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Near, yet so far: The effect of pictorial cues on spatial attention

Michael E.R. Nicholls [a,*], Jason D. Forte [b], Tobias Loetscher [a], Catherine A. Orr [b], Mark J. Yates [b], John L. Bradshaw [c]

[a] School of Psychology, Flinders University, Australia
[b] Department of Psychology, University of Melbourne, Australia
[c] Department of Psychology, Monash University, Australia

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ABSTRACT

Distinct cognitive and neural mechanisms underlie perception and action in near (within-reach) and far (outside-reach) space. Objects in far space can be brought into the brain's near-space through tool-use. We determined whether a near object can be pushed into far space by changing the pictorial context in which it occurs. Participants ($n = 372$) made relative length judgements for lines presented in near space, but superimposed over photographs of near and far objects. The left segment of the line was overestimated in the baseline and near-context conditions whereas the right was overestimated in the far-context. The change from leftward to rightward overestimation is the same when lines are physically shifted from near to far space. Because participants did not have to do anything in relation to the photograph, the results suggest that simply viewing images with a near/far context can cause a shift of attention along the distal/proximal axis, which may reflect differential activation of the ventral/dorsal visual streams.

1. Introduction

Although it may appear seamless, the brain divides three-dimensional space into a number of categories. One category runs along the proximal/distal axis. Near (peri-personal) space is generally considered to comprise the part of space that is within reach, whereas far (extra-personal) space is outside of reach. Whether there is a sharp boundary in the way the brain codes near and far space is a matter of debate. While Berti et al. (2002) concluded that there was a clear distinction between near and far space in neglect patients, studies in the general population suggest a gradual change as an object moves along the proximal/distal axis (see, Longo & Lourenco, 2006, 2007). Irrespective of whether the boundary is sharp or gradual, different neurological mechanisms are associated with processing near and far space (for a review, see Konen and Kastner (2008)). Lesion studies in primates reveal that the post-arcuate (area 6) and pre-arcuate (area 8) areas are associated with processing near and far space, respectively (Rizzolatti, Matelli, & Pavesi, 1983). For humans, regional cerebral blood flow research reveals activation of brain regions associated with the dorsal (intraparietal sulcus) and ventral (medial temporal cortex) streams for the bisection of lines placed in near and far space, respectively (Weiss et al., 2000).

The dorsal/ventral distinction between near and far space may be aligned with functional implications related to 'actionable' objects. Milner and Goodale (1995) suggested that the dorsal stream is responsible for the visual control of action whereas the ventral stream enables the visual representation of the environment. Dorsal stream activation for near space may therefore reflect the fact that the object is also actionable. The connection between near space, actionable object and the dorsal visual stream, may not be that strong, however. In a PET study, Weiss, Marshall, Zilles, and Fink (2003) found that the neural representations of near and far space were independent of the motor/perceptual nature of the task.

Another spatial category runs along the lateral axis and is defined by the body's midline. Patients with damage to the posterior parietal cortex in the right hemisphere often suffer from visuospatial neglect (Nichelli, Rinaldi, & Cubelli, 1989). For objects placed in near space, the neglect manifests as an inability to perceive and/or attend to stimuli placed in the contralesional (left) hemispace (Nichelli et al., 1989). For some patients a dissociation has been observed whereby leftward neglect is observed for objects placed in near space, but not far space (Halligan & Marshall, 1991). For other patients, the reverse is true and they show leftward inattention for objects in far, but not near space (Vuilleumier, Valenza, Mayer, Reverdin, & Landis, 1998).

Near and far space also interacts with attentional asymmetries in the intact brain. When an object is placed in near space, the features on the right receive less attention. As a consequence, when

* Corresponding author. Address: School of Psychology, Flinders University, Bedford Park, SA 5052, Australia. Fax: +61 3 9347 6618.
E-mail address: mike.nicholls@flinders.edu.au (M.E.R. Nicholls).

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asked to bisect a line placed in near space, participants reliably place the bisector slightly to the left of the true centre (McCourt, 2001). This bias is thought to originate from the same cognitive/neural mechanisms that give rise to clinical neglect (Bjoertomt, Cowey, & Walsh, 2002), and for this reason, it is often referred to as pseudoneglect. Pseudoneglect is also affected by the manipulation of near and far space. When lines are placed outside of reach, the leftward bisection bias can be annulled (Bjoertomt et al., 2002; McCourt & Garlinghouse, 2000) or revered towards a rightward bisection bias (Longo & Lourenco, 2006).

The boundary between near and far space is not fixed and can be manipulated. In the primate brain, objects out of reach can be brought into 'reach' and processed by dorsal stream mechanisms through the use of a rake (Iriki, Tanaka, & Iwamura, 1996). For humans, Berti and Frassinetti (2000) found that, when using a laser pointed to make bisections, a neglect patient bisected to the right for lines placed in near space – but not far space. If the same patients used a stick to make the bisection, rightward bisections were observed in both conditions. Berti and Frassinetti (2000) suggested that tool use caused a remapping of space whereby an object in far space was brought into 'reach' by use of the tool. A similar effect has been observed for pseudoneglect in the general population. Longo and Lourenco (2006) presented lines at distances ranging from 0.3 m to 1.2 m. When the bisection was made using a laser pointer, leftward bisections were observed for near stimuli, which reversed to a rightward bisection bias for far stimuli. When the bisection was performed using a stick, however, leftward bisections were observed irrespective of viewing distance.

