Approach and Avoidance Motivation: Visual Asymmetries And Replicability

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Summary

Two possible responses to environmental stimuli exist, approach or avoidance. Approach motivation is defined as goal attainment, whereas avoidance motivation is defined as withdrawal from threat. The decision to approach or avoid a stimulus is the cornerstone for which all proceeding behaviour is based on. The current thesis sought to expand on previous motivational research, which has indicated that line bisection can effectively measure approach and avoidance motivational lateralisation. No evidence was found to suggest that either the landmark or greyscales tasks can reliably measure motivational lateralisation, suggesting that more research is needed to fully understand what conditions are required for visuospatial tasks to reliably reflect motivational processes. The effect of approach and avoidance motivation was also explored within the upper and lower visual fields, as well as at near and far distances. No evidence was found to suggest that either elevational position or proximal position affect motivational judgements.

A lack of significant results made it difficult to significantly expand existing theoretical models of approach and avoidance lateralisation; however, several key points relating to psychological science as a whole were explored. The current thesis provided evidence that suggests publication biases are inflating the number of significant findings that are reported in published works and that this problem is worse now than it was fifty years ago. Despite this, the psychological community has recently begun to openly discuss changes that might be implemented to reduce publication biases and increase the validity and replicability of published work. The current thesis explored one promising solution to publication biases – registered reports. Registered reports were found to have many advantages over more traditional publication procedures, such that the soundness of methodological and analytical procedures could be insured before data collection even began.

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I dedicate this thesis to my family: Steph, Mum, Dad, Brett and Bella. By some twist of fate I was lucky enough to marry a smart, hardworking and beautiful young woman who supported me throughout my PhD. Steph, your unconditional love and support have contributed more to this PhD than you might realise, I love you. Mum, Dad and Brett, it might seem like this thesis is a long way from cray fishing in the Bay, but the lessons I learned about commitment, hard work and perseverance served me well during my PhD. I love all you guys.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Research from this thesis has been, or will be, published in the following articles:

Leggett, N. C., Thomas, N. A., Loetscher, T., & Nicholls, M. E. R. (2013). The life of p: "Just significant" results are on the rise. *The Quarterly Journal of Experimental Psychology, 66*(12), 2303-2309. doi: 10.1080/17470218.2013.863371

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4th North Sea Meeting on Brain Asymmetries. *Lateral shifts for approach and avoidant stimuli: A failure to replicate.*

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42nd Australasian Experimental Psychology Conference. *The thin line between approach and avoidance: Line bisection cannot measure motivation lateralization.*

"We simply assume that the way we see things is the way they really are or the way they should be. And our attitudes and behaviours grow out of these assumptions. The way we see things is the source of the way we think and the way we act…"

Stephen R. Covey

Foreword: Origins of Laterality

Early in the nineteenth century, the idea that a particular cognitive process could be localised to any one specific region of the brain was largely dismissed (Thompson-Schill, 2005), as were phrenologists' reports of selective language impairments following damage to the frontal lobes (Gall & Spurzheim, 1809). Resistance to such claims first began weakening in 1861, when Pierre Paul Broca reported on Leborgne, a 51-year-old patient who had been unable to produce speech for several years. Following Leborgne's autopsy, Broca linked a lesion on the surface of her left frontal lobe to her deficits in producing speech (Broca, 1861a, 1861b). Over the next few years, Broca was presented with more cases of patients who had speech deficits, as well as left frontal lobe damage. This led Broca to conclude that speech must be localised to the left frontal lobe, specifically to what is now known as 'Broca's area' (Broca, 1865).

Broca's initial discovery was the first to provide scientific evidence for theories of lateralisation. Since then, other lateralised functions have been discovered, including left-hemisphere processes such as language (Frost et al., 1999; Wernicke, 1970) and right-hemisphere processes such as facial perception (Kanwisher, McDermott & Chun, 1997) and attentional allocation (Kinsbourne, 1970; Posner & Petersen, 1989). Other processes, such as motivation (Elliot & Covington, 2001), have been found to be lateralised across both hemispheres, with approach motivation displaying left-hemisphere dominance and avoidance motivation showing right-hemisphere dominance. The current thesis focuses on the interaction between attentional allocation and motivation, with the former being discussed first.

Chapter 1: Lateralisation of Attention

The longitudinal fissure divides the human brain into the left and right hemispheres, which are connected by the corpus callosum (Cameron, 1917). The left and right sides of the brain control the contralateral sides of the body, as well as receiving visual, auditory, and tactile information from the contralateral side (see Figure 1). As such, attentional allocation to the left side of space is controlled by the right hemisphere, and attention to the right side of space is controlled by the left hemisphere (Kinsbourne, 1970).

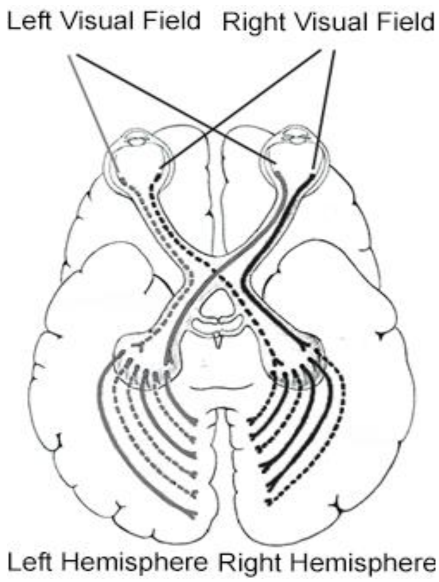

Figure 1. Depiction of the visual system, displaying left visual field information going to the right hemisphere and vice versa.

Hemispatial Neglect

Definition

Neglect is characterised by patients' inability to attend to stimuli in their left visual field (Adair & Barrett, 2008). Hemispatial neglect occurs after damage to posterior aspects of the right cerebral cortex, usually after stroke (Ringman, Saver, Woolson, Clarke & Adams, 2004). Specifically, neglect can occur after damage to the temporoparietal junction and/or inferior parietal lobule, as well as multiple discrete cortical and subcortical structures in the right hemisphere (Adair & Barrett, 2008; Bartolomeo, 2007, 2014). According to Kinsbourne's (1970) activation-orientation hypothesis, hemispatial neglect is caused by asymmetrical activation of the left and right hemispheres during visuospatial attention tasks. The damaged right hemisphere is unable to inhibit the left, which presents behaviourally as over-attending to the right side of space, while neglecting the left. It is worth noting that although neglect can occur after left hemisphere damage, this form of neglect occurs less frequently and is generally less severe (Kleinman et al., 2007). This might be because the right hemisphere is responsible for more global spatial representations, whereas the left hemisphere is responsible for more focussed representations. As such, patients with left-hemisphere brain damage are likely to be able to recognise and attend to, at least part of, objects in the right side of space (Kleinman et al., 2007).

Symptomology

Neglect is accepted to be an attentional disorder, as patients display neglect symptoms in the absence of any sensory or motor deficits (Adair & Barrett, 2008). Additionally, symptoms can occur cross-modally, with patients commonly neglecting sounds on their left side, stimulation to the left side of their body or even neglecting the left of imagined or remembered scenes (Parton, Malhotra & Husain, 2004). As the left hemisphere is relatively more active than the damaged right hemisphere, neglect patients also have difficulty with disengaging from right side distracters (Mort et al., 2003). Even when actively looking at the left side of an object, patients will show no awareness of that side (Ferber, Danckert, Joanisse, Goltz & Goodale, 2003; Heilman & Valenstein, 1979), unless they are prompted to do so (Heilman & Valenstein, 2011). Difficulties with mobility are also a common issue, as patients have been shown to consistently deviate to the right while walking[1] (Grossi, Lepore, Napolitano & Trojano, 2001; Huitema et al., 2006; Robertson, Tegnér, Goodrich & Wilson, 1994; Turton et al., 2009), and are prone to bump into objects on their left side (Paolucci et al., 2001; Teasell, McRae, Foley & Bhardwaj, 2002). Other examples of symptoms include ignoring food on the left side of their plate or only washing the right side of their body (Adair & Barrett, 2008).

[1] Some research has reported walking deviations on both left and right sides for neglect patients, possibly tied to neglect severity (Tromp, Dinkla & Mulder, 1995) and leftward deviations while using a wheelchair (Turton et al., 2009; Webster et al., 1995).

Diagnosis

Hemispatial neglect can be diagnosed via a number of methods. The most common of these is the paper-and-pencil line bisection task, where patients are asked to bisect a line at the midpoint. Neglect patients consistently bisect lines far to the right of true centre, due to over-attending to the right, and neglecting the left, side of space (Heilman & Valenstein, 1979). A similar version of line bisection is the landmark task, where patients are presented with a pre-bisected line (commonly bisected at the midpoint) and asked which side of the line is longer. Patient show a strong rightward bias here also, which exemplifies the attentional nature of hemispatial neglect, as motor biases would not be reflected in this version of the task (Harvey & Miller, 1995).

Another perceptual task is the greyscales task, which requires patients to judge the overall darkness of two left–right mirror-reversed luminance gradients. For each stimulus pair, one of the greyscales is shaded black to white, from left to right, and the other is shaded in the reverse direction (see Figure 2). Because the stimuli are aligned vertically, patients' responses (top or bottom) are orthogonal to the direction of interest, thus reducing the potential influence of lateral response biases. Neglect patients display a strong rightward bias on this task, as they do not attend to the left of either brightness gradient and thus perceive one as being much darker overall (Mattingley et al., 2004; Mattingley, Bradshaw, Nettleton & Bradshaw, 1994).

Figure 2. Example of the greyscales task

The chimeric faces task is also used to diagnose hemispatial neglect. In this task, patients view a composite face that is sad on one half and happy on the other (see Figure 3). When asked whether the face is overall more happy or sad, patients neglect left, and report only right, side emotional qualities (Mattingley et al., 1994). Chimeric faces are a useful early method of diagnosis, as patients' attentional deficits result in quick and confident responses, despite the facial stimuli being equal parts happy and sad.

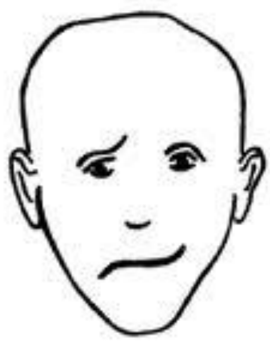

Figure 3. Example of chimeric face stimuli

Neglect Sub-types

Egocentric and Allocentric Neglect

Two distinguishable forms of neglect, egocentric (viewer-centred) and allocentric (object-centred), have been observed (Adair & Barrett, 2008; Doricchi & Incoccia, 1998; E. B. Marsh & Hillis, 2008). Egocentric neglect is characterised by the neglect of the left side of space in reference to the patient's midline. In a case study of two patients with egocentric neglect, Bisiach and Luzzatti (1978) asked each person to imagine they were first standing in front of the Piazza Del Duomo, a highly familiar plaza. They were then asked to describe what they imagined seeing. Both patients recalled more details from their right visual field compared to their left. Next, each patient was asked to imagine they were looking at the Piazza from the back, instead of the front. Again, both patients recalled more details from their right visual field compared to left. As such, the neglected space from one condition later became the attended space, demonstrating that the attentional deficit was based on the patient's vantage point, rather than the physical stimuli itself.

Allocentric neglect, on the other hand, is the neglect of the left side of an object (Hillis, Rapp, Benzing & Caramazza, 1998). Caramazza and Hillis (1990) found that patients with allocentric neglect made more spelling errors on the beginning (left) half of words, regardless of whether the word was presented left-to-right, rotated ninety degrees, or mirror-reversed. The cancellation task (see Figure 4), where patients are asked to find targets amongst an array of targets and distracters, is a useful tool for diagnosing allocentric neglect. In Figure 4, targets are open ended circles ("c"). If the patient had egocentric neglect, targets on the left side of the array would not have been crossed out. Instead, the patient with allocentric neglect has been unable to cross out targets with the salient feature (the gap) on the left side of each target, regardless of the spatial location. This shows that patients with allocentric neglect are unable to attend to the left side of objects, based on the inherent left-right orientation of the object itself and regardless of the spatial position of the patient.

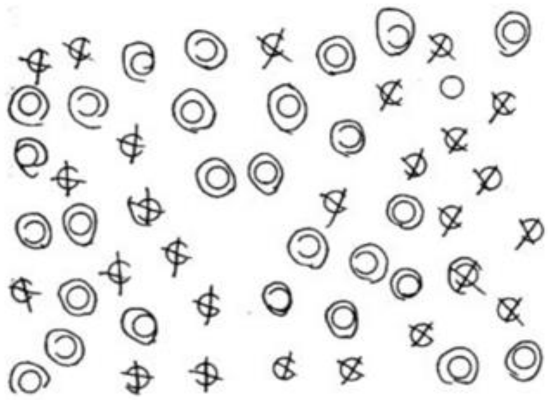

Figure 4. Example of a cancellation task completed by a patient with allocentric neglect (Adair & Barrett, 2008). The patient neglects circles with gaps on the left side, regardless of spatial location.

As well as displaying behavioural differences, egocentric and allocentric neglect reflect damage to dissociable brain regions (Hillis, 2005). Prior to analysing patients' brains via magnetic resonance imaging (MRI) procedures, Hillis (2015) categorised neglect patients, via a standard battery of neglect tests (e.g., cancellation task, scene copying task), as suffering from egocentric, allocentric or both forms of neglect. The MRI data showed that egocentric neglect was associated with the angular gyrus and the supramarginal gyrus, whereas allocentric neglect was most strongly associated with the superior temporal gyrus and the posterior inferior temporal gyrus. Hillis (2005) found that of 16 hemispatial neglect patients, 25% presented with exclusive allocentric neglect, 70% with exclusive egocentric neglect, and 1 patient with both allocentric and egocentric neglect.

Input- and Output-based Neglect

Neglect can also be characterised by two separate groups of symptoms. The first is sensory attentional (input-based) neglect, which encompasses deficits in perceiving visual stimuli, and the second is motor intentional (output-based) neglect, which describes deficits in directing movement toward the left side of space. In a study by Loetscher and colleagues (2012), brain damaged patients were asked to manually bisect lines at the midpoint. Seventy-five percent of the 16 patients bisected significantly to the right of actual centre, demonstrating hemispatial neglect. Of this majority, only twenty-five percent were able to easily recognise their erroneous bisections afterwards, indicating a unique deficit in directing movement to the left, but not in directing attention leftward. These data show that input- and output-based deficits are dissociable and suggest that separate brain regions might be linked to input- and output-based processes (Adair & Barrett, 2008; Bartolomeo & Chokron, 2001; Bisiach, Ricci, Lualdi & Colombo, 1998; Schwartz, Barrett, Kim & Heilman, 1999).

Distance

Neglect symptoms can be confined to, or present across, three different spatial proximities; personal, peripersonal (near), and extrapersonal (far) space (Halligan & Marshall, 1991; Previc, 1990). Personal space is the region of space occupied by the body. Personal neglect presents in the absence of physical motor impairments and patients do not recognise, nor can they use, limbs on the left side of their body (Guariglia & Antonucci, 1992; Halligan & Marshall, 1991). Peripersonal space is defined as space not touching the body, but within arm’s reach (Previc, 1990). Patients with peripersonal neglect are unable to attend to stimuli on the left side, within their reachable space. These patients may or may not show signs of neglect when attending to stimuli outside of arm’s reach. Patients with extrapersonal neglect, on the other hand, are unable to attend to leftward stimuli outside of their reachable space, while not necessarily presenting with any attentional deficits within personal or peripersonal space.

Research has shown that neglect within near and far spaces are dissociable. Halligan and Marshall (1991) reported on a neglect patient who displayed neglected for stimuli within near space but not for stimuli within far space. Other research has found that small samples of neglect patients display stronger neglect for stimuli in far, compared to near, space (Berti et al., 2002; Cowey, Small & Ellis, 1994; Pitzalis, Di Russo, Spinelli & Zoccolotti, 2001). Attentional mechanisms for near and far space have also been shown to be dissociable. Lesion analyses have suggested that near space processes are based in the dorsal stream (see Figure 5), from the visual cortex to the posterior parietal lobe - including the dorsal occipital cortex, intraparietal cortex, ventral premotor cortex and thalamus (Butler, Eskes & Vandorpe, 2004; Committeri et al., 2007). Far space processes have been linked to the ventral steam, from the visual cortex to the inferior temporal lobe – including the ventral occipital cortex and the medial temporal cortex (Butler et al., 2004; Committeri et al., 2007). Research also links the dorsal and ventral streams to attentional allocation to the upper and lower visual fields, respectively (Cappelletti, Freeman & Cipolotti, 2007).In this way, the lower and upper visual fields are tightly linked to near and far space (Previc, 1990).

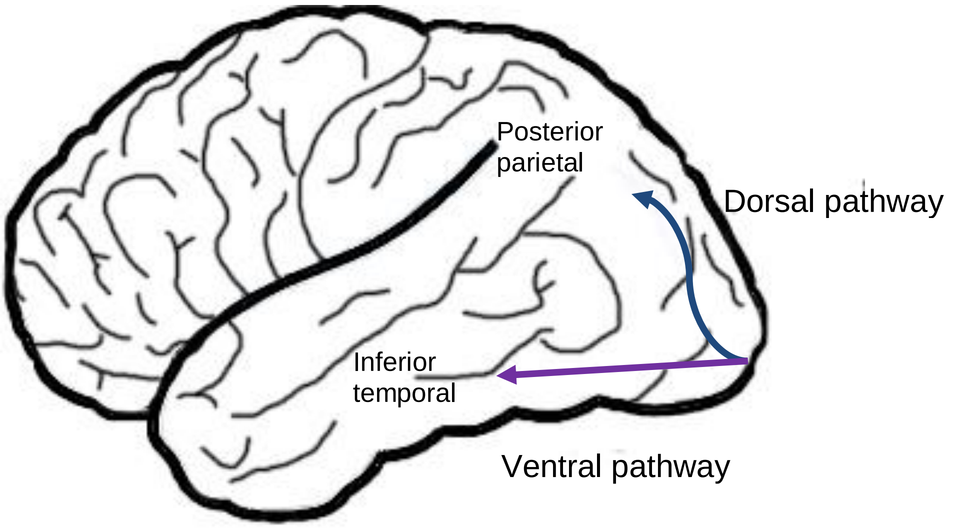

Figure 5. Visual depiction of the dorsal and ventral streams of processing

Treatment

Unfortunately, treatment options for hemispatial neglect are limited in both their availability and effectiveness. Treatments take either a top-down, or a bottom-up approach. Top-down therapies focus on cognitive strategies aimed at helping patients attend to the neglected space. For example, scanning strategies can help patients shift their whole field of vision leftward, such that previously unattended left space moves to the centre of a patient's vision and can be attended more easily. While these therapies are less invasive and can be effective, they also require patients to be aware of their disorder, which can be problematic due to the frequency of which patients lack of awareness of their disability (anosognosia).

Bottom-up therapies require less active involvement from patients than their top-down counterparts and rely more on physical therapies. Some bottom up therapies seek to shift attention leftward, either by stimulating left neck muscles to induce leftward heard turns or by administering a small amount of cold water to the right ear canal to elicit leftward eye scanning (Adair & Barrett, 2008). Less invasive bottom-down therapies shift patients' visual field leftward by presenting leftward moving stimuli or by using prismatic glasses. Prismatic adaptation involves patients wearing lenses that shift their visual field 10 to 12 degrees to the *right* side of space. After visuomotor adaptation, the glasses are removed and an after-effect is observed (Rossetti et al., 1998), such that attention is shifted to the left, previously neglected, side of space. Prismatic adaptation is effective in the treatment of hemispatial neglect, with some studies suggesting that prismatic adaptation can last up to three weeks (Luaute, Halligan, Rode, Rossetti & Boisson, 2006; Newport & Schenk, 2012; Pisella, Rode, Farne, Tilikete & Rossetti, 2006).

Pseudoneglect

Whereas the neglect of the left visual field is obvious in clinical populations, a more subtle bias towards the left, termed pseudoneglect, exists in the normal population (Bowers & Heilman, 1980; Bradshaw, Bradshaw, Nathan, Nettleton & Wilson, 1986; Jewell & McCourt, 2000). Pseudoneglect and clinical hemispatial neglect are thought to have similar theoretical and neurological underpinnings, whereby underlying brain mechanisms responsible for the attentional deficits in neglect are also responsible for pseudoneglect (McCourt & Jewell, 1999). McCourt and Jewell (1999) tested both hemispatial neglect patients and normals on variations of the line bisection task. They found that response biases from both groups were similarly affected by several stimulus factors: leftward line position increased biases, thicker lines elicited lesser biases and neglect patients' biases decreased as line elevation increased, whereas normals' biases increased as line elevation increased. These data provide behavioural evidence for a shared neurological underpinning of hemispatial neglect and pseudoneglect.

Brain imaging and stimulation studies also support the theory that neglect and pseudoneglect share neurological mechanisms. Hemispatial neglect mainly occurs after damage to right parietal brain regions, resulting in an impaired ability to disengaging from, and attend to, right and left stimuli, respectively (Adair & Barrett, 2008; Bartolomeo, 2007, 2014). Functional MRI (fMRI) studies have found that the right superior and right inferior parietal lobules are activated while normals complete visuospatial attentional tasks (Cicek, Deouell & Knight, 2009; Gereon R Fink et al., 2000). Transcranial direct current stimulation (tDCS) has also linked posterior parietal regions to processes of attentional allocation, with Loftus and Nicholls (2012) finding increased and decreased pseudoneglect during neuronal excitation of the right and left posterior parietal lobules, respectively. Because pseudoneglect and hemispatial neglect share a neurological basis, a greater understanding of neglect can be gained by investigating the natural leftward bias of typical people.

