BRAIN RESEARCH 1387 (2011) 108–115

available at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/brainres

BRAIN RESEARCH

Research Report

# Upper and lower visual field differences in perceptual asymmetries

Nicole A. Thomas[a,*], Lorin J. Elias[b]

[a]School of Psychology, Flinders University of South Australia, GPO Box 2100, Adelaide, SA 5001, Australia
[b]Department of Psychology, University of Saskatchewan, Canada

ARTICLE INFO

*Article history:*
Accepted 19 February 2011
Available online 26 February 2011

*Keywords:*
Lateral bias
Spatial attention
Presentation time
Greyscales task
Pseudoneglect

ABSTRACT

A leftward spatial bias has been observed with visuospatial attention tasks, including line bisection and the greyscales task. Upper and lower visual field differences have been observed on various tasks, with a lower visual field advantage occurring for motion, global processing and coordinate spatial judgments. Upper visual field advantages occur for visual search, local processing and categorical judgments. In perceptual asymmetries research, upper and lower visual field differences have not typically been scored separately, as most presentations have been central. Mixed results have made it difficult to determine whether lateral biases are stronger in the upper or the lower visual field. As length of presentation time differed in prior studies, this factor was examined to determine whether it would lead differential biases to emerge in each visual field. The greyscales task was used to investigate the interaction of visual field and presentation time within subjects ($N=43$). Eye tracking was used during the task and supported the hypothesis of a stronger left bias in the lower visual field. Presentation time and visual field interacted to influence performance. Prolonged presentation led to a stronger leftward bias in the lower visual field whereas the leftward bias was stronger in the upper visual field during brief presentation. Results showed a relation between the lower and left visual fields and the upper and right visual fields, which has not previously been shown in perceptual asymmetries. Further, it is suggested that functional differences between the visual streams could underlie the visual field differences in perceptual asymmetries.



## 1. Introduction

Neurologically normal individuals show a leftward spatial attention bias, referred to as pseudoneglect, due to its similarity to clinical hemineglect (Bowers and Heilman, 1980; Jewell and McCourt, 2000). This phenomenon has been examined using a variety of tasks, such as line bisection (Luh, 1995; McCourt and Jewell, 1999) and the landmark task (Dufour et al., 2007). Line bisection tasks typically demonstrate a leftward bias as individuals tend to bisect lines to the left of center in both manual (i.e., Barrett et al., 2000; Luh, 1995) and computerized line bisection (i.e., McCourt and Jewell, 1999; Rolfe et al., 2008). The landmark task is a perceptual version of the line bisection task where participants are shown a pre-transected line and they are to indicate whether the left or the right side of the line appears shorter (Milner et al., 1993; Rueckert and McFadden 2004). On the landmark task, participants falsely indicate that the right end of the line is shorter

* *Corresponding author.* School of Psychology, Flinders University, GPO Box 2100, Adelaide, SA 5001, Australia. Fax: +61 08 8201 3877.
E-mail address: nicole.thomas@flinders.edu.au (N.A. Thomas).

0006-8993/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.brainres.2011.02.063

the majority of the time (Dufour et al., 2007, Milner et al. 1993; Rueckert and McFadden 2004).

Perceptual asymmetries in judgments of luminosity have been investigated using the greyscales task (Nicholls et al., 1999). Participants are shown a pair of mirror-reversed rectangles, where one is dark on the left side and the other is dark on the right, with each gradually becoming lighter on the opposite side. Participants tend to select the image that is dark on the left side as being darker overall, despite the images being equiluminant. Similar tasks assessing numerosity, size (Nicholls et al., 1999), and distance (Krupp et al., 2010) have been developed and participants tend to choose the image with the investigated characteristic (i.e., larger, closer, etc…) on the left side most often on these measures as well.

A number of potential explanations have been proposed to account for these leftward biases. Scanning and reading habits (Chokron et al., 1998; Manning et al., 1990) as well as premotor/intentional biases (Brodie and Pettigrew, 1996; Heilman and Valenstein, 1979) might lead to perceptual asymmetries. However, Nicholls and Roberts (2002) demonstrated that these factors cannot account for the left bias entirely as right-to-left readers and bimanual responding also lead to leftward biases.

The explanation with the most support is that of an attentional bias (e.g., Niemeier et al., 2008). As the posterior parietal area in the right hemisphere is primarily responsible for spatial attention (e.g., Corbetta et al., 1995; Posner and Petersen, 1990; Posner and Rothbart, 2007), attention is preferentially directed toward the left side of space. This is supported by neuroimaging data demonstrating that visuospatial attention networks are more activated by left visual field information (Siman-Tov et al., 2007). Further, neuroimaging data indicate that the right hemisphere is more active during line bisection and landmark tasks (Bjoertomt et al., 2002; Çiçek et al., 2009; Fink et al., 2000; Fink et al., 2001; Foxe et al., 2003).

