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Walking blindfolded unveils unique contributions of behavioural approach and inhibition to lateral spatial bias

Mario Weick [a,*], John A. Allen [a], Milica Vasiljevic [b], Bo Yao [c]

[a] School of Psychology, University of Kent, UK
[b] Behaviour and Health Research Unit, University of Cambridge, UK
[c] School of Psychological Sciences, University of Manchester, UK

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ABSTRACT

Healthy individuals display a tendency to allocate attention unequally across space, and this bias has implications for how individuals interact with their environments. However, the origins of this phenomenon remain relatively poorly understood. The present research examined the joint and independent contributions of two fundamental motivational systems – behavioural approach and inhibition systems (BAS and BIS) – to lateral spatial bias in a locomotion task. Participants completed self-report measures of trait BAS and BIS, then repeatedly traversed a room, blindfolded, aiming for a straight line. We obtained locomotion data from motion tracking to capture variations in the walking trajectories. Overall, walking trajectories deviated to the left, and this tendency was more pronounced with increasing BIS scores. Meanwhile, BAS was associated with relative rightward tendencies when BIS was low, but not when BIS was high. These results demonstrate for the first time an association between BIS and lateral spatial bias independently of variations in BAS. The findings also contribute to clarify the circumstances in which BAS is associated with a rightward bias. We discuss the implications of these findings for the neurobiological underpinnings of BIS and for the literature on spatial bias.

1. Introduction

Striving for outcomes that benefit the organism, and being vigilant for threats, are two fundamental survival strategies in many species (Wilson, Coleman, Clark, & Biederman, 1993). The behavioural approach system (BAS; Gray, 1972) and the behavioural inhibition system (BIS; Gray, 1975, 1990) are two analogous regulatory mechanisms that are manifested in affective, cognitive, and behavioural traits (Carver & White, 1994; Fowles, 1980). Activation of BAS is linked to the experience of positive affect and goal-directed behaviour. In contrast, activation of BIS is linked to the experience of anxiety, increased sensitivity to threatening cues, and disruption of ongoing processes. The aim of the present research is to probe the independent and joint associations of these motivational orientations with spatial attention.

1.1. Lateral bias and BAS

Activation in the contralateral cerebral hemisphere modulates the orientation of attention (e.g., Kinsbourne, 1970; Milner, Brechmann, & Pagliarini, 1992). Accordingly, temporal or enduring shifts in the balance of activation in the two hemispheres are associated with a bias in attention to the left or to the right side of space. Researchers often employ the line-bisection task to examine such shifts in hemispatial attention (for review see Jewell & McCourt, 2000). The task requires individuals to segment lines into two equidistant elements. The magnitude and the extent of bisection errors correlate with lateralised neural activity (Nash, McGregor, & Inzlicht, 2010).

Approach motivation is associated with greater relative left (vs. right) prefrontal brain activation (see Coan & Allen, 2003a; Harmon-Jones & Allen, 1997), reflecting asymmetries in dopaminergic signalling (Berridge, España, & Stalnaker, 2003). Several studies have linked approach motivation to right-oriented lateral bias. For example, Tomer (2008) observed a strong association between lateral bias assessed using a greyscale task (Nicholls, Bradshaw, & Mattingley, 1999) and self-reported novelty seeking – a construct that correlates with self-reported approach motivation (Carver & White, 1994; Mardaga & Hansenne, 2007). Employing an

* Corresponding author at: School of Psychology, University of Kent, Keynes College, Canterbury, Kent CT2 7NP, UK.
E-mail address: m.weick@kent.ac.uk (M. Weick).

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experimental manipulation of approach motivation, Friedman and Förster (2005, Study 3) found a greater right-oriented bias relative to participants in a neutral state of mind.

The circumstances in which approach motivation induces a shift in attention have come under scrutiny. Roskes, Sligte, Shalvi, and De Dreu (2011) argued that the right-oriented bias observed in approach-motivated individuals only arises under high time pressure. In their analysis of Fédération Internationale de Football Association (FIFA) World Cup penalty shootouts, Roskes and colleagues found that goalkeepers were more likely to dive to the right than to the left in penalty shootouts, but only when their team was behind. Following a failed attempt to replicate these results in other major football tournaments (Price & Wolfers, 2014), Roskes, Sligte, Shalvi, and De Dreu (2014) conceded that it remains unclear under which circumstances approach-motivation is linked with a right-oriented bias. Their remark dovetails the findings of Nash et al. (2010, Study 2), who found that people with high self-esteem are more oriented to the right than people with low self-esteem, but this discrepancy only emerged after people re-lived a personal dilemma.

In sum, converging evidence suggests that approach-motivation is associated with a right-oriented bias, but little is known about the circumstances that engender the bias. In the present research we sought to address this, separating the contributions of BAS and BIS to lateral bias.