Pseudoneglect is stronger in dextrals (Jewell & McCourt, 2000) and weaker in older populations (Benwell, Harvey, Gardner & Thut, 2013; Schmitz, Dehon & Peigneux, 2012). Although pseudoneglect is a smaller bias than that of hemispatial neglect, over attention to the left has been found to cause people to bump into things on their right (Nicholls, Loftus, Mayer & Mattingley, 2007; Turnbull & McGeorge, 1998) and professional sports people to miss shots on goal to the right more often than the left (Nicholls, Loetscher & Rademacher, 2010).

The last few decades of pseudoneglect research has, for the most part, concluded that Kinsbourne's (1970) activation-orientation hypothesis, which states that attention is biased in the opposite direction to the more relatively activated hemisphere, best describes the mechanism driving pseudoneglect (Kim et al., 1999; Ungerleider & G, 2000). For example, Siman-Tov et al. (2007) briefly presented participants (150 ms) with images of faces or houses in the left or right visual field. Using an MRI paradigm, they found that areas associated with covert visuospatial attention (dorsal and ventral frontoparietal regions as well as subcortical structures such as the thalamus and basal ganglia) were preferentially activated by left visual field stimuli. Although such evidence supports a *Laterality Account* of pseudoneglect, there remains some debate as to how greatly other mechanisms, such as scanning or motor biases, contribute to the effect of pseudoneglect.

Influence of scanning

Investigations into the effect of scanning on visual biases have returned mixed results. These studies often rely on comparing native left-to-right and right-to-left reading populations, which have been shown to initiate visual scans from opposing sides (Chokron, Bartolomeo, Perenin, Helft & Imbert, 1998). Several studies have found that left-to-right readers over attend to leftward stimuli, whereas right-to-left readers either show no bias or over attend to rightward stimuli (Bradshaw et al., 1986; Brodie & Pettigrew, 1996; Chokron et al., 1998). Other research suggests that visuospatial biases occur even when scanning is controlled for (Bultitude & Aimola Davies, 2006; McCourt & Olafson, 1997; Nicholls & Roberts, 2002). Nicholls and Roberts (2002) experimentally manipulated scanning direction on a line bisection task by asking participants to stop a marker at the centre of the line. This marker either travelled from the left end to the right, inducing a rightwards scan, or from the right end to the left, inducing a leftwards scan. Motor biases were controlled through the use of bimanual responses. No difference in response biases were found between scanning conditions, and participants bisected lines significantly leftward in each condition. McCourt and Olafson (1997) also controlled for scanning biases, by presenting the landmark task tachistoscopically (for 150 ms), which did not allow time for eye movements (see also Bultitude & Aimola Davies, 2006). Their data revealed significant pseudoneglect, despite participants being unable to scan landmark stimuli. These studies indicate that, at the very least, a large component of pseudoneglect is due to perceptual mechanisms.

More recently, research has suggested an ‘Interactive Account’ of pseudoneglect, which states that attentional biases are modulated by scanning direction (Rinaldi, Di Luca, Henik & Girelli, 2014). Rinaldi et al. (2014) tested two monolingual groups (left-to-right Italians and right-to-left Israelis) and a bilingual group (bilingual Israelis) on two versions of a cancellation task. One version included English words and letters, the other Hebrew words and letters, as distracter stimuli. They found that left-to-right readers showed an overall leftward bias on both versions of the cancellation task, right-to-left readers showed an overall rightward bias on both versions and bilingual participants showed no bias on either cancellation tasks. Given that the Italian and Israeli groups displayed differential biases on the cancellation tasks, a wholly 'Laterality Account' of pseudoneglect is not supported by this data. Instead, based on the fact that the Israeli group's rightward bias was not simply a mirror of the Italian group's leftward bias, an 'Interactive Account' of pseudoneglect is more likely. This interactive account suggests that neurobiological asymmetries drive pseudoneglect and scanning direction modulates this effect (Rinaldi et al., 2014).

Spatial planes of pseudoneglect

Dissociable perceptual mechanisms have been found to allocate attention across vertical and proximal spatial dimensions (Previc, 1990). Differences in attentional biases have been observed between stimuli in near and far space (Longo & Lourenco, 2006), as well as between stimuli in the upper and lower visual fields (Thomas & Elias, 2011).

Distance

Just as dissociations between peripersonal and extrapersonal clinical neglect have been found (Butler et al., 2004; Committeri et al., 2007; Halligan & Marshall, 1991; Keller, Schindler, Kerkhoff, Rosen & Golz, 2005), dissociable brain regions allocate attention in near and far space. Two positron emission tomography (PET) studies observed greater cerebral blood flow in the dorsal and ventral streams while participants undertook visuospatial tasks in near and far space, respectively (Weiss et al., 2000; Weiss, Marshall, Zilles & Fink, 2003). Dorsal regions include left parietal and left premotor cortices whereas ventral regions include the occipital cortex (bilaterally) extending through the lingual gyrus and the hippocampal gyrus into the medial occipitotemporal cortex (Weiss et al., 2003). Research has shown that the ventral stream is lateralised to the right hemisphere (Corbetta & Shulman, 2011; Vossel, Geng & Fink, 2014). Thus, visuospatial tasks that draw on dorsal stream processes (e.g., near space tasks) produce leftward attentional biases (McCourt & Jewell, 1999; Thomas & Elias, 2010). However, depleting right hemisphere ventral stream processes, via far space tasks, biases attention to the right (Corbetta & Shulman, 2011).

Dorsal and ventral links to near and far space, respectively, have been demonstrated behaviourally. Dorsal stream processes have an egocentric frame of reference and focus on object movement and manipulation, the *where* of the stimuli. Ventral stream processes, on the other hand, have an allocentric frame of reference and focus on recognising and identifying objects, the *what* of stimuli (Goodale, Milner, Jakobson & Carey, 1991). Several studies have asked participants to bisect lines, using a laser pointer, at various distances from the body. Typically, pseudoneglect is found for lines within reachable space and a gradual rightward shift emerges as distance increases beyond reachable space (Longo & Lourenco, 2006). The gradual nature of the representation of space as near or far suggests that, although both dorsal and ventral processes are active within all regions of space, the level of activation depends on distance. This research supports neurological data and highlights the dissociable processing of near and far space (Varnava, McCarthy & Beaumont, 2002; D. Wilkinson & Halligan, 2003).

Although near space is generally described as the space within arm's reach, several studies have shown that near representations can be both expanded and contracted. Longo and Lourenco (2006) asked participants to bisected lines at various distances, using either a long stick or a laser pointer. When the laser pointer was used, pseudoneglect gradually decreased as distance increased. However, when the long stick was used, far space was remapped as near space and leftward biases were observed across all distances (see also Ladavas, 2002). The expansion of near space has also been observed, during wheelchair use (Galli, Noel, Canzoneri, Blanke & Serino, 2015), walking (Noel et al., 2015), and in people high claustrophobic fear (Lourenco, Longo & Pathman, 2011). Seraglia, Priftis, Cutini and Gamberini (2012) have suggested that far space, up to 2.4 meters, can be remapped as near space. The opposite effect can also be observed, with Coello, Bourgeois and Iachini (2012) finding that peripersonal space decreased when threatening stimuli were orientated towards participants.

Upper and lower visual fields

Attentional allocation to the upper and lower visual fields is closely linked to near and far space (Previc, 1990). The link between near/lower and far/upper stimuli is likely due to similarities between stimulus properties within these regions. Previc (1990) posits that stimuli in the lower visual field are most likely to be in near space and thus processed by the dorsal stream. Conversely, stimuli in the upper visual field are likely to be in far space and therefore processed by the ventral stream. During a visual search task, Loughnane, Shanley, Lalor and O'Connell (2015) found that participants were quicker at detecting right side targets in the upper visual field and left targets in the lower visual field. Similarly, greater leftward biases have been found for the greyscales task when presented in the lower visual field (Thomas & Elias, 2011). These studies suggest that the dorsal stream allocates attention to both near space and the lower visual field, whereas the ventral stream allocated attention to both far space and the upper visual field.

Chapter 2: Approach and Avoidance Motivation

“Nature has placed mankind under the governance of two sovereign masters, pain and pleasure. It is for them alone to point out what we ought to do, as well as to determine what we should do… they govern us in all we do, in all we say, in all we think”

Bentham, 1907

Over the past half century, responses to pleasure and pain have been scientifically investigated in one way or another. Thorndike (1911) originally proposed the ‘law of effect’, which stated that responses leading to satisfaction are strengthened and responses leading to discomfort are weakened. This idea has been refined throughout the history of psychological science by: Pavlov (1927), who classified behaviour as either an orientation toward or away from a stimulus; Lewin (1935), who determined that goal-objects in the ‘life space’ possess positive or negative valence which attract or repel, respectively; Murray (1938), who defined adient needs that push an organism in a positive way toward an object and abient needs that force an organism to separate itself from an object; and Maslow (1955), who defined deficit needs, which seek to reduce negative states of tension, and growth states, which seek to increase positive stimulation.

Past research has culminated in two terms, approach and avoidance motivation, which define the cognitive processes responsible for the classification of, and the reaction to, positive and negative stimuli (see Elliot & Covington, 2001 for a review). Approach and withdrawal discriminations, or the evaluation of stimuli as either ‘good’ or ‘bad’, are the primary reaction of humans and animals alike, to environmental stimuli (Davidson, 1992; Schneirla, 1965; Zajonc & Markus, 1988). Approach motivation is driven by positively valenced stimuli and is congruent with goal attainment (e.g., eating a chocolate cake). Conversely, avoidance motivation is elicited by negatively valenced stimuli and presents as withdrawal behaviour, (e.g., fear reaction to a spider; Elliot, 1999; Elliot & Covington, 2001).

Lateralisation

Several studies exploring approach and avoidance reactions in various animal species have suggested that approach and avoidance motivation are right and left lateralised, respectively (see Vallortigara & Rogers, 2005 for a review). Several species have been shown to be more likely to withdraw from simulated predator stimuli, by jumping away, when the predator is presented within the left visual field compared to the right visual field (toads: Lippolis, Bisazza, Rogers & Vallortigara, 2002; dunnarts: Lippolis, Westman, McAllan & Rogers, 2005; chicks: Lippolis & Rogers, in preparation). Also, fear responses in rats have been shown to be reduced by right hemisphere lesions (R. Robinson, 1985). Conversely, feeding responses have been found to be left lateralised, such that toads preferentially strike prey in their right visual field (Vallortigara, Rogers, Bisazza, Lippolis & Robins, 1998) and many species of birds forage more from their right visual field (Güntürkün, 1993; Güntürkün & Kesch, 1987; Ventolini et al., 2005). These visual asymmetries reflect a lateralisation of approach and avoidance motivation in many animal species.

Neurological evidence

Neuroimaging studies have shown that approach and avoidance motivation are lateralised processes (Cacioppo, Priester & Berntson, 1993; Coan & Allen, 2003; Faries, Kephart & Jones, 2014; J. S. Maxwell, Shackman & Davidson, 2005). In an fMRI study, Spielberg and colleagues (2012) asked participants to complete an emotional Stroop task, which involved reporting the colour of approach, avoidance, and neutral words, while ignoring the meaning of the words. They found the suppression of approach and avoidance words was associated with activation of the left and right dorsolateral prefrontal cortices, respectively. Using a similar paradigm, Compton and colleagues (2003) also found greater involvement of right occipito-parietal regions in response to avoidance words, but failed to observe any asymmetries for approach words (see Spielberg et al., 2013 for a review).

Electroencephalogram (EEG) asymmetries also provide evidence for approach and avoidance lateralisation (Faries et al., 2014; Harmon-Jones, Gable & Peterson, 2010). Greater relative left prefrontal activation has been linked to increased approach-related positive affect and diminished avoidance-related negative affect (Tomarken, Davidson, Wheeler & Kinney, 1992), as well as greater trait behavioural activation (Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997). Depression, which is characterised by decreased levels of approach motivation, has also been linked to diminished left frontal cortical activity (Henriques & Davidson, 1990). Although there is a great deal of evidence for lateralised activation based on approach and avoidance motivation, some research has failed to find activational asymmetries during the presentation of approach and avoidant images (Uusberg et al., 2014).

Behavioural evidence

In addition to evidence from neuroimaging procedures, behavioural techniques such as auditory priming, body posture and congruent motor movements have also been used in support of motivational lateralisation.

Auditory Modality

Lateralised sounds have been shown to activate contralateral brain regions (Kinsbourne & Hicks, 1978), which in turn has been used to investigate motivational lateralisation. Fetterman, Ode and Robinson (2013) primed the left or right hemispheres by presenting unilateral sounds. Following this, participants had to categorise visually presented verbs as either approach- or avoidance-related. They found that priming the right hemisphere facilitated avoidance-related categorization and priming the left hemisphere facilitated approach-related categorization. Using a different paradigm, Friedman (2007) hypothesised that ascending tones would elicit approach motivation, whereas descending tones would elicit avoidance motivation. Across four experiments, Friedman found that descending tones impaired performance on an anagram task, hindered cognitive flexibility, promoted vigilance behaviours, and produced a leftward perceptual bias, all indicators of avoidance-related right hemisphere activation. Although no effects were found for ascending tones, Friedman reasoned that this might be because negative stimuli are intrinsically more salient than positive stimuli (Baumeister, Bratslavsky, Finkenauer & Vohs, 2001).

Body Posture

Positional asymmetries as well as body sway have been found to reflect dissociation between approach and avoidance motivation. Early research on attitudes defined cognitive responses to environmental stimuli as behavioural dispositions to act in a certain way (Allport, 1935; Bogardus, 1931). Lewin (1935) postulated that we assign positive and negative valence to environmental objects and events, which in turn directs our behaviour toward, or away from, stimuli. Osgood (1953) similarly argued that the positive or negative ‘sign’ of an object contains salient representations of approach- or withdrawal-related behaviours associated with that object. More recently, Lang, Bradley and Cuthbert (1990) argued that environmental stimuli immediately activate positive-approach or negative-avoidance responses. A novel example of behavioural priming through approach and avoidance motivation is that of kissing. Güntürkün (2003) observed that people are twice as likely to turn their head to the right, compared to the left, when kissing. He concluded that the increased activation of the left hemisphere, associated with approach motivation, predisposes the rightward turning of the head.

More experimentally, two studies have used Wii balance boards to measure participants' full body responses to approach and avoidance stimuli (Brunyé et al., 2013; Eerland, Guadalupe, Franken & Zwaan, 2012). Brunyé and colleagues (2013) asked participants to stand on a Wii balance board and observe images of various foods. Following this, participants rated the images on a 5-point Likert scale, ranging from highly non-preferred to highly preferred. Their data showed that participants leaned forward in response to preferred food items and backwards for non-preferred food items. Using a similar paradigm, Eerland and colleagues (2012) presented positive, negative, and neutral images to participants standing on a Wii balance board. During the passive viewing phase, participants stood still and viewed each image for 1 second. During the responding phase, participants had to lean to one side (left or right, depending on group allocation) to bring up the next image. Their results showed that, during the passive phase, participant leaned forward for positive images, compared to neutral and negative images. No difference was found between the neutral and negative conditions. During the responding phase, although participants leaned backwards for both positive and negative images, compared to neutral images, body postures was significantly more backwards for negative images. No dissociable lateral displacements were observed between the positive and negative conditions. Although the active and passive phases showed different patterns of results, with the avoidance effect being delayed, Eerland and colleagues (2012) suggest that some of their avoidance stimuli might be less automatically processed than their approach stimuli. Overall, these two studies show that people are unconsciously predisposed to physically approach or withdraw from positive or negative stimuli, respectively.

Congruent motor movements

One paradigm often utilised in the approach/avoidance literature is that of congruent motor movements. Cacioppo et al. (1993) found that participants found stimuli more positive when they enacted an approach movement, compared to an avoidance movement. An approach movement consisted of arm flexion, such as is made when pulling an object close to the body, whereas an avoidance movements consisted of arm extension, such as is made when pushing an object away from the body. In another example, J. S. Maxwell and Davidson (2007) presented arrows, which were either pointing toward or away from the participant, to the left or right side of a fixation. Participants were instructed to perform arm flexion when an arrow was pointing toward them and arm extension when an arrow was pointing away. They found that flexion responses were facilitated by right visual field targets, and extension by left visual field targets, suggesting that approach-related behaviours elicited left hemisphere activation and avoidance-related behaviours elicited right hemisphere activation. Additionally, arm flexion has been found to increase left-lateralised processes such as creativity (Friedman & Förster, 2000, 2001), fun-seeking and task persistence (only in men; Haeffel, 2011) and global processing (Förster, Friedman, Özelsel & Denzler, 2006; Nussinson, Hafner, Seibt, Strack & Trope, 2012), whereas arm extension has been linked to the right-lateralised process such as analytical reasoning (Friedman & Förster, 2010). Overall, these findings indicate that arm flexion elicits left hemisphere, approach-related activation, and arm extension elicits right hemisphere, avoidance-related activation.

Flexion and extension arm movements have been found to facilitate responses to approach and avoidance stimuli, respectively. Neumann and Strack (2000) asked participants to categorise adjectives as positive or negative, via button presses, while enacting arm flexion or extension with their non-dominant hand. Arm flexion was completed by placing one’s palm on the underside of a table and gently pressing up, whereas arm extension was completed by placing one’s palm on the top of a table and gently pressing down. Their results showed that arm flexion facilitated the categorisation of positive adjectives, compared to negative adjectives[2], whereas arm extension facilitated the categorisation of negative adjectives, compared to positive adjectives.

Using a similar paradigm, Rotteveel and Phaf (2004) made flexion and extension gestures part of participants’ responses. A vertical stand held two response buttons: the lower button was pressed downward, by extending one’s arm, and the upper button was

[2] It should be noted that, although the authors discuss this result as meaningful, the *t*-test failed to reach significance $t(11) = 1.3$, $p = .057$ (one-tailed)

pressed upward, by contracting one's arm. Participants were presented with happy and angry faces and were asked to categorise them, as happy or angry, as quickly as possible. The response mapping of the buttons was counterbalanced across participants, such that half the participants had a congruent response mapping (flexion for happy, extension for angry) and the other half had an incongruent response mapping. Rotteveel and Phaf (2004) found that congruent responses were faster than incongruent responses, such that arm flexion facilitated the classification of happy faces and arm extension facilitated the classification of angry faces. However, this congruency effect was not replicated when participants were asked to classify faces as male or female, indicating that valenced stimuli must be explicitly processed in order to facilitate behaviour.

Several authors argue that approach and withdrawal behaviours are automatically and unconsciously activated by approach and avoidance motivational states, regardless of whether stimuli are processed explicitly or implicitly. Chen and Bargh (1999) presented positive and negative words, and asked participants to categorise them as positive or negative, as quickly as possible. Participants were either assigned to a congruent or incongruent response group. The congruent group classified words as negative or positive by pushing (arm extension) or pulling (arm flexion) the response lever, respectively. Response mapping was reversed for the incongruent group. The expected congruency effect was found, with positive and negative words being categorised faster when pulling or pushing the lever, respectively. Chen and Bargh (1999) conducted a second experiment where half the participants always responded by pushing the lever and the other half always pulled the lever. Participants responded, as quickly as possible, to the appearance of stimuli and ignored the emotional valence. Therefore, participants did not explicitly evaluate the emotional valence of faces. The results of the second experiment mirrored the first, with congruency effects being found for happy/flexion and angry/extension pairings, suggesting that approach and avoidance motor movements are automatically and unconsciously predisposed by stimulus valence.

Using a similar paradigm, Duckworth, Bargh, Garcia and Chaiken (2002) presented positive and negative abstract images to participants. Participants were assigned to two groups: a group that pulled a lever to respond and a group that pushed a lever to respond. Participants were told the experiment was a reaction time assessment and they were to respond to the appearance of stimuli, as quickly as possible. Results showed reactions to negatively valenced stimuli were faster for ‘push responses’ and reactions to positively valenced stimuli were quicker for ‘pull responses’. These results further suggest that implicit, automatic evaluations of stimulus valence are sufficient to engage approach and avoidance behaviours.

Some more recent research has argued that the link between motivation and action is contextually based. Lavender and Hommel (2007) asked participants to classify images as positive or negative, by moving a doll toward or away from the computer screen. Half of the participants were asked to move the doll toward the screen for positive images and away for negative images, with a reversed response mapping for the other half. They predicted that pulling the doll away from the screen would constitute an avoidance movement, whereas pushing the doll toward the screen would constitute an approach movement. To be clear, Lavender and Hommel (2007) predicted that, in their particular experimental design, arm flexion would be facilitated by *negative* images, and arm extension would be facilitated by *positive* images, and this is indeed what they found. Negative images facilitated moving the doll away from the screen, via arm flexion, and positive images facilitated moving the doll toward the screen, via arm extension. These results therefore reflected a compatibility effect based on context, rather than the more intuitive, learned association as observed by Chen and Bargh (1999).

In a similar experiment, Markman and Brendl (2005) placed each participant’s name in the middle of a virtual corridor and presented positive and negative words above or below their name. Because both the name and the valenced word were presented within the virtual corridor, words present above the name were given the illusion of being further away, while words presented below the name were given the illusion of being closer. Participants were allocated two response groups: a congruent group and an incongruent group. The congruent group were instructed to move positive words toward their name and negative words away from their name. This response mapping was reversed for the incongruent group. Arm flexion and extension were therefore needed for positive and negative responses alike. Results of the experiment showed that participants were faster to move positive words toward, and negative words away from, their name. Importantly, this effect held regardless of whether the response required flexion or extension. Interestingly, an overall trend was observed for negative words to facilitate *flexion*, and positive words to facilitate *extension*, which also speaks against automatic, unconscious approach/flexion and avoidance/extension mapping.

