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Perceptual asymmetries in normal children and children with attention deficit/hyperactivity disorder

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Abstract

Perceptual asymmetries in normal right-handed children (7–12 years of age) and children with attention deficit/hyperactivity disorder (ADHD), combined type, were investigated using various chimeric stimuli in free-viewing conditions. In the face-matching task, participants indicated which of two symmetrical face chimeras more closely resembled the original; in the chimeric faces task, participants indicated which of a pair of faces appeared happier; and in the grey scales task participants indicated which of two shaded rectangles appeared to be darker overall. Leftward biases were found for normal children with no effects of age. Contrary to expectations, normal leftward biases were also found for ADHD children in the face-matching and the chimeric faces tasks; however, a significant leftward bias was not observed in the grey scales task. The absence of anomalous perceptual bias in ADHD children on these purely perceptual tasks, suggests that anomalous perceptual asymmetries observed in other tasks (line bisection and cancellation tasks) may have been confounded by the motor response, and/or the explicit spatial components of those tasks.

Keywords: Perceptual asymmetries; ADHD; Children; Lateralization; Attentional bias; Chimeras

1. Introduction

Studies of line bisection, dichotic listening, and various tachistoscopic tasks have been used to assess perceptual asymmetries, and to draw inferences about hemispheric lateralization, in adults and children. In studies of horizontal line bisection, where participants are required to mark the mid-point, right-handed adults tend to bisect lines slightly to the left of their true centre (Bowers & Heilman, 1980; McCourt & Olafson, 1997), although this bias has not been found by all investigators (Nielsen, Intriligator, & Barton, 1999; Werth & Poeppel, 1988). In dichotic listening tasks, two different auditory stimuli are presented to the left and right ears simultaneously. A right ear advantage (REA), that is, superior report of right compared to left ear items, has been found in normal individuals for processing verbal stimuli such as words and syllables (Ley & Bryden, 1982). This REA is believed to result from left hemisphere lateralization for verbal processing. Emotional stimuli, on the other hand, are preferentially detected in the left ear (Freeman & Traugott, 1994), possibly reflecting right hemisphere lateralization for emotion.

Perceptual asymmetries in vision have traditionally been studied using tachistoscopic tasks, in which stimuli are presented rapidly and unilaterally to the left or right visual field (and therefore, to the corresponding right and left hemispheres, respectively). These asymmetries have also been reproduced in free-viewing tasks, although in the latter, stimuli are not transmitted exclusively to a single hemisphere. It has been demonstrated that right-handed adults attend consistently more to leftward features of a variety of facial and visuospatial stimuli than to those on the right (e.g., Luh, Redl, &

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Levy, 1994). The free-viewing tasks typically use pairs of stimuli in which each stimulus is a mirror reversal of the other, and where the salient feature (such as the smile on a face) is on the left in one of the pair and on the right in the other. Participants tend to select the stimulus with the salient feature on the left-hand side more than the stimulus with the salient feature on the right-hand side (e.g., David, 1989; Luh et al., 1994).

Right-handed adults have been found to recognize faces (e.g., Rhodes, 1985), and base judgements of gender (e.g., Luh et al., 1994) and emotion (e.g., David, 1989; Luh et al., 1994), more via leftward than rightward features of the face. This leftward bias can be affected by the type of emotion to be judged (Magnussen, Sunde, & Dyrnes, 1994) and by handedness, with left-handers showing reduced or atypical asymmetries (David, 1989; Luh et al., 1994). Bias for leftward features has also been observed for non-facial stimuli, such as judgements of brightness and numerosity (Nicholls, Bradshaw, & Mattingley, 1999), and somewhat less consistently for shape (see Nicholls et al., 1999; but cf., Luh et al., 1994).

