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Research Report

Egocentric reference in bidirectional readers as measured by the straight-ahead pointing task

Seta Kazandjian[a,b,*], Eve Dupierrix[a], Esther Gaash[c], Itamar Y. Love[c], Ari Z. Zivotofsky[c], Maria De Agostini[d], Sylvie Chokron[a,b]

[a]ERT TREAT Vision, Laboratoire de Psychologie et NeuroCognition, UMR 5105 CNRS-Université Pierre Mendès France, 1251, avenue Centrale, 38040 Grenoble, France
[b]Service de Neurologie, Fondation Ophtalmologique Adolphe de Rothschild, 25 rue Manin, 75019 Paris, France
[c]Gonda Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel
[d]Laboratoire d'Epidémiologie et Biostatistique, Inserm U 780, Villejuif, France

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ABSTRACT

The present study aimed to show that bidirectional reading and language exposure influence the position of egocentric reference (ER), the perceived direction of the body's sagittal axis proposed to act as an anchor for movements in extracorporeal space. Directional factors (e.g., visual scanning bias and reading habits) have been proposed to influence visuospatial performance, such as in line bisection and figure drawing. In past studies, bidirectional readers have been less consistent in demonstrating a bias compared to unidirectional readers. Using a straight-ahead pointing task to assess egocentric reference, we compared 14 unidirectional left-to-right readers (Uni-LR) to three bidirectional reading groups that differed in the reading direction of their native language and/or the level of their second language literacy: 16 low-English literate, native right-to-left, bidirectional readers (Lo-Bi-RL), 13 high-English literate, native right-to-left, bidirectional readers (Hi-Bi-RL), and 15 native left-to-right, bidirectional readers (Bi-LR). Participants were asked to point straight-ahead while blindfolded using either a left-to-right or a right-to-left scanning direction to approach the subjective sagittal midline. Uni-LRs showed left-side spatial bias when scanning left-to-right and right-side bias during right-to-left scanning, Bi-LRs and Lo-Bi-RLs (i.e., intermediate level or less in their second language) demonstrated the opposite pattern, and Hi-Bi-RLs showed left-side spatial bias regardless of scanning direction. Results are discussed in terms of accuracy and spatial bias regarding the interaction between reading direction and spatial cognition based on the level of bidirectional literacy and language exposure.

* *Corresponding author.* Equipe TREAT VISION, Laboratoire de Psychologie et NeuroCognition (UMR 5105 CNRS), Service de Neurologie, Fondation Ophtalmologique Rothschild, 25-29 rue Manin, 75019 Paris, France. Fax: +33 01 48 03 68 59
E-mail address: seta.kazandjian@upmf-grenoble.fr (S. Kazandjian).

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1. Introduction

Egocentric reference (ER), the perceived direction of the body's sagittal axis, has been proposed to act as an anchor for movements in extracorporeal space (Jeannerod and Biguer, 1987). A common way of testing the direction of the ER is with a proprioceptive straight-ahead pointing task, by asking participants to point straight ahead while blindfolded and to record this subjective position (Bartolomeo and Chokron, 1999; Chokron et al., 2004; Chokron and Imbert, 1995a; Jeannerod and Biguer, 1987; Richard et al., 2004;Werner et al., 1953). ER is considered to result from the permanent integration of incoming sensory (visual, vestibular, neck, proprioceptive) and motor-related signals (Biguer et al., 1988; Jeannerod and Biguer, 1987; Karnath et al., 1994; Ventre et al., 1984). As originally proposed, in normal conditions ER lies on the sagittal axis due to symmetrical functioning of the multiple neural structures which process sensory information, thus splitting personal and extra-personal space into two equal halves. In support of this theoretical framework, the perturbation of this usual symmetry by unilateral sensorimotor stimulation or a unilateral cerebral lesion has shown to directly modulate the construction of the ER. For instance, Karnath et al. (1994) found a shift in straight-ahead pointing among normal adults during neck vibrations and/or caloric vestibular stimulation with ice water. Such a link between on-going sensorimotor integration and ER was also evidenced by the influence of directional exploration of space (either visual or proprioceptive) in straight-ahead judgment among healthy adults and brain-damaged patients (for review see Chokron, 2003). By imposing a starting point that is to the right or left of the objective midline (0°), the participant must find or return to midline by scanning space either from left-to-right (LR) or from right-to-left (RL). According to these studies, when the arm is positioned to the left of the objective 0°, healthy LR-reading adults tend to present an ER shift that is to the left of the objective 0°. Conversely, when scanning from right-to-left, a shift to the right is observed.

