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Psychiatry Research 125 (2004) 269–275

PSYCHIATRY RESEARCH

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Spatial attention in individuals with pervasive developmental disorders using the gap overlap task

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Received 16 September 2002; received in revised form 30 August 2003; accepted 18 December 2003

Abstract

The present study examined spatial attention in individuals with pervasive developmental disorders (PDD) using the gap overlap task and analyzed the express saccade, which is defined by its extremely short reaction time, as a measure of the state of attention. Participants were required to move their eyes to the target stimulus appearing on the left or right side of a fixation point. In this task, participants had to disengage their attention from the central fixation point and shift it to the peripheral target stimulus. In the gap condition, the fixation point disappeared 200 ms before the target stimulus was presented, and in the overlap condition, the fixation point remained while the target stimulus was presented. Saccade latencies were not different between the groups. However, the express saccade was more frequent in the PDD group than in the normal group in the overlap condition. We conclude that individuals with PDD have deficiencies in attentional engagement. Moreover, our study suggests that analysis of the express saccade will be useful in further examinations of attentional processes in PDD.

Keywords: Autism; Attention process; Saccadic eye movement

1. Introduction

Despite a tremendous increase in research, the causes of autism are still unclear. Autism is diagnosed on the basis of behavioral and developmental features such as impairments in reciprocal social interaction, communication, and imagination, and the presence of repetitive and ritualistic behavior (American Psychiatric Association, 1994). Some researchers have proposed that attentional abnormalities, particularly in spatial attention, underlie such features of autism as inflexibility, repetitive behavior and overselectivity (Lovaas et al., 1971; Casey et al., 1993; Wainwright-Sharp and Bryson, 1993; Wainwright and Bryson, 1996; Townsend et al., 1996, 1999, 2001).

According to Allport (1989), spatial attention is a function of spatially directed attention and spatial selectivity. Regarding spatial attention, Posner and Cohen (1984) outlined a model in which the critical components of spatial attention are defined

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0165-1781/04/$ - see front matter
doi:10.1016/j.psychres.2003.12.012

as disengagement, shift, and engagement of attentional sources. The findings from patients with acquired brain damage suggest that these components are correlated with specific brain areas (i.e. disengagement is correlated with the parietal cortex, shift is correlated with the superior colliculus, and engagement is correlated with the thalamus) (Posner et al., 1982; Posner and Cohen, 1984; Posner and Petersen, 1990).

Some studies on spatial attention in individuals with pervasive developmental disorders (PDD) have indicated problems in attentional disengagement and shift (Casey et al., 1993; Wainwright-Sharp and Bryson, 1993; Wainwright and Bryson, 1996; Townsend et al., 1996, 1999, 2001), and in attentional engagement (Kemner et al., 1998; van der Geest et al., 2001).

The present study follows the same line as a study by van der Geest et al. (2001), which examined attentional engagement and disengagement in children with autism using a gap overlap task. In the gap overlap task, when a temporal gap is introduced between the disappearance of a central fixation point and the appearance of a new target stimulus, the saccade reaction times are reduced compared to when no gap is introduced (gap effect; Saslow, 1967). This difference in saccade reaction times has been explained by the difference in attentional disengagement (Fischer and Weber, 1993). In the gap condition, in which an initial fixation point disappears before a target appears, attention on the fixation point is disengaged automatically. However, in the overlap condition, in which the fixation point remains after the target appears, attention on the fixation point is disengaged due to the appearance of the peripheral target stimulus. Therefore, the saccade reaction times in the overlap condition are longer than in the gap condition.

Fischer and Ramsperger (1984) examined the express saccade, which is defined by its extremely short reaction time (70 ms in the monkey, 100 ms in man). Fischer and Weber (1993) reported that engaged visual attention tends to inhibit the express saccade, and disengagement of attention leads to the express saccade; thus, the express saccade is a useful measure of the state of attention. Regarding the neurophysiological mechanism for producing express saccades, Sparks et al. (2000) described the express saccade as being triggered by a motor burst of collicular neurons. Furthermore, Munoz and Wurtz (1992) showed that when fixation cells in the rostral pole of the superior colliculus are inhibited artificially after microinjection of muscimol, an express saccade occurred. These fixation cells discharge tonically when the eyes are fixated and pause during saccades, and have been implicated in the control of active visual fixation and suppression of saccadic eye movements (Dorris and Munoz, 1995).

Developmental studies of attentional disengagement (Atkinson et al., 1988; Hood and Atkinson, 1993; Matsuzawa and Shimojo, 1997) have suggested that the inability of young infants to disengage their attention from a stimulus on which they are fixated is responsible for their difficulty in orientation. Different developmental time courses were shown for the gap and overlap disengagement, with early maturation of the gap disengagement ability and later maturation of the overlap disengagement ability.

Van der Geest et al. (2001) concluded that children with autism have a weak attentional engagement on a visual stimulus because of a reduced gap effect (i.e. the difference in saccade reaction times between the overlap condition and the gap condition). Moreover, as the overall saccadic reaction times did not become slower, they also concluded that there were no specific problems in attentional disengagement. However, van der Geest et al. did not analyze the express saccade as a measure of the state of attention. Furthermore, it is possible that anticipatory responses might be included in the data of van der Geest et al.

Thus, in this study, we investigated spatial attention in individuals with PDD using the gap overlap task. To clarify whether a problem of spatial attention exists in engagement only, or in both engagement and disengagement in individuals with PDD when using the gap overlap task, we analyzed the occurrence of express saccades as a measure of the state of attention. To clarify the meaning of express saccades, we used a procedure that excludes anticipatory reactions (i.e. varying the duration of the fixation point, and randomizing gap trials and overlap trials).