Measurement of kinesthetic sense in dyslexic children before and after proprioceptive treatment

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Introduction

Developmental Dyslexia: A disorder in learning to read that occurs, in the absence of sensory or neurological disorders and despite normal intelligence, adequate schooling, and sufficient sociocultural opportunities[1]. The etiology is unknown. It is often accompanied by motor and attentional disorders. Measured in the laboratory, proprioceptive dysfunction separates dyslexics from normal readers and correlates with the degree of dyslexia[2].

Proprioceptive Dysfunction Syndrome (PDS): Described in 1979 by Martins da Cunha as Postural Deficiency Syndrome, it's characterized by the association of motor control, spatial and multi-sensory integration disorders. The presence of PDS is constant in dyslexic children[3].

Kinesthesia: A form of sensitivity that, independently of sight and touch, provides specific information about the position and movements of different parts of the body. It is based on complex neurological mechanisms involving mainly proprioception and efference copyi. Although it is routinely measured in the laboratory, there is currently no clinical test that can be used to assess it in a simple and reproducible way in children.

Hypothesis

1. The use of a kinesthetic sense measure validated in adults[4] makes it possible to recognize a population of dyslexic children from a population of normal readers.

2. Proprioceptive treatment improves kinesthetic sense in a group of dyslexic children versus a group of untreated dyslexic children.

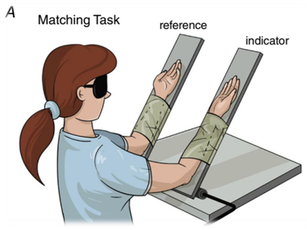
Material and Method

Kinesthetic sense is tested in two ways (Proske[4]) in :

1. A group of 50 dyslexic children compared to a group of 30 normal-readers children (mean age 9 years; 34 girls and 46 boys)
2. A group of 70 dyslexic children who received proprioceptive treatment including:
   - 47 children with good motor control and visual spatial localization (Maddox Perceptual test),
   - 23 children with no more muscular or spatial disorders and with normalized multi-sensory integration.

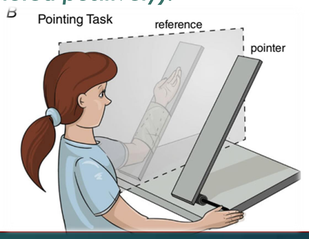
All children are right-handed.

Standardized reading tests (ODEDYS & ELFE[5]) were used to verify the reading level of dyslexics and normal readers. Forearm and pointer angles are measured with inclinometers located on the top of each paddle. The hinges are collinear with the elbow joint.



Matching task (Fig. A). *Child seated, blindfolded, forearms attached to movable paddles by Velcro straps placed just below the wrist, palms up. With the arm bent at 90°, the subject performs an isometric contraction of the biceps at approximately 50% of its maximum strength. The left arm - reference arm - is passively bent at an angle between 40° and 50° and actively maintained by the subject in this position. The child must then actively lower the right arm - the indicator arm - at a very slow speed, in order to bring it to the same level as the reference arm. The same technique is used in flexion, preceded this time by an isometric contraction of the triceps. The 2 manipulations are repeated 5 times in a row. (If the arm actively mobilized by the subject (right arm) stops higher than the reference arm (higher angle), the inter-arm distance is noted negatively. Finally, if the active arm stopped lower (lower angle) than the reference arm is noted positively).*

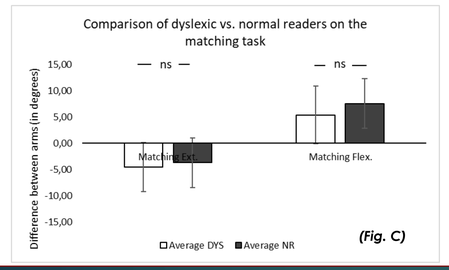
2. Pointing task (Fig. B). *The two arms are separated by a screen hiding the reference arm which is attached to the planchette as in 1. Its position being adjusted by the experimenter and actively maintained by the child. The experimenter moves the paddle visible to the child until the child reports that the angle of the paddle corresponds to the angle felt at the reference arm.*



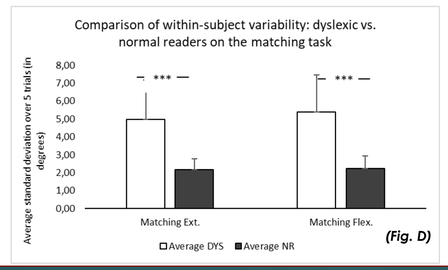
Results

Comparison between dyslexic group and normal reader group.