1.2. Lateral bias and BIS

Compared to BAS, the neurological underpinnings of BIS have been elusive and subject to conceptual disagreements (see Amodio, Master, Yee, & Taylor, 2008, for a review). Some researchers conceptualised BIS as behavioural avoidance, anatomically linked to right-sided activity in the prefrontal cortex. However, this conceptualisation ignores the fact that the motivation to escape harm (withdrawal) is *not* mediated by BIS in Gray's framework (Gray & McNaughton, 2003). Furthermore, a number of studies failed to establish a link between BIS and frontal asymmetry, casting further doubt on the lateralisation of BIS (e.g., Coan & Allen, 2003b; De Pascalis, Cozzuto, Caprara, & Alessandri, 2013; Harmon-Jones & Allen, 1997; Wacker, Heldmann, & Stemmler, 2003; but see Peterson, Gable, & Harmon-Jones, 2008).

According to Heller (1993), threatening conditions prime the right hemisphere and trigger higher activity in right posterior areas. This anxiety/arousal function is consistent with a right-sided orienting network for attention, which responds to novel and unexpected events and acts as a "circuit breaker" for focal processing (Corbetta & Shulman, 2002, p. 212). Increased activation in BIS mediates the experience of anxiety and facilitates the disruption of ongoing behaviour (Carver & White, 1994; Fowles, 1980, 1988; Gray, 1982). Thus, there are strong grounds to assume an association between BIS and posterior hemisphericity. This assumption has received preliminary support in EEG studies (Balconi, Brambilla, & Falbo, 2009; Hewig, Hagemann, Seifert, Naumann, & Bartussek, 2006).

To date, little is known about the independent association between BIS and orientating bias. Some studies examined the consequences of behavioural avoidance for performance on the line bisection task (Friedman & Förster, 2005; Roskes et al., 2011). However, since avoidance was conceptualised as withdrawal in these studies, which as discussed above is not mediated by BIS, the findings have limited relevance. In another line of work, Wilkinson, Guinote, Weick, Molinari, and Graham (2010), found that inducing a sense of powerlessness experimentally fostered a left-oriented bias in two motor tasks. Whilst consistent with the framework discussed here, one can only speculate about the involvement of BIS in the effects of powerlessness. It is important to note that experimental manipulations aimed at increasing activation in BIS may also inadvertently reduce activation in BAS, thus confounding the individual contributions of the two motivational systems to lateral bias.

Garner et al. (2012) found that individuals scoring simultaneously high on BIS *and* low on BAS exhibited a stronger leftward bias in visual orienting than individuals scoring simultaneously high on BAS *and* low on BIS. These results are consistent with a right-sided specialisation for BIS (inducing a leftward attentional bias). However, grouping participants into two quadrants – high BIS/low BAS and low BIS/high BAS – creates a perfect correlation between BIS and BAS. Consequently it remains unknown whether Garner and colleagues' findings speak to an effect of BIS that occurs independently of variation of BAS, an effect of BAS that occurs independently of variation in BIS, or an effect that derives from an interaction of the two motivational systems.

To summarise, the cognitive neuroscience literature points to a right hemisphere specialisation for BIS. However, compared to BAS, the hemisphericity of BIS is less well understood. Importantly, at present there is no conclusive evidence that activation in BIS fosters a left-oriented bias in attention independently of variation in BAS.

1.3. The present research

In the present research, we sought to probe the individual and joint contributions of BAS and BIS to lateral spatial bias. Doing so provides the first empirical test of an independent association between BIS and lateral spatial bias, and furthers our understanding of how individual differences are manifested in neurobiological processes. It also sheds light on the circumstances in which activation in BAS is associated with a right-oriented bias (cf. Price & Wolfers, 2014; Roskes et al., 2014).

In order to probe spatial bias in a task that is sufficiently demanding for self-regulatory dispositions to manifest (see Coan, Allen, & McKnight, 2006), we asked participants to walk across a room in a straight line, blindfolded, aiming for a target on the other side. This task capitalises on the fact that the orientation bias manifests itself in mental representations of space (see Brooks, Della Sala, & Darling, 2014, for a review). In absence of visual feedback, people often depart from a straight trajectory and deviate to either side (e.g., Boyadjian, Marin, & Danion, 1999; Vuillerme, Nougier, & Camicioli, 2002). We expected individual differences in self-reported BIS and BAS to uniquely account for variations in participants' walking trajectories. We used motion tracking to capture participants' locomotion during task performance.

2. Method

2.1. Participants

Eighty right-handed students at a British University participated for course credits. Locomotion data from two participants were lost due to a technical error, thus leaving a final sample of 78 participants (60 females, 17 males, 1 other gender; $M_{Age} = 20.15$, $SD_{Age} = 4.15$). All participants had normal or corrected-to-normal vision, and none reported any history of motor problems or neurological disease.

2.2. Materials

2.2.1. Individual difference measures

Participants completed the trait BAS/BIS inventory (Carver & White, 1994), embedded in a battery of unrelated questionnaires.