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Brief article

Left to right: Representational biases for numbers and the effect of visuomotor adaptation

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Abstract

Adaptation to right-shifting prisms improves left neglect for mental number line bisection. This study examined whether adaptation affects the mental number line in normal participants. Thirty-six participants completed a mental number line task before and after adaptation to either: left-shifting prisms, right-shifting prisms or control spectacles that did not shift the visual scene. Participants viewed number triplets (e.g. 16, 36, 55) and determined whether the numerical distance was greater on the left or right side of the inner number. Participants demonstrated a leftward bias (i.e. overestimated the length occupied by numbers located on the left side of the number line) that was consistent with the effect of pseudoneglect. The leftward bias was corrected by a short period of visuomotor adaptation to left-shifting prisms, but remained unaffected by adaptation to right-shifting prisms and control spectacles. The findings demonstrate that a simple visuomotor task alters the representation of space on the mental number line in normal participants.

Keywords: Mental number line; Mental representation; Space; Visuomotor adaptation; Perception

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1. Introduction

Patients with right parietal damage and unilateral neglect exhibit a perceptual deficit for the left (contralesional) side of physical space (Heilman, Watson, & Valenstein, 1993). As a result, for line bisection tasks, neglect patients bisect the line far to the right of its true centre. Unilateral neglect is not restricted to stimuli that are physically present and also occurs for mental imagery (Bartolomeo, Bachoud-Lévi, Azouvi, & Chokron, 2005) and mental representations of numbers. The mental number line is thought to have a left-to-right organization whereby low and high numbers are represented in the left and right sides of space, respectively (Dehaene, Bossini, & Giraux, 1993). As a result, when judging the distance between two numbers, left neglect patients misplace the midpoint to the right (i.e. toward the higher number) – analogous to their rightward misbisection of physical lines (Vuilleumier, Ortigue, & Brugger, 2004; Zorzi, Priftis, Meneghello, Marenzi, & Umilta, 2006; Zorzi, Priftis, & Umilta, 2002; but cf. Dorrichi, Guariglia, Gasparini, & Tomaiuolo, 2005).

While left neglect patients misbisect mental and physical lines to the right, normal participants demonstrate a leftward bias (Nicholls, Bradshaw, & Mattingley, 1999; Nicholls & Loftus, 2007). This leftward bias reflects pseudoneglect, a phenomenon that causes the leftward stimulus properties to be overestimated relative to those on the right (Bowers & Heilman, 1980). Pseudoneglect manifests itself on physical line bisection tasks, where the perceived midpoint of a line is shifted left of the true midpoint (Jewell & McCourt, 2000; McCourt, 2001), but is also observed for judgments of luminance (Mattingley, Bradshaw, Nettleton, & Bradshaw, 1994; Nicholls et al., 1999; Nicholls, Mattingley, Berberovic, Smith, & Bradshaw, 2004), size and numerosity (Nicholls et al., 1999). Leftward biases have also been observed for the mental representation of stimuli, such as the recall of familiar scenes (McGeorge, Beschin, Colnaghi, Rusconi, & Della Sala, 2007), mental alphabet lines (Nicholls & Loftus, 2007) and mental number lines (Longo & Lourenco, 2007).

The clinical symptoms of neglect can be ameliorated through adaptation to right-shifting prisms, improving performance on a wide range of visuospatial tasks (Frassinetti, Angeli, Meneghello, Avanzi, & Làdavas, 2002; Pisella, Rode, Farnè, Tilikete, & Rossetti, 2006) including explicitly spatial tasks such as physical line bisection (Rossetti et al., 1998) and non-explicitly spatial tasks such as temporal order judgments (Berberovic, Pisella, Morris, & Mattingley, 2004) and mental imagery (Rode, Rossetti, & Boisson, 2001). Rossetti et al. (2004) found that left neglect for the mental number line was improved by adaptation to right-shifting prisms, leading them to suggest that adaptation alters higher-level representations of space.

Wearing right-shifting prisms causes objects to appear to the right of where they actually are, so that when the wearer first points to an object, they miss to the right. Subsequent movements must be adapted if they are to be accurate, a complex process known as 'prism adaptation' (PA), which involves two key components – 'strategic control' and 'spatial realignment' (Redding, Rossetti, & Wallace, 2005). Strategic control is a short-term process whereby initial reaching errors are rapidly detected and reduced. Spatial realignment involves a shift of sensory–motor refer-