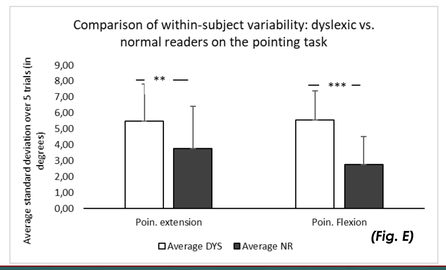
- Comparison of the means of inter-arm deviations (in degrees) between dyslexic and normo-reading subjects showed no significant difference on either the matching (Fig. C) or the pointing (not shown) tasks. On the other hand, when measuring variability within trials of the same subject (standard deviation), there was a significant intergroup difference($p < 0.001$) between dyslexic and normo-reading subjects on the matching and pointing tasks (Fig. D and Fig. E).



(Fig. C)

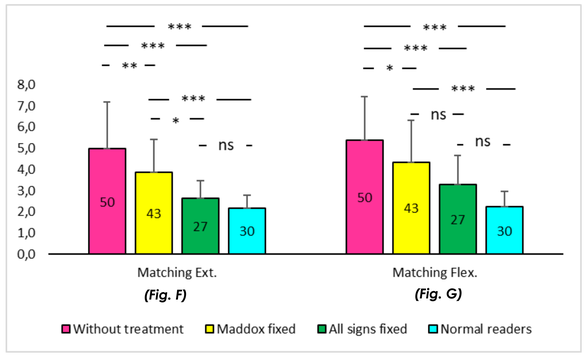


(Fig. D)



(Fig. E)

Effects of proprioceptive processing on the kinesthetic sense.



(Fig. F) *(Fig. G)*

The group of dyslexic children was subdivided into two subgroups according to whether motor control and visual spatial localization (Maddox Perceptual test) were adjusted or whether a normalization of multisensory integration tests (effect of sound on vision) was added. A significant reduction in variability was observed as the treatment progressed, until there was no longer any significant difference with the group of normal-readers. This effect appears for both tasks (Fig. F and Fig. G).

Discussion

Dyslexic and normal-readers children differ significantly in the variability of responses on 5 successive trials. This variability is reminiscent of the lability that has been demonstrated in spatial tests and tests of interference between proprioception, hearing and vision in dyslexic children [6,7]. The clinical test proposed by Proske for the measurement of kinesthetic sense is reliable and easy to perform in children. A study on a larger number of cases could allow the establishment of an index of variability of kinesthetic "acuity" from the study of standard deviations during several successive trials. It could serve as a potential indicator of the presence of dyslexic disorders and justify to begin a diagnostic workup exploring the child's reading abilities. This index could also serve as a control of effectiveness during proprioceptive management.

*Bibliography : **1 :** Definition of Dyslexia. (2002). International Dyslexia Association. Available from: https://dyslexiaida.org/definition-of-dyslexia/ (consult on 13/03/2023) **2 :** Laprevotte J, Papaxanthis C, Saltarelli S, Quercia P, Gaveau J. Movement detection thresholds reveal proprioceptive impairments in developmental dyslexia. Sci Rep. (2021) Jan 11;11(1):299 **3 :** Pozzo T, Vernet P, Creuzot-Garcher C, Robichon F, Bron A, Quercia P. Static postural control in children with developmental dyslexia. Neurosci Lett. (2006) Aug 7;403(3):211-5. **4 :** Proske U, Gandevia SC. Kinesthetic senses. Compr. Physiol. (2018) 8:1157–1183. **5 :** ODEDYS. (2008). Available from : www.cognisciences.com/IMG/ODEDYS2-ELFEpresentationgene (consult on 13/03/2023) **6 :** Quercia P, Quercia M, Feiss LJ, Allaert F. The distinctive vertical heterophoria of dyslexics. Clin Ophthalmol. (2015) Sep 25 ;9 :1785-97. **7** : Quercia P, Pozzo T, Marino A, Guillemant AL, Cappe C, Gueugneau N. Children with Dyslexia Have Altered Cross-Modal Processing Linked to Binocular Fusion. A Pilot Study. Clin Ophthalmol. (2020) Feb 13;14:437-448.*