A phenomenon that remains relatively unexplored is how the left bias is influenced by upper and lower visual field presentation. Upper and lower visual field differences have been observed across various tasks (see Christman and Niebauer, 1997 for a review; Previc, 1990), with a lower visual field (LVF) bias emerging in many instances. Considering motion processing, an LVF advantage is seen for direction discrimination (Amenedo et al., 2007; Edwards and Badcock, 1993), segmentation of moving targets (Lakha and Humphreys, 2005), motion in depth (Regan et al., 1986), and centripetal motion processing (Edwards and Badcock, 1993; Raymond, 1994). The LVF advantage in motion perception is thought to be related to the role of the LVF in visuomotor coordination and in guiding locomotion (Christman and Niebauer, 1997), as primarily LVF information is utilized during locomotion and predatory behavior (e.g., Foley and McChesney, 1976; Guez et al., 1993; Murasugi and Howard, 1989; Prete, 1993).

An LVF advantage has been observed on both spatial and temporally based tasks. For example, searching for a target amongst distracters (Rezec and Dobkins, 2004), reaction time (Payne, 1967), spatial resolution (Carrasco et al., 2002; Rezec and Dobkins, 2004), perceiving illusory contours (Rubin et al., 1996), and contrast sensitivity at low to moderate spatial frequencies (Cameron et al., 2002; Carrasco et al., 2002; Lundh et al., 1983; Rijsdijk et al., 1980) all demonstrate an LVF advantage. The critical flicker fusion task is used to examine visual persistence by determining the frequency at which individuals view either a steady light or alternatively see a flicker (Landis, 1954). This task has shown an LVF advantage, which some suggest is related to temporal resolution (see Christman and Niebauer, 1997 for a review). Color matching appears to be superior in the left LVF (Pennal, 1977); however, this might simply reflect temporal processing. There is also some evidence that spatial and temporal resolution effects interact (see Christman and Niebauer, 1997 for a review). As an overestimation of perceived spatial frequency has been shown in the left LVF (Edgar and Smith, 1990), it suggests lateral LVF biases might emerge on other tasks.

Overall, tasks demonstrating an LVF advantage have shown a left visual field advantage whereas those showing an upper visual field (UVF) advantage demonstrate a right visual field advantage (Christman and Niebauer, 1997). Both upper and right visual field advantages are seen for local processing, categorical judgments, such as object identification, and visual search (Efron et al., 1987, 1990; Previc and Blume, 1993) whereas lower and left visual field advantages are reported for global processing and coordinate spatial judgments requiring visuomotor coordination, and global motion (Christman, 1993; Kosslyn, 1987; Niebauer and Christman, 1998; Previc, 1990). Interestingly, these findings showed that left–right differences were confined to lower space and upper–lower differences only occurred in the left visual field, suggesting a functional linkage between the lower and left visual fields and the upper and right visual fields (Christman and Niebauer, 1997).

The same relation has been observed in visuospatial attention as hemispatial neglect is most pronounced in the left and lower visual fields (Rubens, 1985). Although hemispatial neglect is typically characterized by a rightward orienting bias, an LVF bias might also occur, with evidence suggesting neglect is most severe in the left LVF (Rubens, 1985). It should be noted that hemispatial neglect can also occur following left brain damage, but it is reported less frequently (Kleinman et al., 2007). Kleinman et al. (2007) found that 19% of patients presented with right hemispatial neglect, illustrating that neglect following left hemisphere stroke occurs less frequently than after right hemisphere damage.

Interestingly, few studies to date have examined upper and lower visual field differences in perceptual asymmetries using horizontal stimuli. McCourt and Garlinghouse (2000) and McCourt and Jewell (1999) investigated potential visual field differences using computerized line bisection. Pre-transected lines were presented tachistoscopically (150 ms) at 3.6° and 5.8° visual angle (respectively) either above or below the midline. Participants identified the location of the transector with respect to the perceived midpoint of the line (left or right of center). In both studies, McCourt and colleagues found a stronger leftward bias when the stimuli were located in the UVF.

Barrett et al. (2000) examined UVF and LVF differences using free-viewing manual line bisection (unlimited time to complete). Line bisection was performed at 40.5 cm either above or below the horizontal plane, meaning that the actual distance between the UVF and LVF presentations was much larger than in the task used by McCourt and Garlinghouse