Studies that have employed a congruent motor movement paradigm have returned mixed results. Chen and Bargh (1999) originally concluded that flexion and extension automatically and unconsciously predisposed approach and avoidance motivation, respectively. Although some studies support these findings (Duckworth et al., 2002), others have demonstrated that the approach/flexion and avoidance/extension pairings are contextually dependent (Lavender & Hommel, 2007; Markman & Brendl, 2005) or require valenced stimuli to be explicitly processed (Rotteveel & Phaf, 2004). These latter studies suggest that behavioural and motivational pairings are not wholly automatic and are, at least in part, processed at higher-levels. Additionally, and perhaps most problematic for congruent motor movement paradigms, a registered replication of Chen and Bargh (1999) was unable to reproduce the original effect, reporting anecdotal evidence in favour of the null hypothesis (Rotteveel et al., 2015). Overall, the literature suggests that motivational states can predispose certain motor movements, although it is yet to be determined conclusively whether this occurs automatically or at higher-levels of processing.

Line bisection

An alternate tool which might prove useful for motivational research is line bisection. Line bisection performance reflects hemispheric asymmetries, which can be indicators of approach and avoidance motivation (Armaghani, Crucian & Heilman, 2014; Cattaneo et al., 2014; Nash, McGregor & Inzlicht, 2010). Line bisection has previously been used as an index of approach-related processes, such that positive affect (Drake & Myers, 2006), writing about cherished values (Shrira & Martin, 2005) and narrowed attention (Förster, Liberman & Kuschel, 2008) shift line bisection rightward. Line bisection has also more recently been used as a direct, more straightforward method of measuring state approach and avoidance motivation (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010; Naylor, Byrne & Wallace, 2015; Roskes, Sligte, Shalvi & De Dreu, 2011). Approach-related left-hemisphere activation produces more rightward response biases than avoidance-related right-hemisphere activation. For example, Cattaneo et al. (2014) asked participants to haptically bisect a rod while listening to silence, laughing, or crying auditory stimuli. They found that leftward biases were reduced during the crying condition, compared to the silence and laughing conditions. They attributed this reduction to increased left hemispheric activation during approach motivation.

Nash and colleagues (2010) were the first to explicitly link line bisection performance with approach motivation. Using an EEG paradigm, they found line bisection performance was significantly correlated with approach-related brain activation in the left pre-frontal cortex (Spielberg et al., 2013). In a second experiment, they compared the line bisection scores of individuals with high and low self-esteem, in challenge and no-challenge conditions. The challenge condition asked participants to describe a situation where they had been challenged academically, whereas the no-challenge condition had participants describe a friend's situation instead of their own. High self-esteem individuals have previously been found to display high levels of approach motivation during challenging situations, compared to low self-esteem individuals (McGregor, Gailliot, Vasquez & Nash, 2007; McGregor, Nash & Inzlicht, 2009). They found that those with low self-esteem bisected slightly to the left of centre in both the challenge and no-challenge conditions, whereas high self-esteem individuals showed a rightward bias during the challenge condition and a leftward bias during the no-challenge condition. These were the first results to show that line bisection reliably reflects left-hemisphere activation during approach motivation and that line bisection adequately registers changes in state motivation.

Naylor and colleagues (2015) used a similar paradigm to demonstrate situational changes in approach and avoidance motivation. Participants were placed in high or low trait approach groups, based on their initial trait approach score on the BIS/BAS scale. Participants first completed a line bisection task, which acted as a baseline measure of motivational lateralisation. Participants then completed two rounds of 'broom ball', which involved participants using a broom to hit a tennis ball into a marked area on the floor. The first round was a low-pressure round, where participants had 10 'practice' turns at broom ball. This round was completed individually and privately, so as to reduce anxiety. The second round was a high-pressure round, where two participants competed against each other, had only 5 shots and were explicitly told not to 'choke' under pressure. Participants completed another line bisection task after this final round. Line bisection performance did not change between baseline and post-test for low trait approach individuals; however, high trait approach individuals bisected rightward at baseline and shifted leftward after the high-pressure round. This study provides further evidence that line bisection is sensitive enough to reflect changes in state approach motivation (see also Roskes et al., 2011).

Line bisection has also been used as a tool for measuring cerebral asymmetries elicited by emotional face stimuli. Cattaneo and colleagues (2014) flanked a line bisection task with happy, neutral, or sad faces. They found that neutral and sad faces produced biases more leftward than happy faces, although sad and neutral faces did not differ. It should be noted that Cattaneo et al. (2014) did not replicate this effect when stimuli were not blocked; however, laterality effects have been found to be stronger during blocked trials (see Schepman, Rodway & Geddes, 2012). Armaghani and colleagues (2014), using a design similar to Cattaneo et al. (2014), found that both happy and sad faces produced biases more leftward than neutral faces, with sad faces tending[3] to elicit stronger leftward biases than happy faces. Although results were not identical, both studies reported a pattern of greater leftward biases for sad faces and suggests that further research is needed to explore under which conditions line bisection can suitably measure motivational lateralisation.

Sad vs angry facial stimuli

Research investigating the link between line bisection performance and motivation has previously used happy and sad faces to elicit approach and avoidance motivation, respectively (Armaghani et al., 2014; Cattaneo et al., 2014). Although happy faces have been shown to reliably elicit approach motivation (Armaghani et al., 2014; Cattaneo et al., 2014; Davidson, Ekman, Saron, Senulis & Friesen, 1990; Reuter-Lorenz & Davidson, 1981; Roelofs et al., 2010; Wentura, Rothermund & Bak, 2000), some research suggests that sad faces elicit both an automatic approach response *and* conscious withdrawal behaviours (Seidel, Habel, Kirschner, Gur & Derntl, 2010). Given that angry facial stimuli have previous been found to elicit avoidance motivation (A. A. Marsh, Ambady & Kleck, 2005; Roelofs et al., 2010), the current thesis used angry facial expressions, in lieu of sad facial expressions, in order to elicit avoidance motivation.

Current Aims

Visuospatial attention and approach and avoidance motivation have each been shown to reliably activate lateralised brain regions (Kinsbourne, 1970; Spielberg et al., 2013). Traditionally, motivation and attention have been studied independent of one another and only recently have the two processes been shown to interact (Armaghani et al., 2014;

[3] Responses biases elicited by happy and sad faces only tended to be different: $t(16) = 1.791$, $p = 0.092$

Cattaneo et al., 2014; Nash et al., 2010). Differential attentional biases across lateral (Adair & Barrett, 2008; Jewell & McCourt, 2000; McCourt & Jewell, 1999), vertical (Thomas & Elias, 2011) and proximal (Longo & Lourenco, 2006; Previc, 1990) dimensions have been extensively researched; however, it is yet unclear how the lateralisation of approach and avoidance motivation presents behaviourally across these spatial dimensions. The current thesis has two main aims: firstly, to confirm recent research that suggest line bisection is a valid and reliable measure of motivational lateralisation (Armaghani et al., 2014; Nash et al., 2010), and secondly, to investigate how approach and avoidance motivation affects attentional allocation across various spatial planes.

Chapter 3: Visuospatial Biases in the Lateral Dimension

Study 1: Experiment 1

Introduction

Nash and colleagues' (2010) paper was the first to experimentally link left hemisphere activation and approach motivation to rightward line bisection biases. This link between line bisection performance and motivation was made by comparing line bisection performance based on high or low intrinsic approach motivation. The first series of experiments sought to replicate this finding, while extending the research to include avoidance motivation. Although two studies now suggest that line bisection is suitable for measuring both approach and avoidance motivation (Armaghani et al., 2014; Cattaneo et al., 2014), at the time of this experimentation, no research had explicitly linked avoidance motivation to line bisection performance. If line bisection is to be used as a cheap and easy alternative to neuroimaging and motor congruency studies, a link must first be established between avoidance motivation and performance on the line bisection task. Otherwise, future studies wishing to employ a line bisection paradigm will be unable to investigate the effect of avoidance motivation.

Rather than testing trait-level approach or avoidance motivation, state-level motivation was experimentally manipulated by presenting happy and angry faces prior to line bisection. In this way, any difference between approach and avoidance conditions cannot be attributed to inherent differences between people who are high on approach or avoidance motivation. Examination of approach and avoidance motivation at the state-level controls for potential effect of individual differences.

Theoretically, approach motivation leads to left hemisphere activation and results in a rightward bisection bias, whereas avoidance motivation activates the right hemisphere and should present as relatively more leftward response biases.

Method

Participants

Thirty Flinders University psychology students (25 female) completed the experiment in exchange for course credit. Participants were aged between 17 and 47 years (M = 24.52, SD = 8.07), had normal or corrected to normal vision and were right handed (M = 97.07, *SD* = 5.59) according to the Edinburgh Handedness Inventory (Oldfield, 1971). Informed consent was obtained prior to the experiment, which was conducted with the ethical approval of the Social and Behavioural Research Ethics Committee of Flinders University.

Apparatus

Stimuli were presented on an Intel Core 2 Duo PC, with a 19” monitor running at a resolution of 1024 x 768 pixels. E-prime 2.0 software (Psychology Software Tools, Inc.; www.pstnet.com/E-prime/e-prime.htm) was used to present stimuli and record responses. Responses were made on a model 200A PST Serial Response Box with five horizontally placed buttons. A chin rest served to keep the visual angle of the stimuli constant and to reduce head movements. Participants were video monitored so as to motivate them to attend to the task.

Stimuli

Line Stimuli.

The line stimulus was 150 mm long and 50mm wide, running along the horizontal axis of the screen. The line stimulus was comprised of 2 black and 2 white bars, positioned diagonally to each another (see Figure 6). The line stimulus was bisected 0.5, 1 or 2 mm to the left or right of veridical centre (the ‘deviation’) so that one side of the line was always slightly longer than the other. The line stimulus itself was placed 3 mm to either the left or the right of the centre of the screen, referred to as the ‘jitter’, to minimise external reference points. The line stimulus was displayed in both an original and mirror-reversed orientation (the ‘polarisation’).

Figure 6. Example of line stimulus

Facial Stimuli.

The faces of five male and five female models were taken from the Karolinska Directed

Emotional Faces database (Lundqvist, Flykt & Ohman, 1998). Each model demonstrated happy, angry[4], and neutral expressions, leading to 30 images overall (see Figure 7). Faces were 150 mm wide and 165 mm high and displayed in the centre of the screen. To increase task difficulty, models' hair was removed by closely cropping the face using an ellipse. Participants were asked to determine the gender of the face during the experiment, which ensured they were attending to and processing the facial stimuli.

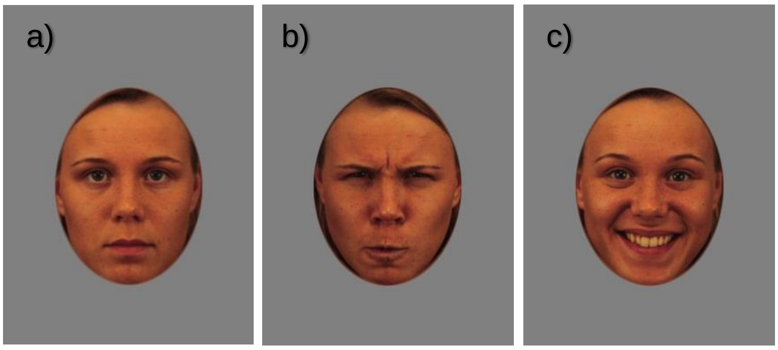

Figure 7. Example of a model expressing: a) neutral, b) angry, and c) happy emotions

BIS/BAS Questionnaire.

The BIS/BAS scales (Carver & White, 1994) measure the salience of avoidance motivation, or the Behavioural Inhibition System (BIS), and approach motivation, or the Behavioural Activation System (BAS), respectively (Elliot & Thrash, 2002; Jorm et al., 1998). The questionnaire consists of 24 statements, such as: "I will often do things for no other reason than that they might be fun", which participants respond to on a Likert scale from 1 (very true for me) to 4 (very false to me). The current study used the BIS/BAS scales to make sure that participants did not differ on trait-level motivation at baseline.

Edinburgh Handedness Inventory.

The Edinburgh Handedness Inventory (Oldfield, 1971) was used to measure participant handedness. The questionnaire consists of 10 actions, such as using scissors, for which participants indicate their hand preference (left, right, or no preference). Scores could

[4] Angry facial stimuli were used in lieu of sad facial stimuli, given that sad facial stimuli have previously been shown to elicit an initial approach reaction (Seidel et al., 2010) and angry faces have previously been found to elicit avoidance motivation (A. A. Marsh et al., 2005; Roelofs et al., 2010).

range from -100 (left hand preference for all tasks) to +100 (right hand preference for all tasks).

Procedure

The experiment was completed in a single session that lasted approximately 45 minutes. Participants began by completing the Edinburgh Handedness Inventory, after which the experimental task was administered. The task was presented with a grey background, to reduce screen luminance. Trials were initiated by a blank grey screen for 200 ms, followed by a central fixation for 500 ms, which participants were asked to focus on (see Figure 8). A facial stimulus was then presented for 200 ms, followed by a blank grey screen for 200 ms, followed by the line stimulus for 500 ms. A blank screen followed the line stimulus until they responded or 2000 ms. Participants were instructed to decide if the right or the left side of the line stimulus had been longer and to make their response using the far left or far right keys of the response box. After participants made their left/right response, the question "Was the face male or female?" was displayed. Participants verbally responded and their response was logged by the experimenter.

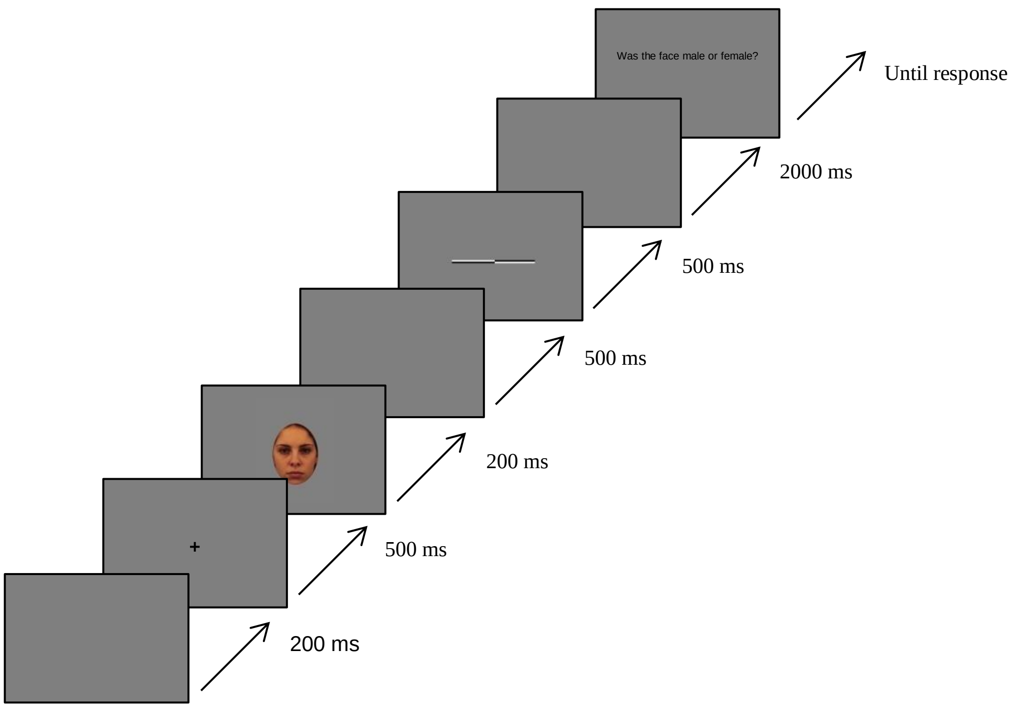

Figure 8. Trial sequence

Participants were pseudo-randomly placed in either the happy group, where they viewed neutral and happy faces, or the angry group, where they viewed neutral and angry faces. Participant allocation to group was determined by order of experimentation, such that participant 1 was in the happy group, participant 2 was in the angry group, and so on. Each face was shown 24 times, with each unique combination of deviation (6 levels), jitter (2 levels), and polarisation (2 levels). Trials were presented in random order across 4 blocks of 120 trials, for a total of 480 trials. The first two blocks consisted of neutral faces and the last two blocks consisted of emotional faces. Neutral faces were presented first to provide a baseline measure free from motivational effects, which could have carried over if emotional faces were presented first. Participants were given a short rest break between each block. Trials where no response was made were repeated at the end of blocks 2 (neutral) and 4 (emotion). Participants completed the BIS/BAS Scales at the completion of the experiment, such that the questionnaire did not affect performance during the experiment. The BIS/BAS Scales are a measure of trait motivation, and as such, scores should not be affected by preceding experimental procedures. Following this, participants were debriefed and allowed to leave.

Results

Participants with an accuracy score below three standard deviations from the mean (*M* = 0.761 *SD* = 0.044) were classified as outliers and were excluded from all analyses (n = 1). Assumptions of normality for all data were confirmed by a Shapiro-Wilk test ($p = .189$). Mauchly's Test of Sphericity indicated that the assumption of sphericity was violated ($p < .001$), therefore Greenhouse-Geisser corrected values are reported.

Two methods of analysis, response bias and subjective point of equality (PSE), were used to ensure that any difference between conditions could be attributed to the data and not to any one analytical procedure.

Response bias

Performance on the landmark task was presented in the form of response biases. For both groups, separate response biases were calculated for neutral and emotional (happy, angry) faces using Equation 1:

$$Response\ Bias = 100\left(\frac{Right\ responses - Left\ responses}{Total\ responses}\right) \quad (1)$$

Possible scores ranged from -100 (left side perceived as longer on all trials) to +100 (right side perceived as longer on all trials).

For the remaining twenty-nine participants, a repeated-measures ANOVA examined the between-groups effect of emotion (happy, angry) and the within-groups effect of expression (neutral, emotional) on response bias. Neither the main effect of expression nor emotion was significant, $F(1, 27) = 0.12$, $p = .731$, $\eta_p^2 = 0.004$ and $F(1, 27) = 0.03$, $p = .859$, $\eta_p^2 = 0.001$, respectively. The interaction between expression and emotion was also non-significant, $F(1, 27) = 0.172$, $p = .681$, $\eta_p^2 = 0.006$ (see Table 1 for descriptive statistics). One-sample *t*-tests analysed whether any response biases were significantly different from zero. These analyses found that no response bias, for either group or condition, was significant (see Table 2).

Table 1

Response bias descriptive statistics, by facial expression and emotion.

	Happy		Angry		Total	
	M	SD	M	SD	M	SD
Neutral	-5.83	23.29	-6.25	20.66	-6.03	21.66
Emotional	-3.83	25.35	-6.43	24.84	-5.09	24.69
Total	-4.83	23.94	-4.36	26.40		

Table 2

One-samples t-tests on response biases for facial expression conditions and emotion groups.

		t	*df*	*p*	*d*
Happy	Neutral	-0.97	14	.348	0.35
	Emotional	-0.59	14	.567	0.21
	Total	-0.81	14	.429	0.29
Angry	Neutral	-1.13	13	.278	0.43
	Emotional	-0.97	13	.350	0.37
	Total	-1.08	13	.302	0.29
Total	Neutral	-1.50	28	.145	0.39
	Emotional	-1.11	28	.277	0.29

Point of subjective equality

The PSE analysis is used to determine the position at which a participant, or a group, was equally likely to respond ‘left longer’ or ‘right longer’. In other words, the PSE is the location on the line at which the bisection is perceived to be at the middle (regardless of its actual location). PSE was calculated as follows:

For each deviation distance (±2 mm, ±1 mm, ±0.5 mm), the proportion of left responses was calculated, for both individual participants and groups, using Equation 2:

$$Proportion\ of\ left\ responses = \frac{Left\ responses}{n} \qquad (2)$$

where *n* is the number of trials for each deviation distance. This resulted in a proportion of 'left' responses for each of the six deviation distances. A least-squares fit probit analysis was used to fit deviation distance for this proportion, which predicted the deviation distance at which the left proportion would be 0.50 (i.e., the PSE). A cumulative Gaussian distribution function was used to model the data using Equation 3:

$$f(x, \mu, \sigma) = \frac{1}{2}\left(1 + \text{erf}\left[\frac{x - \mu}{\sigma\sqrt{2}}\right]\right) \tag{3}$$

where *x* is the deviation, *μ* is the mean (the PSE), *σ* is the standard deviation, and *erf* is the error function. A default *μ* = 0 and *σ* = 1 were used.

R^2 values were calculated to measure goodness of fit, using Equation 4:

$$R^2 = 1 - \left(\frac{residual\ sums\ of\ squares}{corrected\ total\ sums\ of\ squares}\right) \tag{4}$$

The range of R^2 coefficients is 0 to 1, with values close to 1 indicating that the data lie close to the fitted curve (i.e., a good fit).

A repeated-measures ANOVA examined the between-groups effect of emotion (happy, angry) and the within-groups effect of expression (neutral, emotional) on PSE. There was no main effect of expression, $F(1, 27) = 0.11$, $p = .747$, $\eta_p^2 = 0.004$, nor was the main effect of emotion significant, $F(1, 27) = 0.04$, $p = .851$, $\eta_p^2 = 0.001$. The interaction between facial expression and emotion was also non-significant, $F(1, 27) = 0.05$, $p = .821$, $\eta_p^2 = 0.002$ (see Table 3 for the descriptive statistics). One-sample *t*-tests analysed whether any response biases were significantly different from zero. These analyses found that no response bias, for either group or condition, was significant (see Table 4).

Table 3

PSE descriptive statistics, by facial expression and emotion.