The mechanisms underlying these auditory and visual perceptual asymmetries are not clearly understood. The traditional *structural model* of perceptual asymmetry (Kimura, 1967) postulates that contralateral auditory/visual brain areas are more activated during some of these perceptual asymmetry tasks; verbal stimuli presented to the right ear/right visual field have direct access to processing centres in the left hemisphere, whereas left ear/left visual field stimuli have to be transferred across the corpus callosum to reach speech processing areas in the left hemisphere. Similarly, non-verbal stimuli presented to the left ear/left visual field would have direct access to non-verbal, right hemisphere processing, but would have to cross the corpus callosum to reach verbal processing areas in the left hemisphere.

Alternatively, an *attentional model* has been proposed to account for normal perceptual asymmetries (Kinsbourne, 1970). Rather than structural constraints, this model focuses on selective attention and hemispheric activation mechanisms. Because verbal material evokes activity in the language areas of the left hemisphere, attention is directed contraversively to stimulus material on the right. Non-verbal stimuli, on the other hand, evoke predominantly right hemisphere activity, so that attention is directed preferentially to the left. In line with this, Mattingley and colleagues (Mattingley, Bradshaw, Phillips, & Bradshaw, 1993; Mattingley, Bradshaw, Nettleton, & Bradshaw, 1994b; Mattingley, Bradshaw, & Bradshaw, 1995) found that patients with left unilateral neglect due to right hemisphere damage demonstrated a pronounced rightward bias in line bisection, face-processing, and brightness judgement tasks. It appears that in these right-hemisphere-damaged patients, right-hemisphere activation by the task is not enough to compensate for the lesion, and thus a rightward (left hemisphere) bias prevails. This rightward bias has been found to persist even after the resolution of other clinical symptoms of neglect (Mattingley, Bradshaw, Bradshaw, & Nettleton, 1994a).

Perceptual asymmetry tasks have also been administered in a variety of clinical populations. In adults with schizophrenia, for example, a reduction in the normal REA in dichotic listening tasks has been found (e.g., Bruder et al., 1995), which may be interpreted as indicating abnormal left hemisphere functioning in schizophrenia. Jaeger, Borod, and Peselow (1987) reported that depressed patients showed a smaller-than-normal leftward bias in making judgements of emotion (happiness), supporting a postulated right hemisphere dysfunction in depression. Similarly, David (1993) observed reduced leftward bias in the tachistoscopic presentation of happy-sad faces in depressed patients, and no significant left or rightward bias in schizophrenic patients.

Perceptual asymmetries in individuals with attention deficit/hyperactivity disorder (ADHD) have also been observed. Voeller and Heilman (1988) administered a letter cancellation task to seven right-handed ADHD boys. The participants had to cross out target letters on a page, ignoring any non-target (distractor) letters. Their performance resembled that of adults with unilateral neglect following acquired damage to the *right* hemisphere; they omitted more targets overall than did controls, and detected significantly fewer targets on the left side of the page than on the right. Results consistent with those of Voeller and Heilman (1988) were also reported by Adelstein (1995), but not by Ben-Artsy, Glicksohn, Soroker, Margalit and Myslobodsky (1996), in children with ADHD.

In addition, Sheppard, Bradshaw, Mattingley, and Lee (1999) have shown that ADHD children, again like left unilateral neglect patients, tend to bisect horizontal lines to the right of centre. However, a study by Ben-Artsy, Glicksohn, Soroker, Margalit, and Myslobodsky (1996) found no laterality trends or group differences in a line bisection task administered to ADHD and control children. Similarly, Adelstein (1995) reported no significant differences between boys with ADHD (combined type) and control children in a line bisection task. Studies utilizing dichotic listening tasks in children and adolescents with ADHD also have typically failed to observe any differences of lateralization in children with ADHD compared to normal controls, when using (left hemisphere activating) syllables (Oie, Rund, Sundet, & Bryhn, 1998), words (Davidson & Prior, 1978; Manassis, Tannock, & Barbosa, 2000), and (right hemisphere activating) emotional stimuli (Manassis et al., 2000).

Those studies which demonstrated anomalies in perceptual biases are in line with the view that ADHD reflects predominantly *right-sided* frontal–striatal system dysfunction (Castellanos et al., 1996; Heilman, Voeller,