Acquired Spatial Dyslexia: Latest updates, treatment plans, and clinical data

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Abstract

Acquired Spatial Dyslexia (ASD) is a reading disorder that manifests following a brain lesion. In this review article, we discuss the latest updates regarding clinical manifestations, assessment, classification, management and treatment modalities. This is meant to serve as a 'go-to' article to experts managing individuals who present with ASD as opposed to reviewing the plethora of research published.

Keywords: Dyslexia; Attention; Reading Disorder; Neuropsychiatry; Neurology; Neurosurgery; Alexia

Introduction, Clinical Presentation + Types of Dyslexia:

Reading is a complicated skill that involves complex and simultaneous phonological, semantic, cognitive, executive function, and orthographic processes (1–3). It is an intricate component of what connects us as a species, one of our essential forms of communication – language. Issues of communication rise when language is impaired in any way, shape, or form. Language is said to be impaired when (4):

1) Speech is not produced and/or comprehended at appropriate levels,
2) Objects are not identified correctly, or
3) Difficulty in reading text manifests

In the late 19th century, work by Dejerine articulated differences between alexia and agraphia (with or without alexia) (5,6). This marked a significant breakthrough in our understanding of the nature of these

disorders. More recently, in the late 20th century, an improved classification of dyslexias was articulated (7). Marshall and Newcombe (8), included in their work acquired deep dyslexia and acquired surface dyslexia as reading disorders. Later on, visual dyslexia was introduced into the classification (9). Dyslexias are classified into:

1) Peripheral Dyslexias, and
2) Central Dyslexias

The typical presentation in peripheral dyslexia is for an individual to suffer from impaired reading, whilst all other language components (with the exception of retrieving) remain intact (10). In 2014, it was argued by Behrmann and Plaut (11) that pure alexia (a subtype of peripheral dyslexia), in addition to its effect on word recognition, may manifest in issues related to recognition of faces. Neglect dyslexia, another subtype of peripheral dyslexia, characterized by attentional deficits, usually occurs following an insult to the right hemisphere (12–15). The third, and final, subtype of peripheral dyslexia is attentional dyslexia. This is where reading is impaired if more than one word is tasked to the reader; it is hypothesized that this issue is the result of a hindered attenuating filter control mechanism. (16–19)

Central dyslexias are described as aphasia-related reading impairments, classified into: a) surface dyslexia, b) deep dyslexia, and c) phonological dyslexia (7); they seem to be the result of an issue in the connection between linguistic processing and processing of visual input (20).

Surface dyslexia manifests in the impaired ability to read words whose pronunciation and written form are not aligned (G2P conversion), whilst functioning in a normal pattern in regards to 'regular' words and pseudowords (21).

A characteristic feature of deep dyslexia is semantic substitution (8,22). Furthermore, individuals suffering from deep dyslexia read, in order from most reliable to least reliable: nouns, adjectives, adverbs, and verbs (4,23).

Phonological dyslexia is associated with issues regarding language components (24), with a differentiating factor from deep dyslexia being the presence of semantic paralexia (4). In 1996, Friedman (25) raised the argument that deep dyslexia and phonological dyslexia exist in a continuum. However, a simple differentiation between the two is by remembering that in phonological dyslexia, a lexicality effect manifests (26).

Spatial dyslexia is assessed in 3 ways, those being (27):

1) Reading text
2) Single word/non-word reading
3) Tachistoscopic presentation of words

Moreover, multiple neglect and cognitive symptoms manifest. These include (28):

i) Personal Neglect
ii) Peripersonal Neglect

iii) Extrapersonal Neglect
iv) Motor Neglect
v) Perceptual Neglect
vi) Disturbances in visual awareness
vii) Attention disorders
viii) Disorders of spatial cognition

The most-commonly discussed form of spatial dyslexia is neglect dyslexia presenting in context of unilateral spatial neglect (29), defined as a neuropsychological disorder in which patients manifest failure in identification of objects and/or movement execution in the side contralateral to the lesion (28,30,31). Individuals suffering from unilateral spatial neglect following lesions of the right posterior aspect of the brain commit 'left-sided' errors during reading of text, these errors are visual in nature and occur irrespective of phonics (32–34). The order or errors seems to be as follows: 1) substitution of letters, 2) omission of letters, 3) inversion of letters, and, finally, 4) addition of letters (35–38). Neglect dyslexia in the context of unilateral spatial dyslexia has been shown to present with omission and mistakes in reading of words during assessment (39,40).

Errors of neglect seem to occur more frequently in assignments that contain literary elements that are not words whilst reading out loud (27,41–43). Examples of such assignments are when a line is presented under a letter string and the participant is asked to bisect said line (44). Another example would be to compare letter strings located above one another (45). Published data clearly indicates a higher prevalence of non-word neglect errors as opposed to word neglect errors (46).

