LATERALIZATION OF VISUOSPATIAL ATTENTION IN CHILDREN WITH ADHD

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Abstract: The aim of this paper was to perform a review of the literature on the phenomenon of visuospatial attention and its lateralization in normal subjects and in subjects with ADHD. Moreover, we will discuss the phenomenon known as "pseudoneglect" which refers to the leftward bias in visuospatial attention in healthy samples, possibly as a consequence of right hemisphere dominance for visuospatial attention. The degree of such a lateralized visuospatial attention bias is often assessed using the line bisection task.

Keywords: isuospatial attention, lateralization, ADHD.

Introduction

Lateralization of cognitive functions between right and left hemisphere is known to be a significant feature of human brain [19]. It is known that cortical networks of the right hemisphere play a predominant role in visuospatial attention, so that right hemisphere lesions often induce visuospatial neglect, which is characterized by failure of awareness of stimuli presented on contralesional side of space [14].

Visuo-spatial attention is orienting to locations in visual space [27]. The observed asymmetry in visuospatial attention has long been related to right-hemisphere specialization in the mediation of spatial attention; however, the underlying mechanisms of asymmetry have not been elucidated yet [11,23].

One leading model proposes that the right-hemisphere modulates attention within both left and right hemifields, whereas the left-hemisphere would be directed solely toward the right hemifield [7, 8, 11, 23].

The asymmetry of human spatial attention is well documented in both non-healthy and healthy states: right-hemisphere lesions are more frequently associated with hemispatial neglect compared with left-hemisphere lesions and usually cause more severe and persistent deficits [36]; moreover, a leftward bias in the perception, termed right "pseudoneglect," is frequently reported in healthy subjects [26].

Line-bisection performance in neurologically healthy subjects

Pseudoneglect was first documented by Bowers &Heilman [3]. It represents a visuospatial bias in favour of the left side of space displayed by the majority of neurologically normal people. Neurologically, pseudoneglect is posited to arise from anatomical and functional asymmetries of the brain networks subserving visuospatial attention [7, 8]. Lateralization of cognitive functions in the human brain is well established and is thought to facilitate optimal information processing [6].

An important meta-analytic review of pseudoneglect [16] has showed that pseudoneglect can be modulated by a number of variables, such as sex, handedness, hand use and direction of motor scanning [33].

According a traditional and popular theory of neglect it is postulated that the right hemisphere controls goal-directed attention to both sides of space, while the left hemisphere only controls attention to the right side of space. According to this theory, damage to the right hemisphere is associated with more severe spatial attention impairments (as the left cannot compensate), whereas after left hemisphere damage the right hemisphere is able to successfully compensate (i.e., attend to both sides of space) [21].

A classic theory of neglect emphasizes the importance of balanced interhemispheric activation in goal-directed spatial attention. The resulting imbalance in attention is thought to result from relative hyperexcitation of the intact hemisphere due to release of inhibition from the damaged, hypoactive hemisphere [7, 8].

Several neuropsychological methods have been used to measure hemispheric functioning and lateralization, including line bisection and cancellation tasks [8, 9, 48]. During the Line Bisection task, the patient is asked to place a pencil mark at the center of a series of horizontal lines that may vary by length, thickness, justification, orientation, and vertical placement. Displacement of the bisection mark toward the side of the brain lesion is interpreted as a symptom of neglect referred to as perceptual neglect [4, 10, 24].

A meta-analysis of line bisection studies by Jewell and McCourt [16] found that healthy controls, when presented with horizontal lines, show evidence of pseudo-neglect, a slight but significant leftward bias, in their bisections; however, the extent of this bias is dependent both on handedness and the hand used. Bisections made using the left hand were farther to the left of center than were bisections made using the right hand [16].

Line-bisection performance in subjects with ADHD

Moreover, there is evidence that abnormal brain lateralization might be a core component underlying dysfunctions in ADHD [12, 13]. At the structural and neuroimaging level, studies have reported atypical right hemisphere structure [32] in particular, smaller size of right frontal and prefrontal cortex were found in subjects with ADHD. Atypical right hemisphere structure may affect attentional processing and response inhibition [30].

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by three main features – inattention, hyperactivity, and impulsivity(American Psychiatric Association, 2000), and is often accompanied by behavioral, emotional, or learning problems [5] ADHD is estimated to affect about 3-5% of the school-age population.

. The American Psychiatric Association recently published in 2013 DSM-V, the first major revision to the diagnostic manual for psychiatric disorders since 1994. In DSM-V [2], ADHD is included in the section on Neurodevelopmental Disorders, rather than being grouped with the disruptive behavior disorders. In DSM-V there are three categories referred to as combined presentation, predominantly inattentive presentation, and predominantly hyperactive-impulsive presentation. ADHD-I type has problems in sustained and selective that indicate the decrease of fronto-striatal networks and parietal lobe’s activation. The deficit has been shown in right cortical regions (prefrontal, parietal) and subcortical regions (straiatal, thalamic) as well.

The clinical features of these deficits are shown through pathological bias in visuospatial attention. However, recent imaging and behavioral studies indicate that the disorder may more accurately include two subtypes: ADHD- Inattentive type (ADHD-I) and ADHD-Combined type (ADHD-C), integrating the Hyperactive-Impulsive and Combined types [5, 33]. These with ADHD-C are also at an increased risk (two to three times higher) for aggressive and antisocial behavior over those with ADHD-I [20].

In subjects with ADHD, the normal asymmetrical development seems to be disturbed concerning the prefrontal anatomic lateralization, with lack of the normal increase in the right-sided prefrontal cortex [28]. There are several studies in this field that have exhibited a relation between ADHD and reduction of awareness for visual stimulations in leftside of the space [31]. A recent publication confirms reduced frontal cortical thickness in children, adolescents and adults with ADHD compared to healthy controls [1].

However, evidence is growing to support the idea that it is mainly the right hemisphere in individuals with ADHD (with no differentiation between subtype) that is dysfunctional [14,15], which is partially based on the observations that the symptoms of ADHD are similar to those seen in patients with acquired right hemisphere lesions [24]. Other studies have reported abnormalities in the left hemisphere; in particular, slightly greater left posterior cingulate cortex that relates to memory, emotions, and motivation by reward, and is involved in both the dorsal attentional network, and the fronto-parietal control network for executive motor control [21, 22, 34].

In conclusion, as we can see from the studies noted, pseudoneglect is an interesting phenomenon and deserving of significantly more attention in the field of cognitive science. Typically developing children showed a symmetrical neglect that means a leftward bias with left hand use and a rightward bias when the right hand was used to bisect horizontal lines, consistent with other studies investigating children with the line bisection paradigm [29].Moreover, the results of previous studies approve an overall rightward bias in line bisection in children diagnosed with ADHD. Sheppard and colleagues suggested that the rightward bias noted in children with ADHD (without any medication) resulted because these children had a reduced ability to direct attention to the left side of space, consistent with the right hemisphere dysfunction theory of ADHD [29]. This was attributed to an *underactivation*in frontostriatal structures of the right hemisphere [4, 29]. This underactivation mightlead to a neglect of the left side of space, which may in turn shift spatial attention toward the right hemispace and result to a rightward bias when bisecting horizontal lines.

However, this model only fits to the results of the ADHD-C group. The leftward bias (*pseudoneglect*) in healthy adult controls, which is similar to the bias of the ADHD-I group, is assumed to be the result of a right hemispheric activation based on the visuospatial character of the linebisection task [10].

The importance of treating ADHD as a heterogeneous disorder was highlighted through the findings of differential line-bisection performance by participants with ADHD-I and ADHD-C.

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