	Happy		Angry		Total	
	M	SD	M	SD	M	SD
Neutral	-0.14	0.63	-0.17	0.54	-0.15	0.58
Emotional	-0.10	0.62	-0.16	0.66	-0.13	0.63
Total	-0.12	0.59	-0.16	0.58		

Table 4

One-samples t-tests on PSEs for facial expression conditions and emotion groups.

		t	*df*	*p*	*d*
Happy	Neutral	-0.88	14	.396	0.31
	Emotional	-0.63	14	.537	0.23
	Total	-0.80	14	.437	0.29
Angry	Neutral	-1.15	13	0.272	0.45
	Emotional	-0.90	13	.382	0.34
	Total	-1.06	13	.309	0.39
Total	Neutral	-1.43	28	.163	0.37
	Emotional	-1.11	28	.277	0.29

BIS/BAS scales

BIS and BAS scores were compared, to see if any differences between trait approach and avoidance motivation existed between the happy and angry groups. An independent-samples *t*-test showed no difference between the angry (*M* = 23.80, *SD* = 4.69) and happy (*M* = 24.87, *SD* = 3.89) groups on BIS scores, *t*(27) = 0.62, *p* = .541, *d* = 0.25. Similarly, there was no difference between the angry (*M* = 14.87, *SD* = 2.83) and happy (*M* = 14.40, *SD* = 3.02) groups on BAS scores, *t*(27) = 0.35, *p* = .729, *d* = 0.16. These results indicate that the groups did not differ in their trait approach/avoidance motivation.

Discussion

No differences were found for response biases or PSEs between emotional groups. This differs from previous research, which has shown that happy faces elicit more rightward line bisection biases than angry faces (Armaghani et al., 2014; Cattaneo et al., 2014). Several methodological issues could account for these null findings.

Line bisection tasks are inherently variable and prone to individual differences (Manning, Halligan & Marshall, 1990). These differences result from variability in individual participant strategy, such as scanning direction, anticipatory errors (i.e., stopping before the line's middle) or perseverative errors (i.e., stopping after the line's middle). Any combination of these scanning strategies and error types can have different effects on participants' resulting response biases (Manning et al., 1990). The current data reflected this inter-participant variability, as can be seen by the large standard deviation of the overall response bias (*M* = -4.60, *SD* = 25.17).

The high variability within the data suggests two things: firstly, that the current study may have had insufficient power to detect differences between the groups, and secondly, that a within-subject design may be better suited for the methodology. It has been suggested that between-subjects designs need three to four times as many participants to reach acceptable levels of statistical power, compared to within-subjects designs (Bellemare, Bissonnette & Kröger, 2014). The current experiment had a power level of approximately 0.77, which falls just short of the recommended power level of at least 0.8 (Ellis, 2010). Although the between-subjects design controlled for any carry-over effects of happy and angry faces, a side-effect was likely a reduction of power and increased variability in the data. Future studies might consider a within-subjects design, if the methodology could ensure that carry-over effects do not occur between approach and avoidance conditions.

Another issue with the current experiment, although not directly contributing to the null effect, is the use of curve fitting procedures to calculate PSE. The landmark task in the current experiment used six deviations, meaning that the proportion of left response data could only be plotted along these six points. Prior research that used similar curve fitting procedures had 13 transection points, on which data could be plotted, enabling a more accurate curve to be fitted (McCourt & Olafson, 1997). Curve fitting procedures, especially least-squares fit models, are also extremely sensitive to within-participant outliers (Finney, 1947). Given the variable nature of line bisection, coupled with the limited number of transector locations in the current methodology, curve fitting procedures may not be able to accurately fit a truly representative curve to the data. This was not necessarily an issue in the current experiment; however, future studies should consider either modifying the landmark task methodology to better suit curve fitting procedure or to abandon curve fitting procedures altogether.

Although no differences were found between the happy and angry groups, it is possible that the methodology contributed to this null result. The following series of experiments sought to improve the method in several ways. Firstly, a within-subjects experimental design was used in an attempt to reduce data variability. By comparing performance in the happy and angry conditions within-participants, differences between approach and avoidance conditions were less subject to individual variability. Secondly, PSE scores were not calculated. For curve fitting procedures to be appropriate, a larger number of transector locations would need to be used, which would have significantly increased the duration of the experiment. In an effort to maintain a reasonable experimental running time, the curve fitting procedure was abandoned and only response biases were analysed. Response biases have been shown to be a reliable measure of hemispheric asymmetries and have been used exclusively in many line bisection and landmark studies (Jewell & McCourt, 2000; Longo & Lourenco, 2006; McCourt & Jewell, 1999).

Study 2: Experiment 1

The following series of five experiments was published in *Cognition and Emotion* and is entitled “End of the line: Line bisection, an unreliable measure of approach and avoidance motivation”. This publication is presented here unchanged (Leggett, Thomas & Nicholls, 2015). The current author designed, conducted and analysed the experiments, and is first author on the publication.

Introduction

Throughout the course of evolution, emotions have been shaped to predispose actions, which maximise the chance of survival (Lang et al., 1990). Emotions allow immediate reactions in response to environmental stimuli, particularly when stimuli are evolutionarily commonplace (LeDoux, 1996). As affect is a core process of emotion (Ortony & Turner, 1990), the automatic evaluation of stimuli on a positive – negative affect continuum may be closely linked to action. The valence hypothesis (Davidson, 1984) states that positive emotions are left lateralised and negative emotions are right lateralised. Similarly, recent studies have found that the cognitive processes underlying approach and withdrawal decisions may also be lateralised, such that the left hemisphere is specialised for approach behaviours and the right hemisphere is specialised for withdrawal behaviours (Gable & Poole, 2012; Spielberg et al., 2013; Takeuchi et al., 2014).

Some electroencephalographic data has linked approach behaviours to left prefrontal activation and avoidance motivation to right prefrontal activation (Davidson et al., 1990; Heller, Nitschke, Etienne & Miller, 1997; Nash et al., 2010). Most functional magnetic resonance imaging studies also support the idea that motivation is lateralised (Herrington et al., 2005; Spielberg et al., 2012), although some data differs from this interpretation. An example of this is an fMRI study by Spielberg et al. (2011), they found that activation in the left middle and superior frontal gyri increased as avoidance motivation increased, which suggested bilateral avoidance-related activation. While this finding was unexpected, Spielberg et al. also found that as avoidance motivation increased, activation in the right dorsolateral prefrontal cortex increased and as approach motivation increased, activation in the left dorsolateral prefrontal cortex increased. As a whole, neuroimaging studies suggest that motivational processes are likely lateralised.

In addition to neuroimaging data, paradigms employing directed actions have also shown behavioural differences based on motivation (Chen & Bargh, 1999; Förster, 2004; Friedman & Förster, 2000; Rotteveel & Phaf, 2004). These paradigms employ actions, such as pulling or pushing, which can influence state-level approach and avoidance motivation. The sensation of pulling toward the body (i.e., flexion) is associated with approaching positive stimuli and is lateralised to the left hemisphere, whereas the sensation of pushing away from the body (i.e., extension) is associated with withdrawing from aversive stimuli and is right lateralised (Friedman & Förster, 2000). Reaction time measures are used to determine whether a given factor (e.g., global or focal attention) is facilitated by flexion or extension movements and thus approach or avoidance motivation, respectively. Although such methodologies can associate various factors with approach or avoidance motivation, they are often complex and contextually dependent. For example, Lavender and Hommel (2007) asked participants to use flexion to pull a doll away from a stimulus and extension to push the doll toward the stimulus, which reversed the motivational association such that flexion was associated with avoidance and extension produced an approach congruency. This contextual dependence is problematic for the flexion/extension methodology, as it suggests that the cognitive representation of an action is more important than the action itself. Both flexion and extension movements can therefore potentially facilitate either approach or avoidance motivation.

Several studies have indicated that line bisection is a suitable, more straightforward, task for studying approach and avoidance lateralisation (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010). Line bisection is commonly used to measure relative left and right hemispheric activation (Jewell & McCourt, 2000), whereby participants indicate the perceived midpoint of horizontal lines. Leftward or rightward errors indicate greater relative right or left hemisphere activation, respectively (Milner, Brechmann & Pagliarini, 1992). A variant of the line bisection task, the landmark task, is also commonly used. The landmark task uses pre-bisected lines with a transector slightly to the left or right of centre. Participants are asked to indicate whether the left or the right side of the line is longer. While manual line bisection is used most commonly, the landmark task has the advantage of controlling for motor biases, as participants do not manually bisect the line. As both tasks measure the same underlying phenomenon (i.e., attentional asymmetries), many authors do not distinguish between the tasks (Jewell & McCourt, 2000).

A slight, but consistent, over-attention to the left side of space, known as pseudoneglect (Bowers & Heilman, 1980), is commonly observed on line bisection and landmark tasks (Jewell & McCourt, 2000). A variety of mechanisms have been proposed to account for pseudoneglect, such as visual scanning and motor biases (Chokron et al., 1998); however, it is generally accepted that pseudoneglect occurs due to asymmetries in visuospatial attention (Nicholls & Roberts, 2002). The activation-orientation hypothesis states that the distribution of attention across the left and right visual fields is controlled by two gradients, where left hemisphere activation directs attention to the right visual field and vice versa (Kinsbourne, 1970). Greater relative activation of one hemisphere results in attention being biased toward the contralateral visual field. Therefore, the dominance of the right hemisphere in attentional allocation results in a slight leftward bias, or pseudoneglect.

The effect of approach/withdrawal on line bisection asymmetries has been investigated by Armaghani et al. (2014). They asked participants to bisect horizontal lines with sad, happy, and neutral face flankers. Response asymmetries were more leftward for both emotional conditions than when faces were neutral. There was also an effect of valence, whereby sad faces (withdrawal) produced a stronger leftward bias compared to happy faces (approach). Similar results have been reported by Cattaneo et al. (2014). Once again, participants bisected lines in the presence of happy, neutral and sad faces. In this case, the data showed that happy faces produced a rightward shift in line bisection compared to the neutral and sad faces. Both sets of results are consistent with a left/right lateralisation of approach and avoidance cognition (Nash et al., 2010) and the effect of unilateral hemispheric activation on attentional asymmetries (Milner et al., 1992).

Line bisection serves as a quick and easy alternative to complex motor movement and neuroimaging studies; however, research directly linking line bisection with approach and avoidance motivation is scarce (Nash et al., 2010). Previous research has often failed to control for possible confounds known to affect line bisection performance. In studies by Armaghani et al. (2014) and Nash et al. (2010), participants bisected lines with whichever hand they wanted, thus motor biases could have affected results (McCourt, Freeman, Tahmahkera-Stevens & Chaussee, 2001). Furthermore, the presentation time of lines was uncontrolled by Armaghani et al., Nash et al. and Cattaneo et al. (2014), and this factor influences the strength of response asymmetries (Thomas & Elias, 2011). If line bisection is to be used as a quicker and easier alternative to motor movement and neuroimaging studies, it is important to firstly confirm that line bisection remains a suitable measure of motivation after all extraneous variables are controlled for.

As emotion and motivation are tightly linked (Rodger, 1963), many previous studies have used valenced stimuli, particularly happy and angry faces (Baker, Rodzon & Jordan, 2013; A. A. Marsh et al., 2005; Rotteveel & Phaf, 2004; Stins et al., 2011), to manipulate participants' state motivation. Stins, Roelofs, Villan and Kooijman (2011) found that happy faces primed whole body forward movements, whereas angry faces did not. Roelofs, Elzinga and Rotteveel (2005) found that happy faces facilitated approach-related arm flexion and angry faces facilitated avoidance-related arm extension.

The current study sought to replicate the link between line bisection and motivation, while controlling for the aforementioned potential confounds. The landmark task was chosen in favour of manual line bisection, to control for potential motor biases. Response asymmetries for avoidance stimuli were predicted to be more leftward, compared to neutral and approach stimuli. Response asymmetries for approach stimuli were predicted to be more rightward, compared to avoidance and neutral stimuli.

Method

Participants

To maintain a power level over 0.9, the program G*Power (Faul, Erdfelder, Lang & Buchner, 2007) was used to conduct an a priori power analysis for the planned repeated-measures ANOVA, with one factor of motivation (happy, neutral, angry). As previous studies have either used different designs or failed to report effect sizes, an effect size of η^2_{P} = 0.2 was chosen, as this represents a small sized effect (L. Wilkinson, 1999). This effect size, coupled with a critical alpha of .05 and correlation among repeated measures of .05, indicated that a minimum of 18 participants were needed. Twenty-five Flinders University psychology students (21 female; M_{age} = 22.48, *SD* = 3.60) completed the experiment in exchange for course credit. Participants had normal or corrected-to-normal vision and were right-handed (*M* = 69.20, *SD* = 21.64; Oldfield, 1971). Ethical approval was granted by the Social and Behavioural Research Ethics Committee of the Flinders University and Southern Area Health Service.

Apparatus

Stimuli were presented using a Dell computer, running E-prime 2.0 software (Psychology Software Tools, Inc.; www.pstnet.com/E-prime/e-prime.htm), on a 19" LG FLATRON LCD monitor (resolution of 1024 x 768 pixels at 60Hz). Head movements were reduced and head position maintained, as well as the visual angle of the stimuli being kept constant, by using a chin rest at 500mm from the screen. Responses were made using a model 200A PST Serial Response Box, with five horizontally placed buttons.

Stimuli

The landmark stimulus was a horizontal line 150mm in length. Two 10mm vertical lines were located at the end points of the line, with a third vertical line (bisector) located at 0.5mm, 1mm, or 2mm to the left or right of veridical centre. As the purpose of the task was to elicit a response bias, the task was made difficult. The landmark task was not located in the actual centre of the screen, but instead was jittered 5mm to the left or right of centre, to minimise the effect of external reference points.

For the facial stimuli, the faces of five male and five female models were taken from the Karolinska Directed Emotional Faces database (Lundqvist et al., 1998). Each model demonstrated happy, angry, and neutral expressions, giving rise to a total of 30 images. Faces were 150mm wide and 165mm high and were displayed in the centre of the screen. To increase task difficulty, the models' hair was removed by closely cropping the faces using an ellipse. Participants were asked to determine the gender of the face during the experiment, which ensured they were attending to and processing the facial stimuli.

Procedure

Each trial began with a blank grey screen for 200ms, followed by a fixation cross for 500ms (see Figure 9 for procedural sequence). A face was then presented for 200ms, wherein participants were asked to remember the sex of the face. A blank grey screen appeared for 500ms, which was followed by the line stimulus. Line presentation was kept constant, at 500 ms, across all trials, to avoid any possible effects of presentation time (Thomas & Elias, 2011). This presentation duration is similar to previous research (Gereon R. Fink, Marshall, Weiss, Toni & Zilles, 2002; Nicholls et al., 2012; Thomas, Castine, Loetscher & Nicholls, 2015) and served to minimised viewer saccades (Jewell & McCourt, 2000), while maintaining an acceptable task difficulty.

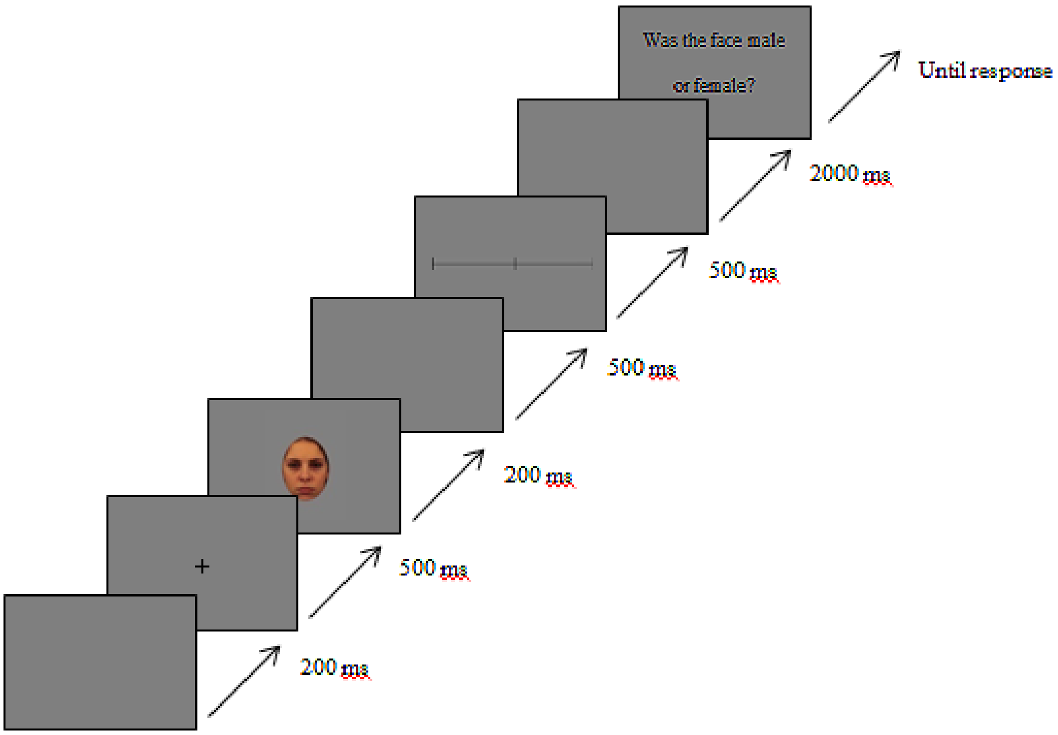

Figure 9. Trial sequence

Participants decided if the right or the left side of the line was longer and responded using the far left key with their left index finger or the far right key with their right index finger. Response key mapping was maintained across all participants, due to the intuitive nature of the response. Participants had a maximum of 2000 ms after the line stimulus disappeared to record their response. Responses outside of this timeframe were classified as misses and were repeated at the end of the block. As such, responses were given for all trials, avoiding any missing data. Participants were then prompted to recall the sex of the face with the following on-screen message: “Was the face male or female?” Participants verbally responded and the experimenter logged their response. No explicit measure of the faces emotionality was taken, so that the purpose of the study was not too obvious to participants. Although this did not allow participants’ attention to the emotional content of the cue to be measured directly, the occurrence of a difference between the conditions would suggest that the emotional content had an effect on the participants.

A 6 (deviation: -2, -1, -0.5, 0.5,1, 2) x 2 (jitter: left, right) x 2 (sex of face: male, female) x 5 (different models) within-participants factorial design was used, which resulted in 120 unique trials. Trials were presented in three counterbalanced blocks of 120 trials each (happy, angry, and neutral) and half the participants viewed the faces in their regular orientation, while the other half saw mirror-reversals. Within each block, trial order was randomised. Participants were given a 2-minute task to complete between blocks, so that any motivational/emotional effects administered in one block did not carry on to the proceeding block. These tasks were the Edinburgh Handedness Inventory (Oldfield, 1971) and a task irrelevant find-a-word puzzle, the order of which was counterbalanced. Each experimental session lasted approximately 30 minutes.

For each experimental condition (happy, angry, and neutral), response asymmetry scores were calculated for the landmark task by subtracting left longer responses from right longer responses. The sum was then divided by the total number of responses and multiplied by 100. Therefore, possible scores ranged from -100 (left side perceived as longer on all trials) to +100 (right side perceived as longer on all trials). Participants showed high accuracy in recalling the sex of the faces (*M* = 91.11%, *SD* = 3.58%), which indicates that participants attended to the facial stimuli. This measure will not be analysed further, as it was not an experimental manipulation, but rather a method of ensuring that participants viewed the faces.

Results and Discussion

We wanted to select a cut-off criterion based on several key factors: (1) excluding inaccurate participants while simultaneously reducing highly variable response biases, (2) maximising the likelihood of finding a motivational effect, and (3) achieving these goals across a series of possible future experiments. Accuracy scores were calculated by dividing the total number of correct responses on the landmark task by the total number of trials. Upon investigation of a histogram of the accuracy data, two groups of participants could be distinguished. The first group, which encompassed the majority of participants (*n* = 20), were clustered around the mean of the sample. Another group of participants (*n* = 5) were clustered at one standard deviation below the mean. The response biases of the inaccurate group were highly variable (*SD* = 47.61), particularly when compared to the remaining participants (*SD* = 17.52). Bearing these points in mind, we decided to use a relatively conservative exclusion criterion of 1 SD to exclude participants who were unable or unmotivated to do the task. For the sake of consistency, this exclusion criterion was used for the remainder of experiments. While it is possible that removing participants with low accuracy scores will reduce the freedom for response biases to occur, a series of five t-tests across experiments found no statistically significant difference in the response biases between included and excluded participants (all *p*s > .05).

For the remaining 20 participants, response asymmetry scores were subjected to a repeated-measures analysis of variance (ANOVA) with one factor, motivation (happy, angry, neutral), which was significant (see Table 5).

Table 5

Response asymmetry score mean (standard deviation) for each motivation condition, for each experiment. One sample t-tests compare response asymmetry scores to zero. ANOVA result for the main effect of motivation is also included.