Using bisection protocols, Reuter-Lorenz and Posner (1990) and Chokron and Imbert (1993) showed that scanning direction reinforced through reading and writing habits could also influence spatial performance suggesting that space perception could be determined by both the imposed on-going space exploration and the scanning direction habits. Similarly, Abed (1991) proposed, that non-directional stimuli, i.e. geometrical forms, can be explored as if they are directional stimuli, e.g., words, and can be influenced by reading habits. Since then several studies have illustrated that LR readers (e.g., French, English and Hindi) transect lines to the left of center whereas RL readers (e.g., Hebrew, Arabic, and Urdu) err to the right of center (Chokron et al., 1998; Zivotofsky, 2004). According to a meta-analytic study reported by Jewell and McCourt (2000), directional scanning is indeed one of the more determinant factors of leftward directional errors in line bisection. The same pattern of results demonstrating lateralized spatial perception consistent with reading direction preference was seen with other visuospatial tasks, such as line length estimation (Chokron et al., 1997; Singh et al., 2000), aesthetic preference (Chokron and De Agostini, 2000), perception of facial affect (Vaid and Singh, 1989), lateral motion bias (Morikawa and McBeath, 1992; Tse and Cavanagh, 2000), and dot-filling (Vaid, 1998).

The role of learning to read and scanning was also investigated using the line bisection task in adults and children. Chokron and De Agostini (1995b) found the expected rightward bias among Israeli, RL reading participants, but a significantly greater rightward bias among the 8-year olds compared to the adults. Rightward spatial bias may decline with greater exposure to LR writing systems, such as foreign LR languages, mathematics and music. Additionally, preschool, 4.5 year old Israeli children showed a rightward bias despite not having yet learned to read. This early RL directional preference was thought to be related to daily exposure to Hebrew and its RL directionality in printed material (i.e., adults reading to children, cartoons, signs and notices, etc.). Comparing French and Tunisian (Arabic, RL reading) children on line bisection, circle-drawing, and dot-filling, Fagard and Dahmen (2003) also found shifts in directional performance associated with language learning. At age 7, Tunisian children (unidirectional, monolingual RL readers) demonstrated faster performance in dot-filling from right-to-left, whereas French children preferred the left-to-right direction. For line bisection, at age 9 French children showed a significant leftward deviation, but Tunisian children (now bidirectional readers) did not show a bias to either side. Therefore, bidirectional reading among bilinguals who read and write in languages with opposing script directions may also have an influence on spatial performance. In a previous study, Braine (1968) had compared the performances of Israeli, Hebrew students at 3rd grade (unidirectional), 5th grade (unidirectional but with addition of LR directional music and math), 7th grade (bidirectional, beginning Hebrew-English), and college age (adult, bidirectional). Results from several spatial and left vs. right visual field preference tasks had demonstrated a similar trend as described by Fagard and Dahmen (2003): younger Israeli children showed a directional preference to the right side, whereas in the 7th grade this tendency diminished, and for the college students a left side preference was observed. In light of these findings, spatial perception seems to evolve with language exposure insomuch as it could be modulated over time due to native language learning and the directional consistency of the culture.

Nachshon and Alek (1981) pointed out that Hebrew readers do not have consistent exposure to or directional preferences for RL reading. As Braine (1968) also mentioned, music, math and English learning in school all introduce a LR reading directionality. The major cities of Israel, especially Tel-Aviv, in some ways have a bidirectional culture. English is taught in schools beginning with the 5th grade (i.e., age 9–10), universities often use textbooks written in English for many science courses (e.g., computer science, sciences, mathematics) while the lectures are presented in Hebrew, most road and information signs are written in both Hebrew and English, and many television shows are aired in English with Hebrew subtitles. Using tasks that assess the directional preference in reproducing both directional (letters and numbers) and non-directional (shapes) arrays, Nachshon and colleagues, as well as others, demonstrated through a series