs

These programs aim to improve the ability to communicate and interact with others (Peterson et al., 2021):

- **Role-playing**: Training individuals to understand nonverbal cues such as facial expressions and body language.
- **Guided interaction**: Organize group sessions for children to help them develop social skills.
- **Video Modeling**: Use videos that demonstrate the right social interactions.

b. Training in understanding non-verbal signals

- Teach individuals how to analyze tone of voice and facial expressions in social situations.
- Develop the ability to perceive personal distances while interacting with others.

6.4 – Motor interventions and occupational therapy

a. Improve fine motor skills

- **Handwriting exercises**: Use techniques such as writing on lined paper or using pens with a comfortable grip.
- **Fine motor activities**: such as the use of manual paste (pate a modeler) or jigsaw games. (Puzzle)

b. Physiotherapy and Occupational Therapy

- Train individuals to improve balance and motor coordination.
- Specialized programs to improve mobility within different environments.

6.5 – Family support and guidance for parents

a. Family Support Strategies

- Provide parents with tools to help their children organize time and manage daily tasks.
- Enhance family communication skills to understand the child's needs and provide appropriate emotional support.

b. Training in the use of positive reinforcement

- Reward positive behaviors to motivate the child to develop his skills.
- Avoid harsh punishment that may lead to low self-confidence.

Nonverbal Learning Disabilities (NVLD) intervention strategies require a holistic approach that combines academic support, social skills training, psychological and behavioral interventions, and enhanced executive functions. It is essential to adapt educational and therapeutic programs to each individual's needs to ensure that the interventions are maximized. The involvement of the family and school in providing a supportive environment contributes to improving the quality of life for individuals with NVLD.

7 – conclusion

Nonverbal learning difficulties (NVLD) are a neurodevelopmental disorder that affects visual-spatial skills, motor coordination, social interaction, and executive functions, while maintaining verbal functioning. From a neurological perspective, NVLD is associated with dysfunction in the structure and functions of brain regions responsible for nonverbal processing, especially the right parietal lobe, cerebellum, and neural pathways that connect them.

- **Right parietal lobe**: plays a crucial role in the processing of visual-spatial information, and research shows that its impaired activity is associated with difficulties in spatial orientation, interpretation of nonverbal signals, and motor coordination.
- **Interlobes Connection**: Imbalance in the connections between the parietal cortex and the frontal lobe is responsible for poor planning, attention, and executive functions, affecting the management of daily tasks and decision-making.
- **Cerebellum**: The cerebellum is associated not only with movement, but also with cognitive processes, as its impairment leads to deficiencies in motor coordination and the ability to learn through experience and social interaction.
- **Imbalances in neural communication**: Recent studies using functional magnetic resonance imaging (fMRI) show reduced activity in the white matter that connects brain regions responsible for nonverbal processing, limiting individuals' ability to integrate visual, motor and social information.
- **The impact of these neurological disorders on cognitive and behavioral performance**

a. **Poor visual-spatial perception**: Difficulty understanding the relationships between objects in space, affecting mathematics, reading, and navigation in the environment.

b. **Limitations in motor learning**: such as poor handwriting, balance, and fine motor skills.

c. **Problems with executive functions**: poor planning, time management, and information organization.

d. **Social interaction**: Difficulty understanding facial expressions and body language, leading to problems with social communication and interpersonal relationships.

Neurological studies suggest that NVLD is not just an academic difficulty, but a disorder caused by a defect in the integration of information across brain regions. Understanding the neurological underpinnings of this disorder helps develop more accurate diagnostic and intervention strategies, such as rehabilitation programs aimed

at improving visual-spatial perception, executive functions, and social interaction through neurological training, academic adaptations, and behavioral therapy.

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