Experiment	Approach	Neutral	Avoidance	Motivation main effect
Experiment 1	**-0.25** (19.91) *t*(19) = 0.06, *p* = .956, *d* = 0.02	**-7.92** (23.38) *t*(19) = 1.51, *p* = .146, *d* = 0.48	**-13.50** (22.04) *t*(19) = 2.74, *p* = .013, *d* = 0.87	*F*(2, 38) = 3.48, *p* = .041, η_{p}^{2} = 0.16
Experiment 2	**-18.33** (27.39) *t*(18) = 2.92, *p* = .009, *d* = 0.95	**-16.75** (28.88) *t*(18) = 2.53, *p* = .021, *d* = 0.82	**-14.47** (29.27) *t*(18) = 2.16, *p* = .045, *d* = 0.70	*F*(2, 44) = 0.56, *p* = .576, η_{p}^{2} = 0.03
Experiment 3	**6.75** (26.67) *t*(19) = 1.13, *p* = .272, *d* = 0.36	**4.83** (27.64) *t*(19) = 0.78, *p* = .444, *d* = 0.25	**6.17** (25.75) *t*(19) = 1.07, *p* = .298, *d* = 0.34	*F*(2, 38) = 2.20, *p* = .803, η_{p}^{2} = 0.01
Experiment 4	**5.51** (24.36) *t*(12) = 0.82, *p* = .430, *d* = 0.32	**5.00** (26.41) *t*(12) = 0.68, *p* = .683, *d* = 0.27	**6.53** (29.79) *t*(12) = 0.79, *p* = .444, *d* = 0.31	*F*(2, 24) = 0.06, *p* = .944, η_{p}^{2} = 0.01
Experiment 5	**-1.43** (23.58) *t*(20) = 0.28, *p* = .784, *d* = 0.09	**5.24** (29.07) *t*(20) = 0.83, *p* = .419, *d* = 0.26	**8.02** (31.25) *t*(20) = 1.18, *p* = .254, *d* = 0.36	*F*(2, 40) = 2.70, *p* = .08, η_{P}^{2} = 0.12
Combined	**-1.86** (26.61) *t*(93) = 0.68, *p* = .499, *d* = 0.10	**-2.34** (29.12) *t*(93) = 0.78, *p* = .438, *d* = 0.11	**-2.25** (29.41) *t*(93) = 0.74, *p* = .460, *d* = 0.11	*F*(8, 178) = 0.06, *p* = .945, η_{P}^{2} = 0.001

A Bonferroni-corrected *p*-value of .017 was used for post-hoc paired-samples *t*-tests. Angry faces elicited greater leftward biases than happy faces, $t(19) = 2.64$, $p = .016$, $d = 0.63$. Neither happy nor angry expressions elicited biases different from neutral faces, $t(19) = 1.68$, $p = .110$, $d = 0.25$ and $t(19) = 1.02$, $p = .322$, $d = 0.35$, respectively. One-sample *t*-tests comparing response biases scores to zero (i.e., no directional bias) showed that pseudoneglect only occurred for angry faces (see Table 5).

Experiment 1 found the expected pattern of results and confirmed that the landmark task is sufficiently sensitive to detect lateral asymmetries evoked by emotional faces (Baker et al., 2013; A. A. Marsh et al., 2005; Reuter-Lorenz & Davidson, 1981; Rotteveel & Phaf, 2004). While this asymmetry likely reflects approach/avoidance lateralisation (Seidel et al., 2010), it is also possible that faces themselves, rather than any motivational state they elicited, biased visuospatial attention (Furl, Gallagher & Averbeck, 2012). The processing of emotional faces also shows lateralised brain activation, with positive emotions having a left hemisphere advantage and negative emotions showing a right hemisphere advantage (Jansari, Tranel & Adolphs, 2000). Experiment 2 investigated whether valenced photographs, in lieu of faces, could elicit similar motivational effects.

Study 2: Experiment 2

Valanced images are thought to affect motivational states due to the close connection between emotion and motivation. Positively and negatively valenced images elicit positive and negative emotions, respectively, similar to happy and angry faces (Lang, Bradley & Cuthbert, 2008). As positive and negative emotions are closely tied with approach and avoidance motivation, valenced images might elicit motivational responses (Dru & Cretenet, 2008; Gable & Poole, 2012; Lavender & Hommel, 2007). Eerland and colleagues (2012) measured participants' centre of balance by having them stand on a Wii balance board. They found that, when presented with cute animals, pleasant scenes, or erotic images, participants leaned forward. In comparison, participants leaned backwards when presented with negative scenes, such as sad and scared people. The effect of valenced images has also been explored using a dot probe paradigm, where images of striking snakes and handguns cued attention more effectively than neutral images (Carlson, Fee & Reinke, 2009). This cueing effect persisted even when images were backwards masked and presented for only 33 ms.

Given that valenced images affect motivational states, Experiment 2 investigated the effect of valenced photographs on the landmark task. It was predicted that results would follow those of Experiment 1, with leftward biases being stronger for avoidance images than approach images.

Method

Participants

As the experimental design was so similar to Experiment 1, the same level of power was expected for the current and all subsequent experiments. Twenty-three Flinders University psychology students (11 female; M_{age} = 26.13, *SD* = 9.44), completed the experiment in exchange for course credit. Participants had normal or corrected-to-normal vision and were right-handed (*M* = 81.96, *SD* = 9.44; Oldfield, 1971). The Social and Behavioural Research Ethics Committee of the Flinders University and Southern Area Health Service granted ethical approval.

Apparatus

The apparatus was identical to Experiment 1.

Stimuli

Thirty photographs (10 approach, 10 avoidance, 10 neutral) from the International Affective Picture System (Lang et al., 2008) were used, with pictures being 340mm wide and 215mm high. Arousal ratings were subjected to a one-way ANOVA, which showed no significant difference between images, $F(2,27) = 2.518$, $p = .099$. Approach photographs had a mean valence of 8.01 (*SD* = 0.23), avoidance photographs had a mean valence of 2.62 (*SD* = 0.40), and neutral photographs had mean valence of 4.54 (*SD* = 0.12). To mirror the procedure of Experiment 1 and to make sure that participants attended to the images, each image was displayed in both colour and greyscale and participants were asked to report on this at the end of each trial.

Procedure

The procedure was similar to Experiment 1, with photographs and the colour/greyscale judgment replacing face stimuli and the gender judgment. A 6 (deviation: -2, -1, -0.5, 0.5,1, 2) x 3 (motivation: approach, avoidance, neutral) x 2 (jitter: left, right) x 2 (colour of image: colour, greyscale) within-participants factorial design was used. Two unique stimuli sets were created from these factors, so that the number of trials each participant completed was identical to Experiment 1. Critically, each participant saw an equal number of left/right jitters and deviations, as well as completing equal trials in each of the approach, avoidance and neutral blocks. Half of the participants viewed photographs in their original orientation, and the other half saw mirror-reversals. Blocks (approach, avoidance, and neutral) were counterbalanced and trials were presented in a random order, with missed trials being repeated at the end of each block.

Results and Discussion

Participants with accuracy scores below one standard deviation from the mean (*M* = 70.00% *SD* = 6.40%) were classified as outliers and were excluded from analyses (*n* = 4). For the remaining 19 participants, response asymmetry scores were subjected to a repeated-measures ANOVA with one factor, motivation (approach, neutral, avoidance), which was non-significant (see Table 5). One-sample *t*-tests showed significant leftward biases in all conditions (see Table 5).

Surprisingly, motivation did not influence biases on the landmark task. Although unexpected, other null results have been reported. Furl et al. (2012) presented participants with image pairs, presented side by side and always consisting of a positive and negative stimulus. They found that participants were more likely to respond left when a happy face was on the left and right when an angry face was on the right. However, no preferences were observed when positive or negative valanced images were used, or 'good' and 'bad' foods. They suggest that facial expressions are a specific set of stimuli that influence motivational state because they have a social dimension. The current findings are consistent with this work, as the faces in Experiment 1 affected performance on the landmark task, and the images in Experiment 2 did not.

Both the current study and that by Furl et al. (2012) used blocked designs, where stimuli from each motivational orientation were presented in separate blocks. Bartholow, Bushman and Sestir (2006) found that repeated exposure to violent scenes desensitizes participants to negative stimuli, decreasing avoidance responses. It is possible that a similar effect occurs for valenced images, whereby repeated exposure to images of the same valence desensitizes participants to that particular motivational orientation, decreasing the motivational effect. In contrast, a mixed-design where participants are unable to anticipate which type of image will be presented next, might increase the influence of motivation on behaviour.

Study 2: Experiment 3

Experimental design, in itself, can causally affect behaviour on various tasks. When visual search arrays are presented in blocks of happy or angry targets, participants display an advantage for finding happy faces; however, when trials are mixed and participants are asked to determine whether the target is happy or angry, participants display an angry face advantage (Craig, Becker & Lipp, 2014). The mixed-list paradox is another example of the importance of considering experimental design. High-frequency words show a recall advantage when presented in blocked lists, but this advantage is nullified (or reversed) for mixed-lists (Ozubko & Joordens, 2007).

Experiment 3 explored whether using a mixed design, where happy and angry faces were presented in the same block, would change the pattern of results observed in Experiment 1. Emotive faces were used as stimuli, as faces provide a stronger manipulation of motivation than valenced images (Furl et al., 2012). If participants become desensitized when stimuli of a single motivational orientation are presented repeatedly, a mixed design should introduce unpredictability across trials, strengthening the effect of motivation on line bisection. However, if a blocked design is necessary to reinforce a particular motivational state (i.e., cumulative effect), the mixed design should cause the effect of motivation on response biases to be reduced.

Method

Participants

Twenty-two students (16 female; M_{age} = 24.50, *SD* = 7.41), completed the experiment. Participants had normal or corrected-to-normal vision and were right-handed (*M* = 66.36, *SD* = 19.95; Oldfield, 1971). All other aspects were the same as the previous experiments.

Apparatus and stimuli

The apparatus and stimuli were all identical to Experiment 1.

Procedure

A 6 (deviation: -2, -1, -0.5, 0.5,1, 2) x 2 (jitter: left, right) x 2 (sex of face: male, female) x 5 (different models) x 3 (motivation: happy, angry, neutral) mixed design was maintained, similar to Experiment 1. The only difference being that the 3 blocks of 120 trials each were not defined by motivational orientation but instead were composed of a mix of happy, angry and neutral faces. All factors were counter balanced within each block and trial order was randomised. All other aspects were identical to Experiment 1.

Results and Discussion

Participants with accuracy scores one standard deviation below the mean (*M* = 70.30%, *SD* = 8.16%) were classified as outliers and were excluded from analyses (*n* = 2). Response asymmetry scores for the remaining 20 participants were subjected to a repeated-measures ANOVA with one factor, motivation (happy, angry, neutral), which found no effect of motivation (see Table 5). One-sample *t*-tests failed to show significant pseudoneglect for all conditions (see Table 5).

The current experiment attempted to replicate the results of Experiment 1, which found that angry faces elicit greater leftward biases than happy faces. The only methodological difference between the experiments was the use of a mixed design. The failure to replicate this effect suggests that the use of a blocked design is important. Potentially, repeated exposure to faces of one emotion is necessary to induce a shift in state motivation (Compton et al., 2003; Rotteveel & Phaf, 2004). Therefore, it is not a matter of individual faces influencing motivation, but that a series of faces cumulatively induces an approach or avoidant motivational state.

Given that faces affect motivation more strongly than valenced images (Furl et al., 2012), it is unlikely that the experimental design was responsible for the observed null result in Experiment 2. Non-facial emotional images may be a weaker manipulation of motivation, as they lack the embodied, social component that is present with faces (Furl et al., 2012). Thus, the landmark task may lack the sensitivity to pick up on the smaller effect produced by valenced images.

Study 2: Experiment 4

The importance of experimental design is not limited to approach/avoidance research, but also plays a key role in line bisection. Fink and colleagues (2002) observed differential brain activation when participants judged “is the mark in the centre of the line or not?” compared to “are the two lines on each side of the mark of equal length or not?”

Specifically, when instructions stressed line length comparisons, the superior parietal cortex was activated. Similarly, Foxe, McCourt and Javitt (2003) found activation of the right lateral occipitoparietal and right central parietal brain regions when using comparable task instructions during EEG recording. In contrast, when the instructions stressed whether the bisection was centrally placed, activation of the lingual gyrus was observed (Gereon R. Fink et al., 2002). Reaction times were also quicker, while maintaining the same degree of accuracy, when participants made the centrality judgment, compared to the line length judgment. These data suggest that slight changes in instruction can modulate the neural mechanisms involved in behaviours associated with the task, influencing task performance. Fink et al's findings are particularly relevant, as Experiments 2 and 3 demonstrated that landmark task performance is sensitive to small changes in both stimuli and experimental design.

Experiment 4 explored whether a change to the task instructions would influence motivation. The instruction change was not expected to change the pattern of results from Experiment 1. As such, a main effect of motivation, with angry faces producing more leftward biases than happy faces, was expected. No differences were expected between the neutral and emotional (happy or angry) faces.

Method

Participants

Nineteen students (9 female; M_{age} = 22.74, *SD* = 3.68) completed the experiment. Participants had normal or corrected-to-normal vision and were right-handed (*M* = 78.16, *SD* = 21.74; Oldfield, 1971). All other aspects were the same as previous the previous experiments.

Apparatus and stimuli

The apparatus and stimuli were identical to Experiment 1.

Procedure

The procedure was similar to Experiment 1, except participants were instructed to decide if the transactor was closer to the right or the left end of the line, instead of indicating which side of the line was longer. Response bias was calculated similar to previous experiments. Left responses were firstly subtracted from right responses. The sum was then divided by the total number of responses and multiplied by 100. Therefore, possible scores ranged from -100 (left responses for all trials) to +100 (right responses for all trials).

Results and Discussion

Participants with accuracy score one standard deviation below the mean (*M* = 64.33%, *SD* = 12.83%) were classified as outliers and were excluded from analyses (*n* = 2). Using the remaining 17 participants, a repeated-measures ANOVA with one factor, motivation (happy, angry, neutral) failed to show a significant main effect (see Table 5). Pseudoneglect was not observed in any of the conditions (see Table 5).

When participants indicated whether the bisection mark was closer to the left or the right end of the line, response asymmetry scores did not differ between happy and angry conditions. This contrasts with the results of Experiment 1, where participants judged which side of the line was longer. Stimuli from Experiments 1 and 4 were identical, indicating that a slight change in task instructions altered the influence of motivation on the landmark task. Following three failures to replicate the findings of Experiment 1, it appears that the influence of motivation on spatial attention is quite specific and only occurs under one set of conditions. With this degree of methodological sensitivity, the landmark task is arguably not suitable for studying the influence of approach and avoidance motivation on attentional asymmetries. As a final demonstration of the influence of motivation on pseudoneglect, a direct replication of Experiment 1 was undertaken.

Study 2: Experiment 5

An exact replication of Experiment 1 was performed to determine the replicability of the effect and also to confirm that emotional faces influence attentional asymmetries only under these precise conditions. The pattern of results was expected to mirror the findings of Experiment 1.

Method

Participants

Twenty-three Flinders University psychology students (18 female; M_{age} = 24.26, *SD* = 5.93), completed the experiment in exchange for course credit. Participants had normal or corrected-to-normal vision and were right-handed (*M* = 73.48, *SD* = 20.80; Oldfield, 1971).

Apparatus, stimuli & procedure

Were all identical to Experiment 1.

Analyses

As the previous three experiments were unable to replicate the original effect of motivation found in Experiment 1, the current experiment utilised two methods of analysis: null hypothesis significance testing (NHST) and Bayesian analyses. NHST, as used in Experiment 1, is the gold standard for statistical analysis within psychological research (American Psychological Association, 2010). This method evaluates the probability of observing a given data set assuming the null hypothesis is true. Although NHST is prolific in psychological literature, there are growing criticisms for this method of analysis (D. H. Robinson & Wainer, 2002). Although many of these concerns are beyond the scope of this paper, one concern in particular is relevant. NHST does not directly test experimental hypotheses but rather tests against the null hypothesis. Essentially, this allows researchers to conclude whether an effect is likely to occur due to chance or not, but does not allow researchers to conclude that no effect exists. Bayesian analyses, however, can provide evidence in favour of both the null hypothesis and the experimental hypothesis (Posada & Buckley, 2004). For this reason, both analytical methods were utilised in this final experiment.

Results and Discussion

Participants with accuracy scores below one standard deviations from the mean (M = 68.71% SD = 7.51%) were classified as outliers and were excluded from analyses (n = 3). The response bias data from the remaining 20 participants were analysed with a repeated-measures ANOVA with one factor, motivation (happy, angry, neutral) and failed to find an effect (see Table 5). A priori planned comparisons were undertaken using paired-samples t-tests, which failed to show any significant differences, p's > .117. One-sample t-tests also failed to reveal pseudoneglect (see Table 5).

Not only were no significant differences observed, the pattern of results was in the opposite direction of what was hypothesised. In Experiment 1, pseudoneglect was greater for angry, compared to happy, faces. In Experiment 5, however, pseudoneglect was stronger for happy faces. Given that this experiment was a direct replication of Experiment 1, these findings are particularly troublesome. These results might indicate that motivation-based effects are highly sensitive to individual differences. Alternatively, the landmark task might simply not be sensitive enough to reliably identify behavioural differences in approach and avoidance motivation.

To illustrate that results were not the product of the statistical method used (NHST), as well as to allow evidence for both the experimental and null hypotheses to be evaluated, Bayesian analyses were conducted for Experiments 1 and 5. The Bayes Factor for Experiment 1 (*BF* = 1.38) showed no more than anecdotal evidence for an effect of motivation, and the Bayes Factor for Experiment 5 (*BF* = 2.96) indicated evidence in favour of the null hypothesis (Kass & Raftery, 1995). Overall, the combined data of Experiments 1 and 5 indicated positive evidence for the null hypothesis (*BF* = 4.08). In conclusion and contrary to previous literature, these results suggest that faces have, at best, a weak and inconsistent effect on landmark task performance.

General Discussion

The lateralisation of approach and avoidance motivation has been well documented (for review, see Spielberg, Stewart, Levin, Miller, & Heller, 2008). Methodologies used to illustrate this lateralisation, such as neuroimaging (Heller et al., 1997; Nash et al., 2010), and motor movement tasks (Chen & Bargh, 1999; Förster, 2004; Friedman & Förster, 2000; Rotteveel & Phaf, 2004), are expensive, complex, and time consuming. Nash and colleagues (2010) suggested that line bisection might provide a reliable and efficient method of observing asymmetries evoked by motivational states. A series of five experiments examined the influence of approach and avoidance motivation on the landmark task, with only one experiment showing a difference in response asymmetry based on motivation. Subjecting the combined data from all experiments to a 3 (motivation: approach, neutral, avoidance) x 5 (experiment: 1, 2, 3, 4, 5) mixed ANOVA also found no effect of motivation (see Table 5). This suggests that the landmark task is unable to reliably measure motivation-based changes in lateral biases.

There are several potential reasons for why the landmark task is unsuitable for measuring motivational biases, the first being individual differences. Manning and colleagues (1990) suggest that within-participant variability tends to be high as a result of variety in line bisection strategy. For example, scanning from the left or the right end of the line, as well as anticipatory (i.e., stopping before the midpoint) or perseverative errors (i.e., stopping after the midpoint) influence directional biases on line bisection and landmark tasks. A variety of strategies can be used by participants throughout a testing session, resulting in leftward or rightward biases for any individual trial. A high level of variability was evident in the current study, as mean response asymmetry scores were significantly leftward, non-significant and even trended toward being rightward. This variability causes line bisection to be a coarse measure of laterality, meaning it is not suitable for observing small lateral differences.

While the literature as a whole supports the lateralisation of approach and avoidance motivation (see Elliot & Covington, 2001 for a review), the specific pattern of results between behavioural studies often changes. For example, effects might only be evident under specific conditions, (under time pressure: Roskes, Sligte, Shalvi, & De Dreu, 2011; slow responders: Wentura, Rothermund, & Bak, 2000), within a subgroup (males: Haeffel, 2011; high BAS participants: Naylor, Byrne, & Wallace, 2015), or for only approach, but not avoidance motivation (Drake & Myers, 2006; Eerland et al., 2012; Schouppe, De Houwer, Richard Ridderinkhof & Notebaert, 2012). Furthermore, some investigators have failed to report any significant effects (J. S. Maxwell & Davidson, 2007), with a recent registered report failing to replicate two of Chen and Bargh's (1999) seminal experiments (Rotteveel et al., 2015). The varying pattern of results suggests that although approach and avoidance motivation are left and right lateralised, this effect is weak and highly sensitive to methodology.

As well as design methodology, the effect of motivation might be sensitive to exclusion criteria. There is still debate within the psychological literature as to how outliers should be classified (Orr, Sackett & Dubois, 1991) and the process remains largely subjective (Cousineau & Chartier, 2010). For example, studies similar to the current series have excluded participants based on malfunctioning equipment, EEG outliers and excessive artefacts (Nash et al., 2010), participants' history of psychological issues (Armaghani et al., 2014) or participants' English proficiency (Chen & Bargh, 1999). Outlier classification can have a pronounced effect on experimental results and Experiment 1 is a good example of this. To exclude inaccurate and highly variable participants the current series of experiments classified participants with accuracies below one standard deviation from the mean as outliers. Had a more lenient exclusion criterion been employed (e.g., a SD of 2.5), and inaccurate participants been included in the analyses for Experiment 1, the main effect of motivation would have failed to reach statistical significance $F(2, 46) = 1.85$, $p = .169$, $\eta_p^2 = 0.07$. Although this is not surprising, given the additional noise these participants add to the data, it is problematic that weak effects, such as the effect of motivation, can be influenced so greatly by the method of outlier classification. It is important to note that the null results reported in experiments two through five remained non-significant when the more lenient exclusion criterion was applied (all *p*s > .1). The conclusions drawn from these experiments therefore do not change. Regardless of the exclusion criteria chosen, the evidence overwhelmingly suggests that line bisection is an unreliable measure of motivational lateralization. Given that outlier classification potentially affects experimental results, it is important for authors to justify the method of exclusion criteria that they employ. This might be particularly important when studying weak effects that are potentially vulnerable to researcher degrees of freedom (Leggett, Thomas, Loetscher & Nicholls, 2013; Wagenmakers, Wetzels, Borsboom & van der Maas, 2011).

