Journal of Experimental Child Psychology 173 (2018) 16–27

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Visuospatial biases in preschool children: Evidence from line bisection in three-dimensional space

Katarzyna Patro [a,*], Hans-Christoph Nuerk [b,c], Peter Brugger [d]

[a] Institute of Psychology and Education, Ulm University, 89081 Ulm, Germany
[b] Tuebingen University, 72076 Tuebingen, Germany
[c] Knowledge Media Research Center, 72076 Tuebingen, Germany
[d] University Hospital of Zürich, 8091 Zürich, Switzerland

ARTICLE INFO

Article history:
Received 5 June 2017
Revised 28 February 2018

Keywords:
Attention
Lateralization
Line bisection
Pseudoneglect
Spatial asymmetry
3D space

ABSTRACT

Spatial attention in adults is characterized by systematic asymmetries across all three spatial dimensions. These asymmetries are evident when participants bisect horizontal, vertical, or radial lines and misplace their midpoints to the left, the top, or far from the body, respectively. However, bisection errors are rarely examined during early childhood. In this study, we examined the development of spatial-attentional asymmetries in three-dimensional (3D) space by asking preschool children (aged 3–6 years) to bisect horizontal, vertical, and radial lines. Children erred to the left with horizontal lines and to the top with vertical lines, consistent with the pattern reported in adults. These biases got stronger with age and were absent in the youngest preschoolers. However, by controlling for a possible failure in hitting the line, we observed an additional unpredicted pattern: Children's pointing systematically deviated away from the line to an empty space on its left side (for vertical and radial lines) or above it (for horizontal lines). Notably, this task-irrelevant deviation was pronounced in children as young as 3 or 4 years. We conclude that asymmetries in spatial-attentional functions should be measured not only in task-relevant dimensions but also in task-irrelevant dimensions because the latter may reveal biases in very young children not typically observed in task-relevant measures.

* Corresponding author.
E-mail address: katarzyna.patro@gmail.com (K. Patro).

https://doi.org/10.1016/j.jecp.2018.03.002
0022-0965/

Introduction

Despite the grossly symmetric anatomical features of the human body, some aspects of our behavior are markedly unbalanced along the left–right dimension. Apart from handedness, horizontal asymmetries in spatial attention may be the most conspicuous in affecting our perception and action. This is evident even in such everyday activities as looking at pictures (Nuthmann & Matthias, 2014), passing through a doorway (Nicholls, Loftus, Mayer, & Mattingley, 2007), and kissing a partner (Shaki, 2013).

Most evidence on attentional biases comes from studies on a phenomenon called "pseudoneglect." This term (Bowers & Heilman, 1980) refers to neurologically healthy persons' slight attentional shift toward the left side of their body and space. It was chosen in allusion to the opposite, and usually much larger, bias evidenced by patients with left-sided neglect after right hemisphere damage (for a review, see Vallar, 2001). Both neglect and pseudoneglect are often measured with a line bisection task (Fischer, 2001; Schenkenberg, Bradford, & Ajax, 1980). In a standard testing procedure, a participant is presented with a horizontal line, printed on a paper or displayed on a computer screen, and asked to mark the line's midpoint. Neurologically healthy participants usually exhibit a systematic small bisection bias to the left of the veridical midline (e.g., Bowers & Heilman, 1980; Bradshaw, Nettleton, Nathan, & Wilson, 1983; Bradshaw, Nettleton, Nathan, & Wilson, 1985; for a review, see Jewell & McCourt, 2000).

Pseudoneglect is often explained by the right hemisphere dominance in spatial information processing, which leads to an attentional bias toward the contralateral left hemifield (Bradshaw, Bradshaw, Nathan, Nettleton, & Wilson, 1986; Bradshaw, Nettleton, Wilson, & Bradshaw, 1987; Kinsbourne, 1970, 1987). Cultural and situational variations in spatial-attentional biases have also been observed such as a reversal of the bias toward the *right* side in right-to-left reading cultures (Chokron, Bernard, & Imbert, 1997; Chokron & De Agostini, 1995; Chokron & Imbert, 1993) or its short-term modulation by scanning direction (Brodie & Pettigrew, 1996; Chokron, Bartolomeo, Perenin, Helft, & Imbert, 1998). Such cultural and situational modulations suggest that spatial-attentional biases might not be entirely determined by a fixed pattern of brain lateralization but could also reflect more flexible and adaptive asymmetries in the spatial-attentional network (Nicholls & Roberts, 2002).

Typically, research on spatial asymmetries has been conducted for (and even sometimes implicitly reduced to) the left–right dimension. However, spatial-attentional asymmetries have also been examined for other line orientations in three-dimensional (3D) space, although less frequently. When the line is oriented vertically, participants misplace its midpoint toward the upper space (Bradshaw et al., 1985; Fink, Marshall, Weiss, & Zilles, 2001; McCourt & Olafson, 1997). Radial line bisection in depth results in a systematic pattern of midpoint displacement away from the body (Barrett, Crosson, Crucian, & Heilman, 2002; Geldmacher & Heilman, 1992; Halligan & Marshall, 1993; Szpak, Thomas, & Nicholls, 2016; Toth & Kirk, 1996). This upward/distal shift in spatial attention is evident in other tasks as well such as comparison of mirror-reversed luminance gradients (Nicholls, Smith, Mattingley, & Bradshaw, 2006) and free-choice distribution of pegs on a surface (Drago, Foster, Webster, Crucian, & Heilman, 2007).

Not only horizontal, but also vertical and radial, biases can be explained by referring to other forms of neural asymmetries. For instance, the vertical attentional shift toward the upper visual space is likely associated with a ventral–dorsal asymmetry of the visual stream (Drain & Reuter-Lorenz, 1996) or, more specifically, with an activation of the object-centered ventral stream through the presentation of a line. Biases in radial (depth) line bisection are presumably driven by lateralization mechanisms analogous to those driving performance in horizontal bisections. Whereas the left hemisphere dominance for motor action subsumes controlling activities in peripersonal space (i.e., close to the body such as reaching or pointing), the right hemisphere mediates visual processing of stimuli in extrapersonal distal space (Heilman, Chatterjee, & Doty, 1995; Shelton, Bowers, & Heilman, 1990; Szpak et al., 2016). However, these neural lateralizations do not preclude the influence of other cultural, linguistic, or educational factors. For instance, biases toward farther and upper space might be modulated by reading habits (e.g., see Göbel, 2015, for vertical biases in spatial-numerical process-