Research that brings distant objects into near space raises the interesting possibility that the reverse may also be possible. That is, can an object in near space be pushed into far space? Lourenco and Longo (2009) investigated this issue by attaching weights to participants' wrists as they bisected lines in near and far space. While the normal left/right shift in bisection was observed for near/far space, the point at which the change occurred was closer. They suggested that the extra effort associated with the weights reduced the size of near space and pushed some near objects into far space. The current study will also investigate whether objects can be pushed from near to far space, but will focus on perceptual manipulations. Research with stimuli such as numbers (e.g. '2' or '9') or objects that have a positional context (e.g. 'hat or 'boots') has shown that the mere presentation of such stimuli causes an automatic shift of attention in lateral (Nicholls, Loftus, & Gevers, 2008) or vertical (Estes, Verges, & Barsalou, 2008) space. For the proximal/distal axis, Robertson and Kim (1999) demonstrated that perceptual depth induced through an 'Ames-like' room illusion affected shifts of spatial attention *within* near or far space. Research also indicates that the focus of attention can be 'depth aware' (Atchley, Kramer, Theeuwes & Anderson, 1997). With this research in mind, the present study investigated whether simply changing the pictorial context in which a stimulus occurs can produce attentional effects that are consistent with a shift *between* near and far space.

Participants completed three conditions. In the *baseline* condition, pre-bisected lines were shown on a plain background and participants judged the relative lengths of the left and right sides of a line. In line with a large body of research (see Jewell and McCourt (2000) for a review) it was expected that the length on the left side would be overestimated due to the effects of pseudoneglect. In the *near* and *far* conditions, the lines were superimposed over photographs of near and far objects, respectively. The near conditions showed photographs of objects within reach (a light switch and a filing cabinet drawer). Because these objects are both located in near space, they are also both potentially actionable. Given that the dorsal stream is specialised for processing objects in near space *and* for programming action in space, it was expected that this condition would activate the dorsal visual stream. As a result, there should be a leftward attentional bias, which causes the length of left side of the line should be overestimated. The far condition showed photographs of far objects (a classical building facade and a verandah) that were not immediately actionable. It was anticipated that these images would activate the ventral stream, which is specialised for distance perception and perception independent of action. Consistent with research in this area (Longo & Lourenco, 2006), a rightward attentional bias was predicted in this condition.

2. Method

2.1. Participants

The sample was drawn from a large undergraduate class ($m = 106$, $f = 358$). To exclude individuals who were perhaps not attending to the task, participants with an accuracy score below chance (50%) were excluded. Participants who were not right-handed were also excluded. This left a sample of 372 participants ($m = 80$, $f = 292$) with a median age of 19 years. Participants gave informed consent and the study was approved by the Human Research Ethics Committee at the University of Melbourne.

2.2. Apparatus and stimuli

Horizontal lines were defined by two short bars (10 mm long and 2 mm thick), which were separated by a horizontal distance of 140 mm. A third bar was placed between the flankers either 2 mm to the left or right of the true horizontal centre.

For the *baseline* condition, three black bars were superimposed over a black horizontal line and placed in the centre of a sheet of white A4 paper. There were four baseline trials, with half of the trials bisected to the left or right (see Fig. 1).

For the *near* and *far* conditions, three white bars were superimposed over black and white photographic images, which were 250 mm wide and 160 mm high. The three bars were aligned with

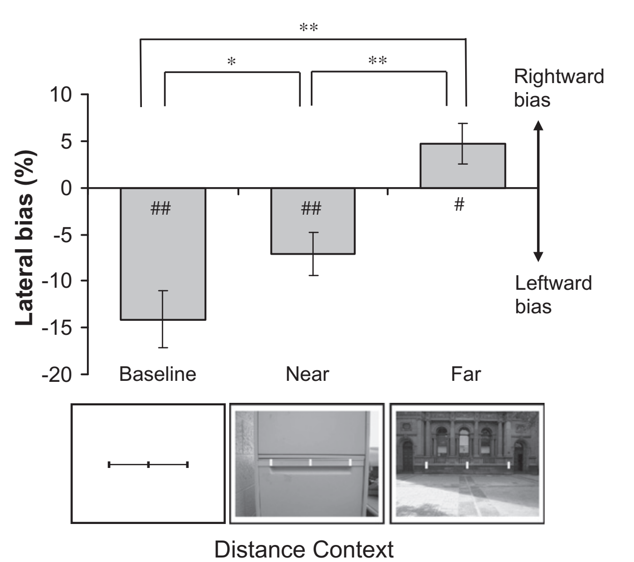

Fig. 1. Mean lateral bias (with ±SE bars) for the baseline, near and far conditions. Negative and positive lateral bias scores indicate leftward and rightward biases, respectively. Results for one sample *t*-tests, comparing each of the conditions with zero are shown along the *x* axis (# = $p < .05$; ## = $p < .001$). Results of post hoc comparison *t*-tests are shown with the bars above (* = $p < .05$; ** = $p < .001$). Examples of the stimuli used in the baseline, near and far conditions are shown below.