A final, and even more problematic finding, is that of a small effect size. In previous research, approach and avoidance conditions often differ from one another, but not from a neutral condition (Eerland et al., 2012; Förster et al., 2006). Furthermore, research with similar experimental designs has not included an effect size (Armaghani et al., 2014; Cattaneo et al., 2014), or has found a similarly small effect (Baker et al., 2013). This may be indicative of a ‘file-draw problem’ (Pautasso, 2010), where null findings are not published, whereas significant but small effects are published. Indeed, our data speak to this; a small effect was found in Experiment 1 ($\eta_P^2 = 0.155$), whereas the exact replication did not return a significant effect, even though the effect size ($\eta_P^2 = 0.12$) was comparable. These data highlight how effect sizes, in conjunction with *p* values, are integral to the interpretation of results.

The positive results observed in Experiment 1 could also be attributable to NHST. The significant effect of happy and angry faces in Experiment 1 was weak and Bayesian analyses indicated that the evidence was “not worth more than a bare mention” (Kass & Raftery, 1995, p. 777). The contrasting results, between null hypothesis significance testing and Bayesian analyses, highlight the importance of interpreting effect sizes alongside significant *p* values, a practice rarely undertaken in psychological literature (Bakker & Wicherts, 2011). Another practice rarely undertaken is replication. The exact replication of Experiment 1 in Experiment 5, and the divergent results, clearly shows that the effect observed in Experiment1 is unreliable.

In conclusion, the landmark task was found to be unreliable in measuring changes in lateral biases elicited by approach and avoidance motivation. This is likely a result of individual variability in pseudoneglect, along with the fact that observable differences in behaviour, caused by approach and avoidance motivation, are small. The importance of interpreting effect size measures along with *p* values is also emphasised, as contrasting conclusions were drawn by employing Bayesian analyses and the more traditional NHST procedure. Taken together, the experiments within this study indicate that line bisection should not be used to measure behavioural differences between approach and avoidance motivation. Future research should focus on the replicability of the motivational effect and under which conditions motivation affects lateral biases.

This concludes the current published paper.

Study 3: Experiment 1

Introduction

The previous study sought to validate claims that the landmark task, compared to neuroimaging procedures, is a quicker and easier method of measuring motivational lateralisation (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010). Unfortunately, our findings indicated the landmark task was unable to reliably show motivation lateralisation, possibly due to inherent variability in landmark task performance. An alternative measure of relative hemispheric activation is the greyscales task (see Chapter 1, p.7). The greyscales task has previously been used to examine lateral asymmetries elicited by factors such as number magnitude (Nicholls, Loftus & Gevers, 2008) and spatial position (Thomas & Elias, 2011). Although both the landmark and greyscales tasks measure hemispheric asymmetries in attention, previous research has failed to find correlations between performances on each (Learmonth, Gallagher, Gibson, Thut & Harvey, 2015). As such, the greyscales task might provide a useful alternative to neuroimaging in measuring the lateralisation of motivation, even though the landmark task could not.

The present experiment investigated whether approach and avoidance stimuli could affect biases on the greyscales task. Previous research has indicated that performance on the greyscales task is modulated by certain lateralised processes (Nicholls et al., 2008; Thomas & Elias, 2010). For example, numbers are spatially represented on a mental number line, such that low and high numbers are represented on the left and right sides of space, respectively (Fias, Lauwereyns & Lammertyn, 2001; Fischer, Castel, Dodd & Pratt, 2003). Nicholls and colleagues (2008) overlaid a greyscales task with a low number (1, 2), a high number (8, 9), or a neutral symbol (&, #; see Figure 10). Participants classified the overlay as high or low (Experiment 1), or odd or even (Experiment 2) and were then asked whether the top or bottom greyscale was darker overall. In both experiments, the results showed that low numbers elicited more leftward biases, and high numbers more rightward biases, than neutral symbols. This illustrated that performance on the greyscales could be modulated by the mental number line, and more broadly, suggests that the greyscales task can be used to reflect lateralised brain functions.

Figure 10. Example of a greyscales stimulus used by Nicholls et al. (2008)

As Nicholls and colleagues (2008) showed that the left to right representation of numbers influences performance on the greyscales task, it is plausible that approach/avoidance stimuli could have a similar effect. The current experiment used a similar paradigm to Nicholls et al. (2008), such that happy, angry, and neutral faces were overlaid on a greyscales task. It was hypothesised that happy faces would elicit more rightward responses, due to approach-related left hemisphere activation. In contrast, it was hypothesised that angry faces would elicit more leftward responses, due to avoidance-related right hemisphere activation.

Method

Participants

Twenty-four Flinders University psychology students (16 female) completed the experiment in exchange for $10 compensation. Participants were aged between 17 and 41 years (M = 25.25, SD = 6.31), had normal or corrected to normal vision and were right-handed (M = 7.48, SD = 2.50) according to the Flinders Handedness Survey (FLANDERS; Nicholls, Thomas, Loetscher, & Grimshaw, 2013). Informed consent was obtained prior to the experiment, which was conducted with the ethical approval of the Social and Behavioural Research Ethics Committee of Flinders University.

Apparatus

Experimental stimuli were presented on an Intel Core 2 Duo PC, with a 19" monitor running at a resolution of 1024 x 768 pixels. E-prime 2.0 software (Psychology Software Tools, Inc.; www.pstnet.com/E-prime/e-prime.htm) was used to present stimuli and record responses. Responses were made on a model 200A PST Serial Response Box with five horizontally placed buttons. A chin rest was used to maintain consistent visual angle between participants and participants were also video monitored, so as to motivate them to attend to the task.

Stimuli

Greyscales task.

On the greyscales task (Nicholls et al., 1999), participants judge which of two left–right, mirror-reversed brightness gradients appear darker overall. For each stimulus pair, one of the greyscales was shaded black to white, from left to right, and the other was shaded in the reverse direction (see Figure 7). The orientation of the dark and light sides ('polarisation') was counterbalanced. Because the stimuli were aligned vertically, responses (top or bottom) were orthogonal to the variable of interest, which was the side that was perceived as darker. Two greyscale lengths, 7.5˚ and 10˚ of visual angle, were used, as previous research has indicated that increased task variability improves attention on task (Nicholls, Bradshaw & Mattingley, 1999). Neither the length nor the polarisation of the greyscales were variables of interest and as such were not analysed.

Schematic faces were superimposed on greyscales stimuli to create happy, angry, and neutral stimuli. As schematic faces are abstractions of actual faces, they were unfamiliar to participants and allowed for tight control of physical features, which could not have been controlled in actual faces (e.g., hair style, eye colour). Happy, angry[5] and neutral faces contained identical physical components, with the spatial arrangements of these features differing depending on emotion (Öhman, Lundqvist & Esteves, 2001).

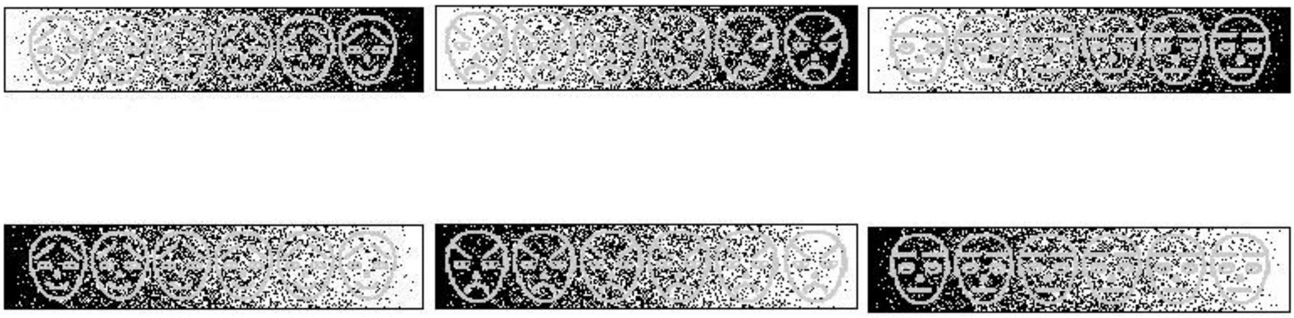

Figure 11. From left to right, examples of happy, angry and neutral greyscales stimuli from the current experiment

Procedure

The experiment was completed in a single session that lasted approximately 30 minutes. At the onset of each trial, a centrally positioned fixation cross was displayed for 250 ms, which participants focussed on to control for initial fixation position. Following this, the greyscales task was presented for 3000 ms. After this time, the greyscales task was replaced with a fixation cross and participants were asked to verbally indicate the emotion of the overlay and then whether the top or bottom greyscale was darker overall. Participants' responses were entered manually by the experimenter.

Trials were randomly presented in 3 blocks of 80 trials each, making a total of 240 trials. Participants were given a 2-minute break between each block, during which time they completed an intrinsic/extrinsic motivation questionnaire, which was unrelated to the present experiment. At the completion of the experiment, participants were asked to rate the emotionality of the faces, on a scale from 1 to 10. This emotionality rating checked whether or not participants viewed the schematic faces as portraying the intended

[5] Angry facial stimuli were used in lieu of sad facial stimuli, given that sad facial stimuli have previously been shown to elicit an initial approach reaction (Seidel et al., 2010) and angry faces have previously been found to elicit avoidance motivation (A. A. Marsh et al., 2005; Roelofs et al., 2010).

emotion. Participants were then debriefed and allowed to leave.

Analyses

Five participants were excluded from the analysis: two did not meet the requirements for right-handedness and three others did not follow task instructions. All participants reported that facial stimuli expressed the intended emotions (*M* = 7.09, *SD* = 1.98). A Shapiro-Wilk test indicated the data were normally distributed (*p* = .200). Mauchly's Test of Sphericity indicated assumptions of sphericity were met (*p* = .595). All post-hoc analyses that include multiple comparisons have been Bonferroni corrected. Bonferroni corrected *p* values can at times be greater than one, and these *p* values have been reported as '*p* > .999' for the sake of readability.

Results

Data from the remaining 19 participants were analysed by a repeated-measures ANOVA with one factor, emotion (happy, angry, neutral), which found a main effect of emotion, *F*(2, 36) = 5.32, *p* = .009, η_P^2 = 0.23. Post-hoc paired-samples *t*-tests showed that angry faces elicited a weaker leftward bias than both happy and neutral faces, *t*(18) = 2.67, *p* = .048, *d* = 0.29 and *t*(18) = 2.71, *p* = .042, *d* = 0.26, respectively. Neutral and happy faces did not produce differing biases, *t*(18) = -0.30, *p* > .999, *d* = 0.03 (see Figure 12). One-sample *t*-tests showed that no biases were significantly leftward of zero; angry *t*(19) = 0.12, *p* = .908, *d* < 0.01, happy *t*(18) = 1.37, *p* = .188, *d* = 0.44, neutral *t*(18) = 1.17, *p* = .256, *d* = 0.38.

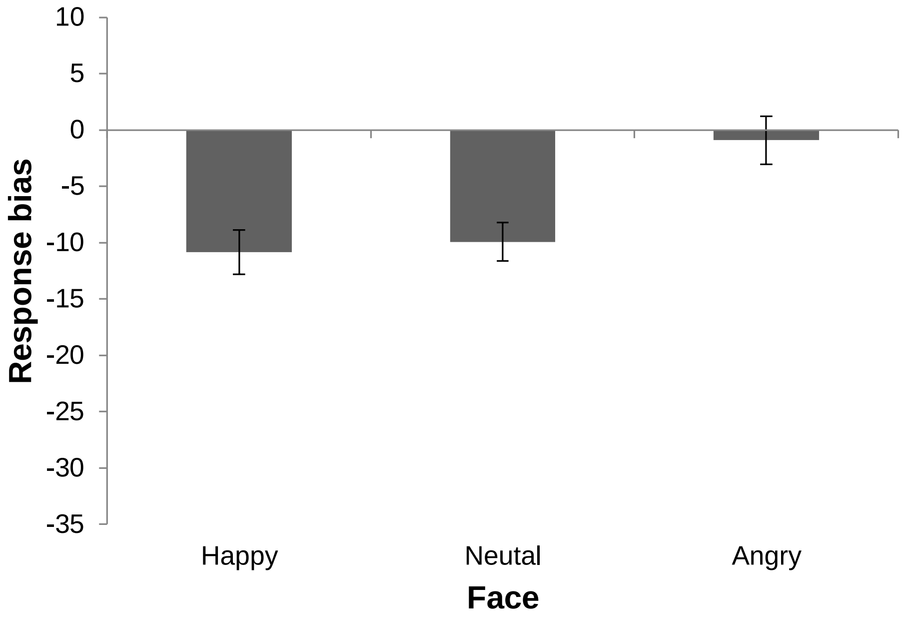

Figure 12. Response biases for happy, neutral and angry face stimuli. Error bars denote within-subjects standard error from the mean and negative biases represent biases leftward of centre.

Discussion

Leftward response biases were reduced following angry faces, compared to both neutral and happy faces, which was unexpected as previous research has indicated that avoidance-related facial expressions elicit right-hemisphere activation, resulting in stronger leftward biases (Armaghani et al., 2014; Cattaneo et al., 2014). The current results indicate that the greyscales task can reliably distinguish between approach and avoidance motivation; however, several aspects of these data suggest that the results should be interpreted cautiously.

Although angry face overlays elicited a reduced leftwards bias compared to both happy and neutral faces, these difference were small[6] (Miles & Shevlin, 2000). These small effect sizes are worrying, as recent research has suggested that weak effects are less replicable (Nosek, Cohoon & Kidwell, 2015). Indeed, Experiment 1 of Study 2 in the current thesis found a small, yet significant, motivational effect. Across three subsequent experiments,

[6] This small effect size was not due to insufficient power, as a post-hoc power analysis indicated sufficient power (0.97).

small changes in the methodology rendered the motivational effect non-significant, until eventually an exact replication of the original experiment failed to reproduce the motivational effect. These results illustrate that motivational lateralisation effects are small and, under certain methodological parameters, unreliable. As such, the small effect found in the current experiment should be interpreted cautiously.

Further complicating the interpretation of these findings, motivational effects were in the opposite direction to the hypothesis. The current study found that both happy and neutral faces elicited biases more leftward than angry faces. This contrasts with the findings of previous research (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010). Armaghani et al. (2014) found that both happy and sad faces produced more leftward biases than neutral faces; however, sad faces elicited significantly more leftward biases than happy faces. Cattaneo et al. (2014) similarly found that sad faces elicited more leftward biases than happy faces, although happy and neutral faces did not differ. Therefore, although previous results have been mixed, avoidance-related faces have always elicited biases more leftward than approach-related faces.

Although the current experiment used angry face stimuli, compared to the sad face stimuli used by both Armaghani et al. (2014) and Cattaneo et al. (2014), this methodological difference is unlikely to explain the current contrasting results. Angry face stimuli have previously been shown to reliably elicit avoidance motivation (A. A. Marsh et al., 2005; Roelofs et al., 2010), whereas one study has suggested that sad face stimuli elicit automatic approach reactions *and* conscious avoidance reactions (Seidel et al., 2010). Therefore, angry face stimuli should in fact elicit avoidance motivation more reliably than sad face stimuli.

Study 3: Replication

Experiment 1 returned an unexpected result and the effect size was small, both aspects of the data which might suggest that the motivational effect is not replicable (Lindsay, 2015; Nosek et al., 2015). A straight replication of Experiment 1 was therefore undertaken, with the simple aim of reproducing the motivational effect. If the motivational effect can be self-replicated, greater faith could be placed in the direction of the effect and the effect itself.

Method

Participants

Based on the results of the previous experiment, G*Power (Faul et al., 2007) was used to conduct an a priori power analysis for the planned ANOVA. The power analysis indicated that, with a partial eta-squared of 0.23 and a critical alpha of .05, a minimum of 14 participants were needed to maintain a power level of at least 0.9.

Twenty-two Flinders University psychology students (18 female), aged between 18 and 38 (*M* = 23.77, *SD* = 6.41), completed the experiment in exchange for $10 AUD. Participants had normal or corrected-to-normal vision and were right-handed (*M* = 9.37, *SD* = 1.17) according to the FLANDERS (Nicholls et al., 2013). Informed consent was obtained prior to the experiment, which was conducted with the ethical approval of the Social and Behavioural Research Ethics Committee of Flinders University.

Apparatus, Stimuli and Procedure

Apparatus, stimuli and procedure were identical to the previous experiment.

Analyses

Four participants were excluded for not following task instructions. An additional three participants rated the emotional expression of stimuli (either happy or angry faces) as 2 out of 10. These participants were therefore excluded as they did not perceive either the happy stimuli as happy or the angry stimuli as angry. A Shapiro-Wilk test indicated the distribution of the data was slightly skewed (*p*'s < .037); however, data were not normalised so that analytical procedures were identical between the original experiment and the replication. Mauchly's Test of Sphericity indicated assumptions of sphericity were met (*p* = .118).

Results

Data from the remaining fifteen participants were subjected to a repeated-measures ANOVA with one factor, emotion (happy, angry, neutral), which did not find a main effect of emotion, $F(2,28) = 2.52$, $p = .099$, $\eta_p^2 = 0.15$ (see Figure 13). Only the angry condition produced a significant leftward bias, $t(14) = 2.25$, $p = .041$ $d = 0.04$, with the happy and neutral conditions producing no significant biases, $t(14) = 1.97$, $p = .069$, $d = 0.69$ and $t(14) = 1.48$, $p = .162$, $d = 0.37$, respectively (see Figure 13).

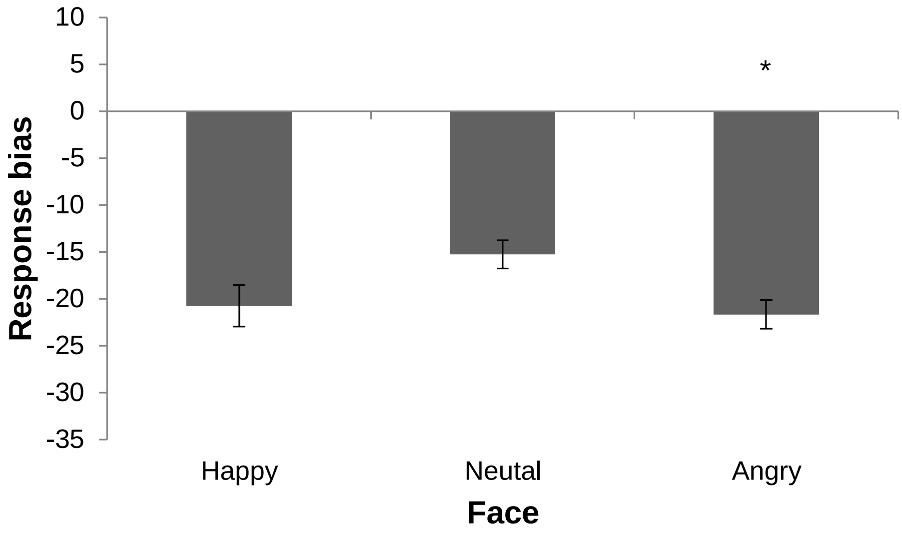

Figure 13. Response biases for happy, neutral and angry face stimuli. Error bars denote within-subjects standard error from the mean and negative biases represent biases leftward of centre. An asterisk (*) denotes a biases significantly different from zero.

As the original experiment and the replication shared identical methodological procedures, data from each experiment were collated and analysed. Data from the combined 34 participants were analysed by a repeated-measures ANOVA with one factor, emotion (happy, angry, neutral), and found that the main effect of emotion was non-significant, $F(1, 66) = 2.15$, $p = .124$, $\eta_p^2 = .06$. This result shows that, overall, the greyscales task is not suitable for measuring motivational lateralisation.

Discussion

The replication, as well as combined data across the two experiments, was unable to reproduce the original motivation effect. Although this might indicate that the greyscales task cannot reliably measure motivational lateralisation, it is also possible that the schematic facial stimuli used in the current experiments did not elicit approach and avoidance motivation. Schematic faces were used in an attempt to reduce emotionally irrelevant perceptual features, given these features have been shown to influence visual search performance (Craig et al., 2014). However, previous research has only used photographic faces to elicit approach and avoidance motivation (Armaghani et al., 2014; Cattaneo et al., 2014). It is therefore possible that the happy and angry schematic faces did not elicit approach or avoidance motivation in the current experiment.

Overall, data from the current study suggest that the greyscales task is an unreliable measure of motivational lateralisation. As the greyscales task has not been previously used to measure motivational lateralisation, only indirect comparisons can be made to other studies. Thomas and Elias (2010) presented greyscale stimuli in the upper and lower visual fields. They found that lower visual field presentation elicited greater leftward biases and upper visual field presentation elicited greater rightward biases. They concluded that these differences were due to dorsal and ventral stream processing. Dorsal stream processing is elicited by lower visual field stimuli and results in greater relative right hemisphere activation, whereas ventral stream processing is elicited by upper visual field stimuli and results in greater relative left hemisphere processing. Theoretically, approach and avoidance motivation elicit similar left and right posterior-parietal hemisphere activation, respectively (Spielberg et al., 2012). However, the results of the current study suggest that motivational lateralisation does not modulate greyscale performance in the same way as lower and upper visual field presentation do.

The failure to replicate the motivational effects across both the greyscales and landmark tasks might have similar underlying reasons. Firstly, both tasks provide a broad indication of hemispheric asymmetry and are inherently variable (Manning et al., 1990). As can be seen by the overall standard deviation of the current study (M = -13.23, SD = 38.92), the noise within the data makes it more difficult for differences between motivational conditions to be statistically significant, especially if these differences are small to begin with.