This effect of 'superiority of words in ND' (27) has been illustrated in the use of compound words (47,48) and 'irreversible binomial forms' such as hit-and-run (27,49).

Research Methodology:

The above-mentioned keywords were entered into a number of online search engines (Google, Google Scholar, PubMed, ResearchGate, etc..) where they resulted in a plethora of articles. All of these that could be downloaded (some were inaccessible to the authors) were downloaded. First, duplicates were removed, after which articles which were found to be irrelevant were excluded, then articles published in 'predatory journals' were excluded, and, finally, all articles which proved to be unusable in this project were excluded.

Following this, the articles at hand were investigated thoroughly and read. The data they possessed is presented here in this article.

Pathophysiology

A number of areas exist within the brain that function in language production and comprehension (50,51). Ergo, it is logical to assume that insults to these areas result in issues with language manifesting.

Acquired spatial dyslexia, similarly to other linguistic disorders is associated with damage to the left hemisphere of the brain (4).

Lesions/insults of the posterior left hemisphere of the brain (52–55) – and, as can be deducted, the right hemisphere (56) – may, and often times do, result in reading disorders.

Surface dyslexia comes to be as the result of insults to the temporal lobe (57).

Phonological and deep dyslexias come to be through insult to the fronto-temporo-parietal areas of the left hemisphere; it seems as if greater insult manifests in deeper (more severe) dyslexia. (24)

Data from a study by Daini and colleagues (28) suggests that reading omissions can be attributed to an 'exploratory deficit', while substitutions may be a result of a perceptual integration deficit.

The above-mentioned finding (neglect errors being more prevalent in non-words as opposed to words) can be explained by the 'top-down facilitation of lexical knowledge on the processing of letters ''degraded'' by neglect' (27). This can be supported by the notion that non-words require, to be identified, more spatial attention compared to words and the letters that make it up (58).

The complex variety in clinical presentations suggests multiple mechanisms, despite published literature suggesting otherwise. (28)

Individuals presenting with substitution errors seem to have fewer overall errors and are 'more sensitive to the lexical status of the string' (28,59).

The mechanism by which behavioral deficits and substitution errors come to be seems to be the same, with presentation depending on the severity of the insult (59–61). A 2005 study (62) disputes this hypothesis, however, as it reports the case of an individual whose clinical presentation was atypical of the aforementioned.

This gave rise to discussion on the topic, and in 2011, a dual mechanism hypothesis was made by Martelli and colleagues (63) in which they discussed different mechanisms for substitution and omission errors. This dual method, whilst presenting an explanation, does not explain why only a few individuals with USN develop reading errors (28). They elaborated the *crowding* phenomenon (64–67) in discussing how these errors come to be.

A 2013 study raised the hypothesis that ND is the manifestation of exploratory deficit of USN (68).

Usually, it is expected that impaired speech immediately equates to impaired reading and vice versa. However, that is not always the case. Data reported by Bishop and colleagues (69) illustrated poor language in children did not immediately equate to impaired reading.

Epidemiology

Generally speaking, around 30% of individuals suffering from a stroke will suffer from some impairments regarding speech processing/language (70,71). USN occurs in 40-80% of patients suffering from acute strokes (72). Neglect dyslexia and other spatial defects occur in 40% of patients suffering from USN (73).

Treatment

A difference in results manifests when different sensory and cognitive therapies are used (74–76)

It seems as if text-level (and possibly word-level) omissions can be significantly improved via optokinetic stimulation (77). The same technique, however, does not seem to possess an effect on 'stimulus-centered reading errors' (77).

Overall, published data indicates selective training in addressing explorative symptoms as well as the combination of top-down techniques with a focus on strategies that address the neglected space and bottom-up techniques that addresses the issue of space representation – with the most recommended trainings techniques being visuo-spatial orientation training and prism adaptation (28,72,78,79)

Despite prism adaptation seeming to have an overall positive effect on individuals suffering, there were certain aspects in which no effect was found:

1) Perceptual Tasks (80)
2) Chimeric face perception (81)
3) Estimation of object sizes (82)
4) Haptic Perception (83)

Data indicates that increased spacing between letters resulted in a reduction of substitution errors, but resulted in an increase in omission errors (84)

Individuals suffering from insults to the left hemisphere seem to recover quicker than those suffering from insults to the right hemisphere (85), this further strengthens the argument for increased plasticity in language function centers of the left hemisphere (86). With the mostly improved areas being processing speed, verbal memory, and visuoconstructive skills (87).

A plethora of factors exists to determine the duration of recovery post-injury, these range from the individual's demographic data, their past medical history, the extent of injury and the specific effect it had on said individual, whether they are provided access to rehabilitation, and much more (4,88–92).

Of course, all causative agents (stroke, TIA, cerebral insult, TBI, etc.) must be addressed.

Author's contributions:

All authors equally contributed to the writing and editing of this article

Conflicts of interest:

The authors hereby declare no conflict of interest

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