The current failure to replicate also highlights the importance of replication, especially for small effects. Recently, the reproducibility of psychological effects has come under scrutiny (Nosek et al., 2015; Rotteveel et al., 2015; Wagenmakers, 2007). A recent initiative, titled ‘The Reproducibility Project: Psychology’ and consisting of 270 collaborating authors who worked to replicate 100 psychological studies, found that effects were weaker in replication attempts compared to original experiments; however, effects with larger original effect sizes were more likely to be reproduced (Nosek et al., 2015). Overall, studies 2 and 3 of the current thesis suggest that weak effects should be replicated multiple times in order to increase one’s faith in the reproducibility and validity of the effect.

Chapter 4: Visuospatial Biases in the Vertical Dimension

Hemispatial neglect is most typically discussed in terms of attentional allocation across the horizontal dimension; however, clinical patients have also displayed impairments in allocating attention across the vertical dimension (Cappelletti et al., 2007; Drain & Reuter-Lorenz, 1996; Kinsbourne, 1993; Pitzalis et al., 2001). Cappelletti et al. (2007) asked five neglect patients to bisect mental number lines, which involved participants reporting which number would perfectly bisect two given numbers. The phrasing of the instructions differed between two groups, such that numbers either represented houses on a street (horizontal condition) or floors of a building (vertical condition). In the horizontal condition, all patients showed typical left side neglect with rightward bisections. However, in the vertical condition, only three of the five patients bisected number lines upwards, displaying neglect of the lower visual field. This study suggests that the attentional processes which operate within the horizontal and vertical dimensions are dissociable. Additionally, within the vertical dimension, processes governing the allocation of attention to the upper and lower visual fields are also dissociable.

Typically developed populations have also been found to differentially allocate attention to the upper and lower visual fields (Drain & Reuter-Lorenz, 1996; Jeerakathil & Kirk, 1994; Nicholls, Mattingley, Berberovic, Smith & Bradshaw, 2004). A bias toward upper visual field stimuli has been found for tasks such as vertical line bisection, the greyscales task and visual search. In an EEG study, Loughnane et al. (2015) asked participants to find a target on a checkerboard. Response times to targets in the lower portion of the checkerboard were linked to greater activation of the right hemisphere; however, no link between targets in the upper visual field and brain asymmetry was found. Additionally, response times were biased to the left for lower visual field targets and tended to be biased towards the right[7] for upper visual field targets. Loughnane and colleagues (2015) concluded that, in typically developed individuals, processes responsible for the allocation of attention to upper and lower visual field targets are dissociable.

Lower and upper visual field processing is thought to be closely linked to near and far space processing, respectively (Previc, 1990). Previc (1990) argued that near space

[7] Response times for left and right targets in the upper visual field tended to be different, $t(23) = 2.37$, $p = .054$.

stimuli are generally presented in the lower visual field, whereas far space stimuli are generally presented in the upper visual field. Dorsal stream processes are responsible for the representation of *where* a stimulus is, as well as how it is moving, which has important implications for the physical manipulation of stimuli in near space. On the other hand, ventral stream processes are responsible for the classification of *what* a stimulus is, which is especially important for stimuli outside of actionable space. For these functional reasons, Previc (1990) suggests that dorsal stream processes underlie both lower visual field and near space processing, whereas ventral stream processes underlie both upper visual field and far space processing.

Experimental evidence also supports the dorsal and ventral stream processing of the lower and upper visual fields, respectively (Corbetta & Shulman, 2011; McCourt & Olafson, 1997). Thomas and Elias (2010) presented participants with a greyscales task in the upper and the lower visual fields, at near and far distances. They found leftwards biases were strongest for greyscales presented in the lower visual field compared to the upper visual field, which suggested that lower visual field stimuli were eliciting dorsal stream processes. No response bias differences between near and far space conditions were found, suggesting that space based difference do not occur when visual angle is kept constant, but that elevational differences do elicit differential dorsal and ventral stream processes. Loughnane et al. (2015) asked participants to find targets on a visual search task as quickly as they could. Although Loughnane et al. (2015) found a response time advantage for targets in the lower visual field, they also found a leftwards response bias in the lower visual field and a trend for a rightwards response bias in the upper visual field. Both of these studies suggest that biases in the lower and upper visual fields are dissociable. Further, the leftward bias in the lower visual field appears to be linked to dorsal stream processes, whereas the rightward bias in the upper visual field in linked to ventral stream processes.

It is worth noting that some research suggests that presentation time interacts with visual field biases (Thomas & Elias, 2011). Studies which have used short presentation times (i.e., 150 ms), such that eye movements cannot occur, have reported stronger leftward biases in the upper visual field (McCourt & Garlinghouse, 2000; McCourt & Jewell, 1999), whereas longer presentation times have resulted in stronger leftward biases in the lower visual field (Barrett, Crosson, Crucian & Heilman, 2000; Thomas & Elias, 2010).

Although the precise mechanisms responsible for this difference is unclear, eye movements might be required to elicit dorsal stream processing of lower visual field stimuli (Thomas & Elias, 2011).

Study 4: Experiment 1

The current experiment sought to explore whether upper and lower visual field presentations facilitate approach and avoidance motivation, respectively. Leftward attentional biases have been linked to both avoidance and lower visual field stimuli, just as rightward attentional biases have been linked to approach and upper visual field stimuli (Armaghani et al., 2014; Barrett et al., 2000; Cattaneo et al., 2014; Loughnane et al., 2015; Thomas & Elias, 2010, 2011). Despite the previous evidence linking both motivation and elevation to attentional allocation, no previous research has examined the effects of approach and avoidance motivation within the upper and lower visual fields.

Given that the previous experiments in the current thesis suggest that broad measures of lateralisation, such as landmark and greyscales tasks, are inappropriate for measuring approach and avoidance motivation, the current experiment used a visual detection task to explore whether approach and avoidance motivation affects attention in upper and lower visual fields differently. It was hypothesised that actively searching for a happy target would increase search efficiency for targets in the upper and right visual fields whereas actively searching for angry targets would increase search efficiency for targets in the lower and left visual fields.

Method

Participants

Twenty-nine Flinders University psychology students (15 female) completed the experiment in exchange for course credit. Participants were aged between 17 and 53 years (M = 25.10, SD = 10.57), had normal or corrected-to-normal vision and were right-handed (M = 9.93, SD = 0.26) according to the FLANDERS (Nicholls et al., 2013). Informed consent was obtained prior to the experiment, which was conducted with the ethical approval of the Social and Behavioural Research Ethics Committee of Flinders University.

Apparatus

Stimuli were presented on an Intel Core 2 Duo PC, with a 19” monitor running at a resolution of 1024 x 768 pixels. E-prime 2.0 software (Psychology Software Tools, Inc.; www.pstnet.com/E-prime/e-prime.htm) was used to present stimuli and record responses. Responses were made on a model 200A PST Serial Response Box with five horizontally placed buttons with ‘Y’ and ‘N’ stuck above the far right and left buttons (placement counterbalanced between participants). A chin rest served to keep the visual angle of the stimuli constant and to reduce head movements. Participants were video monitored so as to motivate them to attend to the task.

Stimuli

The visual detection task was created using the Visual Search Generator, a program written in MATLAB by the author (see Appendix 1). Each array was 20 columns wide and 6 rows tall (284 mm x 70 mm; see Figure 14). Each column had 4 schematic faces placed randomly on each row, totalling 80 faces in each array. No two arrays were the same. Distractor faces were always neutral, such that the happy and angry target conditions were comparable (Frischen, Eastwood & Smilek, 2008). Each target was a happy or angry schematic face, depending on the condition.

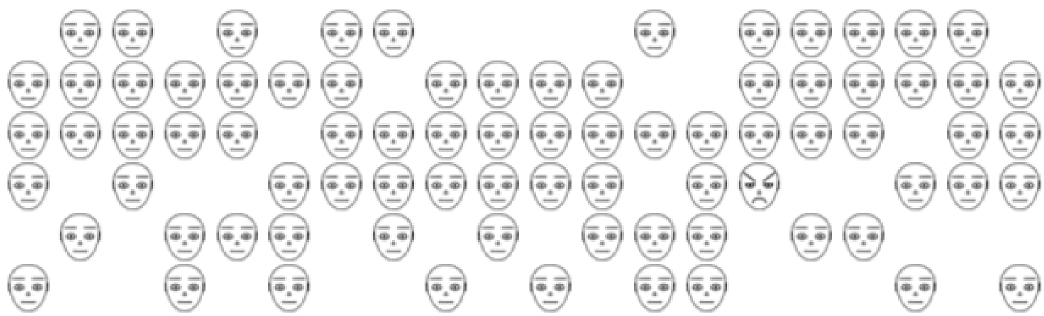

Figure 14. An example of an array in the angry condition

Procedure

The detection task was presented on a white background to contrast with the black outline of the faces. A fixation cross was first displayed for 500 ms, which participants were asked to focus on. Following this, a blank page was displayed for 250 ms and then an array was then presented until participants responded, up to a maximum of for 4000 ms. Participants indicated whether an emotional face was present in the array, as quickly and accurately as possible. Participants used the far left and right buttons of the response box to respond. A blank screen was shown for 500 ms between trials.

Participants completed 2 blocks of trials, one block with angry face targets and one with happy face targets, as motivational stimuli have been shown to be more effective after prolonged exposure (Cattaneo et al., 2014). Each block consisted of 144 trials, which included 120 target arrays and 24 catch trials, where no target existed. Block order was counterbalanced between participants and there was a short break between blocks. Half of the participants viewed the array in its original orientation and the other half saw mirror-reversals, to balance the position of distracters.

Analyses

For each possible target position, inverse efficiency scores were calculated by dividing response time by proportion of correct response. Inverse efficiency scores are a standard way to combine response time and accuracy data (see Townsend & Ashby, 1983). As such, higher search efficiency was represented by lower inverse efficiency scores. As eccentricity has been shown to affect response times in visual search tasks, with searches being more efficient for centrally located targets (Wolfe, O'Neil & Bennett, 1998), both horizontal and vertical target positions were classified as inner or outer targets, in respect to their distance from the centre of the array. There were a total of four horizontal positions, consisting of five columns per level (inner/outer and left/right). There were also three vertical positions, consisting of two rows per level (top, middle, bottom).

Inverse efficiency scores were unable to be calculated for one participant, due to no correct responses for at least one condition, and they were excluded from analyses. A Shapiro-Wilk test indicated the data were normally distributed (p = .087). Mauchly’s Test of Sphericity indicated sphericity for all data (all ps > .479), as such, no method of correction on the degrees of freedom was used. All post-hoc paired-samples t-tests were Bonferroni corrected.

Results

For each possible target position, inverse efficiency scores were calculated by dividing response time by proportion of correct response. As such, lower inverse efficiency scores represented higher search efficiency. Eccentricity affects response times in visual search tasks, with searches for centrally located targets being more efficient (Wolfe et al., 1998). Therefore, both horizontal and vertical targets were classified as “inner” or “outer”, with respect to their distance from the centre of the array. This resulted in four horizontal positions: outer left, inner left, inner right, and outer right (5 columns per level). There were also three vertical positions: top, middle, and bottom (2 rows per level).

Inverse efficiency scores could not be calculated for one participant, who had no correct responses for some conditions; they were excluded from analyses. Mauchly’s Test of Sphericity indicated the assumption of sphericity was met for all data (all *p*s > .479). All post-hoc paired-samples *t*-tests were Bonferroni-corrected.

Data from the remaining 28 participants were subjected to a 2 (emotion: happy, angry) x 2 (vertical position: top, middle, bottom) x 2 (horizontal position: left, right) x 2 (horizontal eccentricity: inner, outer) repeated-measures ANOVA. A main effect of emotion was found, such that angry targets (*M* = 1192.12, *SD* = 371.35) were found more efficiently than happy targets (*M* =1555.80, *SD* = 426.90), $F(1, 27) = 107.205$, $p < .001$, $\eta_P^2 = 0.80$ (see Figure 15).

Horizontal data

The main effect of horizontal position was non-significant, as there was no difference between left (*M* =1335.77, *SD* = 419.94) and right (*M* = 1412.15, *SD* = 455.18) targets, $F(1, 27) = 1.72$, $p = .200$, $\eta_P^2 = 0.06$; however, the expected main effect of horizontal eccentricity was significant, such that inner targets (*M* = 1228.52, *SD* = 426.98) were found more efficiently than outer targets (*M* = 1519.40, *SD* = 402.16), $F(1, 27) = 60.10$, $p < .001$, $\eta_P^2 = 0.69$ (see Figure 15).

The three-way interaction between emotion, horizontal position and horizontal eccentricity was significant, $F(1, 27) = 9.21$, $p = .005$, $\eta_P^2 = 0.25$ (see Figure 15). For ease of interpretation, this three-way interaction was broken down into several two-way interactions. The interaction between emotion and horizontal position was non-significant, *F*(1,27) = 0.96, *p* = .335, η_P^2 = 0.03, demonstrating that the emotion of the target did not influence efficiency differently based on horizontal location. The interaction between emotion and horizontal eccentricity was significant, *F*(1, 27) = 5.67, *p* = .025, η_P^2 = 0.17, with the inner target advantage being stronger for angry compared to happy targets, *t*(27) = 9.24, *p* < .001, *d* = 1.41 and *t*(27) = 6.54, *p* < .001, *d* = 1.02, respectively (see Figure 15).

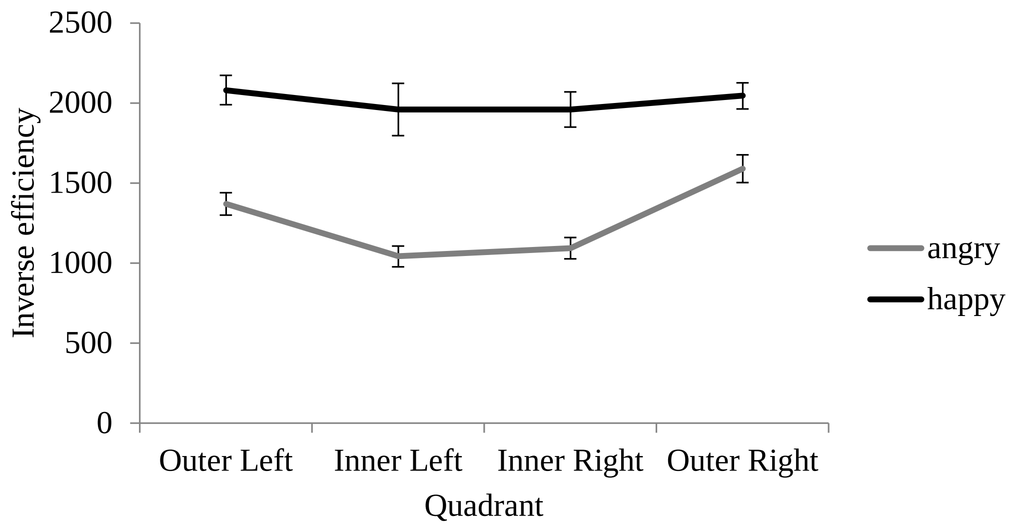

Figure 15. Inverse efficiency scores by emotion and horizontal eccentricity. Error bars denote within-subjects standard error from the mean.

In agreement with previous findings, targets closer to the centre of the array were found more efficiently than targets further from the centre, with this effect being slightly stronger for angry, compared to happy, targets. Overall, angry faces were found more efficiently than happy faces, indicating an anger superiority effect (Öhman et al., 2001). No advantage was found for the search efficiency of faces to the left or right of the array, overall or individually.

Vertical data

The main effect of vertical position was significant, *F*(2, 54) = 14.67, *p* < .001, η_P^2 = 0.35, with post-hoc paired-samples *t*-tests indicating more efficient searches for middle targets (*M* = 1298.44, *SD* = 427.35) compared to both top (*M* = 1390.53, *SD* = 437.04) and bottom (*M* = 1432.90, *SD* = 444.35) targets, *t*(27) = 3.66, *p* = .003, *d* = 0.21, *t*(27) = 5.72, *p*

< .001, *d* = 0.31 (see Figure 16). No difference in search efficiency was found between targets in the top and bottom of the array, *t*(27) = 1.55, *p* = .399, *d* = 0.01.

The interaction between emotion and vertical position was significant, *F*(2, 54) = 5.58, *p* = .006, η_P^2 = 0.17 (see Figure 16). For both the happy and angry conditions individually, targets in the centre rows were more efficiently searched for than targets in the top or bottom portions of the array, all *p*s < .036[8]. Differences between top and bottom targets, for both angry and happy faces, did not survive bonferroni correction, *t*(27) = 0.28, *p* > .999, *d* = 0.03 and *t*(27) = 2.06, *p* = .245, *d* = 0.26, respectively (see Figure 16). It is therefore likely that the emotion by vertical position interaction was driven by the different effect sizes of the nonsignificant differences between top and bottom targets in the angry and happy conditions.

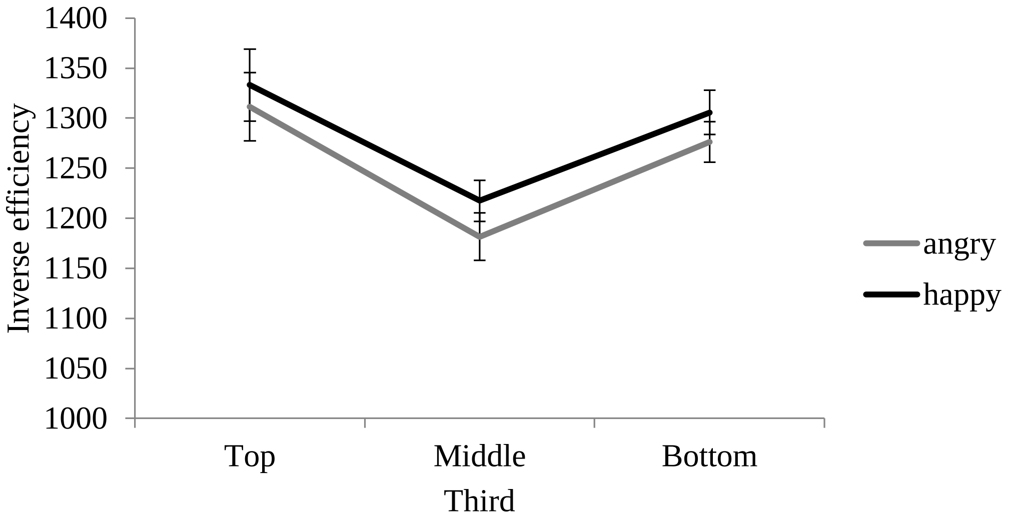

Figure 16. Inverse efficiency scores by emotion and vertical position. Error bars denote within-subjects standard error from the mean

Horizontal and vertical interactions

A trend towards a two-way interaction between horizontal (left, right) and vertical (upper, lower, middle) position was found, *F*(2, 54) = 3.09, *p* = .053, η_P^2 = 0.10; however,

[8] Angry targets: middle vs. top [*t*(27) = 3.03, *p* = .030], middle vs. bottom [*t*(27) = 3.01, *p* = .036]. Happy targets: middle vs. top [*t*(27) = 3.20, *p* = .020], middle vs. bottom [*t*(27) = 6.12, *p* < .001].

search efficiency did not differ between left and right targets positioned in either the top, middle or bottom portions of the array, $t(27) = 1.06$, $p > .999$, $d = 0.23$, $t(27)$ 0.50, $p > .999$, $d = 0.11$ and $t(27) = 2.4$, $p = .120$, $d = 0.43$ respectively. No other three- or four-way interactions were significant[9].

Discussion

The current study used a novel visual detection task to explore whether emotional faces could elicit upper and lower visual field differences. Overall, angry faces were searched for more efficiently than happy faces, which is in line with previous findings and suggests that schematic faces were perceived as happy and angry, as intended (Öhman et al., 2001). However, search efficiency did not differ across the left and right portions of the array. This differs from previous research, which has found lower leftward and upper right biases of attention (Loughnane et al., 2015; Thomas & Elias, 2011). Although the overall advantage for angry face searches might have outweighed any possible motivational effects, there are also several methodological factors that might explain why the current results differ from previous studies.

The current study asked participants to fixate on the centre of each array at the beginning of each trial. This was done to keep initial fixation constant across participants and trials. However, this could have reduced the influence of scanning behaviour, and biased attention toward centrally positioned targets. Indeed, centrally positioned targets had much greater search efficiencies, for both the middle rows and columns. Thomas and Elias (2011) found that controlling for scanning behaviours, by presenting greyscale stimuli for only 150 ms, resulted in no lateral biases in the lower visual field. Admittedly, their task involved participants focussing on a central fixation for the duration of the experiment, whereas the current experiment allowed for eye movements after the original fixation. Loughnane et al. (2015) used a similar design to the current experiment, where participants focussed on a central fixation point at the beginning of each trial. Despite their initial fixation, they found searches were more efficient in the lower left quadrant. It therefore seems unlikely that the current experiment sufficiently reduced scanning

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[9] Three-way interaction between emotion, vertical position and horizontal position: $F(2, 54) = 0.43$, $p = .653$, $\eta_P^2 = 0.02$. Three-way interaction between emotion, vertical position and horizontal eccentricity: $F(2, 54) = 1.65$, $p = .202$, $\eta_P^2 = 0.06$. Three-way interaction between vertical position, horizontal position and horizontal eccentricity: $F(2, 54) = 0.03$, $p = .972$, $\eta_P^2 = 0.001$. Four-way interaction between emotion, vertical position, horizontal position and horizontal eccentricity: $F(2, 54) = 0.77$, $p = .469$, $\eta_P^2 = 0.03$.

behaviour to a degree to account for the null effect. However, the current visual detection task differs from the methodology of both Thomas and Elias (2011) and Loughnane et al. (2015) in that emotional stimuli were used.

It is possible that the facial stimuli themselves supressed the lower left bias which has previously been reported (Thomas & Elias, 2010). Although facial stimuli have previously been used within visual search paradigms, past research has focussed on the effects of facial properties and emotions on overall visual search efficiency, rather than horizontal or vertical biases (see Frischen et al., 2008 for a review). Consistent with some previous research, the current findings supports an anger superiority effect (Hansen & Hansen, 1988; Horstmann & Bauland, 2006; Pinkham, Griffin, Baron, Sasson & Gur, 2010); however, it is difficult to know what biases facial stimuli might elicit in a visual search paradigm. Although previous studies have consistently found that approach-related faces elicit stronger rightward biases than avoidance-related faces, results have been mixed when comparing neutral faces from emotion faces (Armaghani et al., 2014; Cattaneo et al., 2014). Armaghani et al. (2014) found that neutral faces elicited more rightwards biases than both approach- and avoidance-related faces, whereas Cattaneo et al. (2014) found that neutral faces elicited more *leftwards* biases compared to approach-related faces, and no differential biases compared to avoidance-related faces. Thus, because the current study is the first to investigate lateral asymmetries within a visual search paradigm using facial stimuli, it is unclear how neutral face distractors affected asymmetries in visual search performance. Future research might consider using alternative distracter stimuli, such as blank circles.

Overall, the current experiment showed that angry face targets are more efficiently searched for than happy face targets. Additionally, targets closer to the centre of the array are found more efficiently in both the horizontal and vertical dimensions. No left/right asymmetries were found. The current results therefore suggest that visual search for emotional face stimuli is symmetrical across both the horizontal and vertical dimensions.

Chapter 5: Motivational Biases in Depth

Previous research on motivational lateralisation has focussed on left and right attentional biases, whereas research investigating proximal contributions to these biases has been lacking. Thus far, the current thesis has investigated motivational biases in the lateral and vertical dimensions, with two primary findings: 1) the landmark and greyscales tasks do not reliably reflect motivational lateralisation and; 2) motivational stimuli do not elicit attentional asymmetries across either the vertical or horizontal directions on a visual detection task. Therefore, little evidence in favour of motivational effects on standard visuospatial tasks has been provided, suggesting that, although neuroimaging data reliably suggest motivation is lateralised (see Spielberg et al., 2012 for a reivew), behavioural asymmetries are small and difficult to detect.

The current chapter of this thesis will focus on proximal differences in motivational lateralisation. The proximal dimension is split into near and far space (Longo & Lourenco, 2006; Previc, 1990). Previc (1990) argues that near space processing, via the dorsal stream, focusses on the '*where'* properties of an object, e.g., position and movement. This focus allows for the accurate manipulation of objects within arm's reach. Conversely, far space processing, via the ventral stream, focusses on the '*what*' properties of an object, e.g., object recognition, shape and colour. This allows for the accurate identification of objects before they reach actionable space.

Research conducted by Longo and Lourenco (2006; 2007) has shown that dorsal and ventral stream processing elicits leftward and rightward attentional biases, respectively. In their 2006 study, Longo and Lourenco presented participants with a line bisection task at a distance of 30, 60 and 120 cm[10]. When participants used a laser pointer to bisect the lines, biases shifted from leftward for near space stimuli, to rightward for far space stimuli. This illustrates a processing shift from the dorsal to the ventral stream as stimuli moves further away from the body (Previc, 1990). Interestingly, when participants used a long stick to bisect the lines, a constant leftward bias was observed across all distance conditions. This result suggests that far space stimuli can be remapped as near space stimuli through the use of a tool, most likely because tool use allows for the manipulation of objects outside of

[10] Visual angle was held constant across these distances, by adjusting line length.

arms reach.

In addition to tool use, some research suggests that other factors affect the boundary of near space representations. Coello and colleagues (2012) presented threatening stimuli that were either oriented towards or away from participants. They found that near space boundaries were enlarged when stimuli were oriented towards participants, compared to away from the participants. Similarly, Tajadura-Jiménez and colleagues (2011) found that listening to positive, compared to negative, mood-inducing music reduced participants' near space boundaries, such that they were more comfortable to have an experimenter sit closer to them. These results suggest that the boundary between near and far space is plastic and that positive and negative stimuli seem to reduce and expand near space representations, respectively.

Just as the spatial representation of near space is subjective, so is the experience of self-motion. Visual stimuli congruent with the experience of self-motion (e.g., looking out the window of a moving train) can elicit feelings of self-motion, even in the absence of actual motion. This feeling of self-motion, in the absence of actual motion, is termed vection, and occurs when the vestibular system does not receive information which correct the false perception of motion (Fischer & Kornmüller, 1930). In an experimental setting, luminance gratings (see Figure 17), which continually move upwards or downwards, create the illusion of downwards and upwards self-motion, respectively (Palmisano, Bonato, Bubka & Folder, 2007; Palmisano & Chan, 2004). In a similar way, diverging and converging 'star-field' stimuli are used to induce forwards and backwards vection, respectively (Palmisano & Chan, 2004).

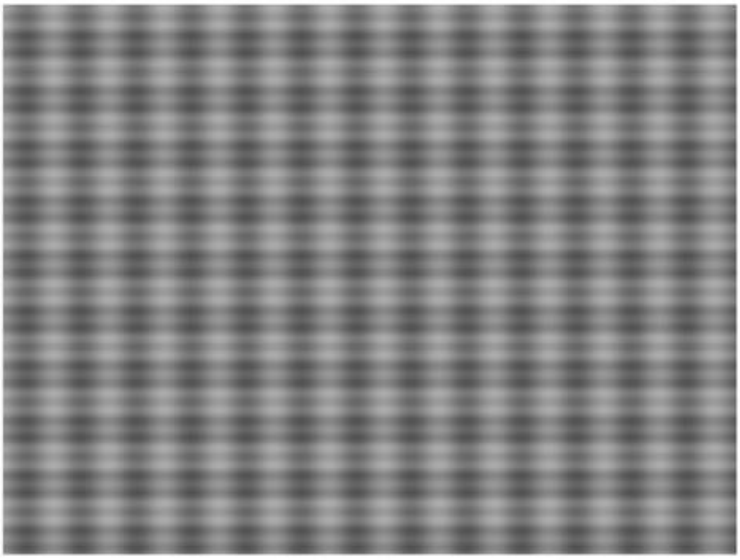

Figure 17. A static example of a luminance grating.

Just as positively valenced stimuli have been shown to enlarge the boundary of near space (Coello et al., 2012; Tajadura-Jiménez et al., 2011), positive stimuli has also been found to modulate the experience of self-motion (Sasaki, Seno, Yamada & Miura, 2012). Sasaki and colleagues (2012) presented participants with a downwards luminance grating while they listened to positive or neutral valenced auditory stimuli. Participants reported greater levels of upwards vection when they were listening to the positive, compared to the negative, auditory stimuli. Conversely, evidence has also been found to suggest that upwards, compared to downwards, vection can elicit greater positive mood (Seno, Kawabe, Ito & Sunaga, 2013; Seno et al., 2012). Seno et al. (2013) elicited upwards and downwards vection in participants and asked them to concurrently recall memories based on keywords. Upwards vection, compared to downwards vection, facilitated the recollection of positive memories[11] as well increasing positive mood in general. These studies demonstrate that vection is linked to the experience of valence, and more generally, mood.

[11] Based on a ‘positivity score’, which was calculated by subtracting the total number of negative memories from the total number of positive memories.

Study 5: Experiment 1

Given that valence is so closely linked to approach and avoidance motivation (Elliot & Covington, 2001; Krieglmeyer, Deutsch, De Houwer & De Raedt, 2010), the current study explored whether forwards and backwards vection facilitates approach and avoidance motivational judgments. A secondary aim of the current study was to investigate whether motivational judgments are made automatically or whether such judgments are reliant on explicitly processing stimuli in an approach or avoidance context. Although some research suggests that approach and avoidance motivation are automatically and unconsciously elicited (Chen & Bargh, 1999), other research suggests that approach and avoidance judgments are contextually dependent (Lavender & Hommel, 2007; Markman & Brendl, 2005). The current study explored this issue by assigning half of the participants to a group where participants made happy/angry judgments, and the other half made male/female judgments.

The current experiment used moving optic flow, or ‘star-field’ stimuli, to induce backwards and forwards vection. Happy and angry facial stimuli were presented on top of the star-field stimuli, and participants were asked to make an explicit (i.e., happy/angry face) or an implicit (i.e., male/female face) judgment. It was hypothesised that forwards vection would facilitate the classification of approach motivational stimuli and that backwards vection would facilitate the classification of avoidance stimuli. However, it was also predicted that this effect would be modulated by task instruction, such that facilitation would only occur for when explicit judgments of approach and avoidance were made.

Method

Participants

Forty-three Flinders University psychology students (36 female) completed the experiment in exchange for $15.00AUD compensation. Participants were aged between 18 and 61 years (M = 25.28, SD = 8.05), had normal or corrected-to-normal vision and were right-handed (M = 74.77, SD = 24.95) according to the Edinburgh Handedness Inventory (Oldfield, 1971). Informed consent was obtained prior to the experiment, which was conducted with the ethical approval of the Social and Behavioural Research Ethics Committee of Flinders University.

Apparatus

Experimental stimuli were presented on an Intel Core 2 PC, with a 19” monitor running at a resolution of 1024 x 768 pixels. E-prime 2.0 software (Psychology Software Tools, Inc.; www.pstnet.com/E-prime/e-prime.htm) was used to present stimuli and record responses. Responses were made on a model 200A PST Serial Response Box, with five horizontally placed buttons. An NEC LT260 projector was used to project the star-field stimuli onto a white board at a visual angle of 81.2° wide x 65.5° high. The monitor (27.3° x 22.2° visual angle) was positioned in the middle and in front of the projector screen.

Participants were seated 700 mm away from the screen on a custom wheeled chair, manufactured by the author. The chair had an attached footrest and bench, such that participants were not anchored to any stationary objects (i.e., the ground, table; see *Figure 18*). As the experimental room was carpeted, a large wooden board was placed under the chair to allow for smooth, easy motion. Prior to experimentation, the experimenter gently rolled the participants forwards and then backwards, to illustrate that physical displacement was possible. Although the participants remained stationary throughout the experiment, vection is stronger when the individual is aware that physical displacement is possible (Palmisano & Chan, 2004). Participants were video monitored so as to motivate them to attend to the task.

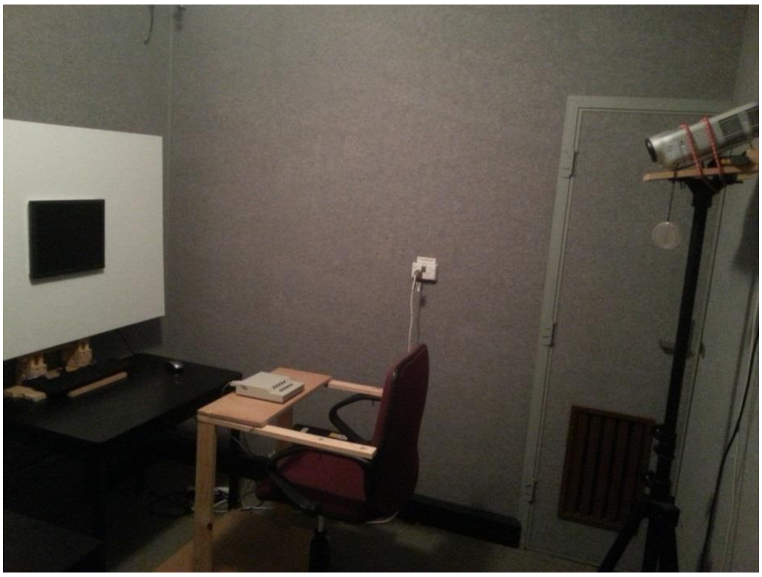

Figure 18. Experimental set up.

Stimuli

Faces.

The faces of seven male and seven female models were used, expressing happiness or anger (see *Figure 19*). The faces were displayed in the centre of the screen and were 12.2° wide by 13.5° tall. Faces were closely cropped using an ellipse, which removed most of the hair, and a black background was used to match the star-field stimuli.

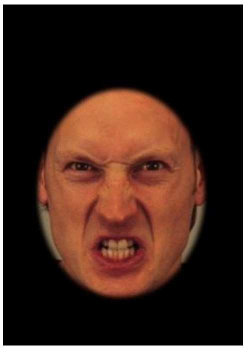

Figure 19. An example of an angry face stimulus

Star-field.

The star-field consisted of white dots on a black background (see Figure 20), with dots converging radially (backwards vection), expanding radially (forwards vection) or not moving at all (control). The videos were 1 minute and 59 seconds long and played on a seamless loop throughout the entire relevant blocks.

Figure 20. Static representation of the star-field stimuli.

Edinburgh Handedness Questionnaire.

The Edinburgh Handedness Questionnaire (Oldfield, 1971) was used to measure handedness. The questionnaire consisted of ten actions, e.g., using scissors, to which participants indicated their hand preference (left, right, or no preference).

Procedure

The experiment was completed in a single session that lasted approximately 35 minutes. As vection can induce motion sickness (Palmisano et al., 2007), participants were assured that they could stop the experiment at any time, particularly if they were feeling unwell[12]. The task was presented with a black background, to match the star-field stimuli. The experiment began with a blank black screen, presented for 200 ms. This was followed by a white fixation in the centre of the screen, which participants focussed on, presented for a random duration between 500 and 2000 ms. A facial stimulus was then presented until the participant made a response, for a maximum of 2000 ms. Facial stimuli were

[12] No participants experienced motion sickness.

stationary, as previous research suggests vection is most strongly induced when foreground images are stationary (Nakamura, 2010) and vection stimuli are not actively attended (Kitazaki & Sato, 2003).

Participants were assigned either to the explicit or implicit group. The explicit group were instructed to make happy/angry judgments, whereas the implicit group made male/female judgments. Participants were told to respond as quickly as they could while maintaining their accuracy. The configuration of the response box was counterbalanced across participants, such that half of the participants responded “happy” or “male” with the far left button and “angry” or “female” with the far right button, with the reverse configuration for the remaining participants.

Trials were presented across 3 blocks, based on vection condition (forwards, backwards, and no vection), of 168 trials, making a total of 504 trials. Block order was counterbalanced across participants. Participants were given a 2 minute break between each block, during which time they completed the handedness questionnaire or an unrelated find-a-word. Within each block, trials were presented in random order and trials that were not responded to were repeated at the end of each block. At the completion of the experiment, participants were asked whether or not they had experienced any perception of self-motion and were then debriefed and allowed to leave.

Analyses

One participant with a total accuracy score below three standard deviations from the mean (M = 92.70 SD = 5.79) was classified as an outlier and was excluded from analyses. A Shapiro-Wilk test indicated that the data were normally distributed (p = .378). Mauchly’s Test of Sphericity indicated sphericity for all data (p > .143 for all). Bonferroni corrections were applied to p values where multiple within-subjects comparisons were made. Data were collapsed across participants who self-reported feeling vection and those who did not, as no differences were found between the two groups, $F(1,38) = 0.22$, $p = .641$, $\eta_p^2 = 0.01$.

Results

Data from the remaining 42 participants were analysed with a mixed repeated measures ANOVA, with the within-participant factors of emotion (happy, angry) and vection direction (forward, backwards, control) and the between-subject factor of task instruction (implicit, explicit). A main effect of emotion was found, showing faster response times to happy (*M* = 658.77, *SD* = 107.38) compared to angry (*M* = 673.15, *SD* = 105.88) facial stimuli, $F(1, 40) = 10.01$, $p = .003$, $\eta_P^2 = 0.2$. No main effect of vection was found, $F(2, 80) = 1.28$, $p = .284$, $\eta_P^2 = 0.03$, nor was the effect of task instruction (explicit, implicit) significant, $F(1, 40) = 1.55$, $p = .220$, $\eta_P^2 = 0.04$. The emotion by vection interaction was non-significant, $F(2, 80) = 0.88$, $p = .419$, $\eta_P^2 = 0.02$ (see *Figure 21*), as was the three-way interaction between vection, emotion and task instruction, $F(2, 80) = 0.05$, $p = .951$, $\eta_P^2 = 0.001$.

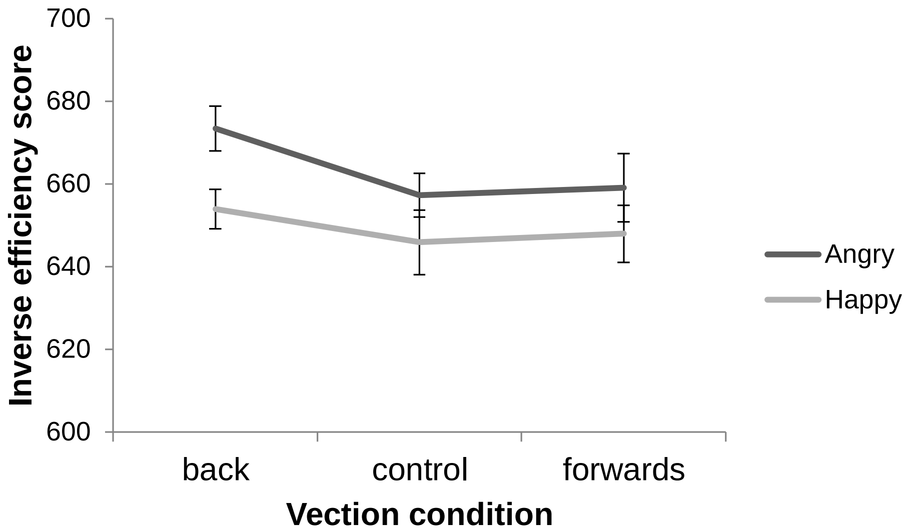

Figure 21. Inverse efficiency scores by emotion and vection conditions. Error bars denote within-subjects standard error from the mean

Discussion

It was hypothesised that angry face processing would be facilitated during backwards vection, whereas happy face processing would be facilitated during forwards vection. Instead, the current experiment found no evidence to suggest that vection facilitates approach and avoidance judgments.

The current findings could suggest that faces did not induce approach and avoidance motivation. Emotional face stimuli have previously been found to elicit approach and avoidance motivation more strongly than other stimuli types, such as images or words (Furl et al., 2012); however, in order to balance arousal across approach and avoidance conditions, previous research has not used highly arousing, negatively valenced stimuli (Coello et al., 2012; Dru & Cretenet, 2008; Furl et al., 2012). Thus far, methodologies that induce slight changes in approach and avoidance motivational states have been proposed to be sufficient in eliciting behavioural differences. However, it is possible that stronger, more negatively valenced stimuli elicit greater behavioural differences, such that dissociations between approach and avoidance conditions become more obvious.

Study 5: Experiment 2

The current experiment utilised the most negatively valenced images in the IAPS database (Lang et al., 2008), along with highly positively rated images sourced from both the IAPS database and the internet[13]. Negatively valenced images included images of diseased children, poverty, dead bodies, and flesh wounds. Positively valenced images consisted of images of baby animals and food. By using stimuli with higher positive and negative valences than previously utilised, it was hoped that dissociations between approach and avoidance stimuli would be greater (Gawronski, Deutsch & Strack, 2005; Hillman, Rosengren & Smith, 2004).

The current experiment used a similar design to Experiment 1. Static images were displayed over star-field stimuli; however, all participants in the current experiment made explicit judgments of valence. Given that the current experiment used more strongly valenced stimuli than Experiment 1, it was predicted that vection conditions would this time influence approach and avoidance judgments. Specifically, it was predicted that the processing of negative images would be facilitated by backwards vection, whereas the processing of positive images would be facilitated by forwards vection.

Method

Participants

Twenty-five Flinders University psychology students (14 female) completed the experiment in exchange for $15.00AUD compensation. Participants were aged between

[13] Google Images (https://www.google.com/imghp) was used to source positively valenced images, by using the search terms ‘cute animals’ and ‘yummy food’, in July of 2013.

18 and 39 years (*M* = 21.20, *SD* = 5.29) and had normal or corrected-to-normal vision. Participants could be right- or left-handed. Informed consent was obtained prior to the experiment, which was conducted with the ethical approval of the Social and Behavioural Research Ethics Committee of Flinders University.

Apparatus

The apparatus were identical to Experiment 1, except that response buttons were labelled “approach” or “avoidance”, with label placement being counterbalanced across participants.

Stimuli

Images.

Images were collected from both the internet and IAPS (Lang et al., 2008) and selected through pilot ratings. Nine pilot participants used 2 ratings scales, each on a scale from 1 to 10, to rate each of the 171 pilot images. The instructions for the motivation ratings scale were:

At one extreme of the scale you felt an urge to reach out, touch, grab, approach the object in the image. If you completely felt like approaching the image, you would respond "10". At the other end of the scale, you felt an urge to withdraw, retreat, flee, distance yourself from the object. If you completely felt like avoiding the object, you would respond "1". If you neither felt like approaching or avoiding the object, you would respond "5".

The instructions for the arousal ratings scale were:

At one extreme of the scale you felt stimulated, excited, frenzied, nervous, shocked, aroused. This means that 'good' and 'bad' images can both make you feel highly excited. If you felt completely excited while viewing the picture you would respond "10". At the other end of the scale, you felt completely relaxed, calm, sluggish, dull, sleepy, unaroused. If you felt completely calm while viewing the picture you would respond "1". If you neither felt calm or excited, you would respond "5".

Overall, 100 images were selected for use in the experiment proper (50 approach and 50 avoidance; see *Figure 22* for an example). Images with the most extreme valence ratings were selected, such that approach images averaged a rating of 7.61 (*SD* = 0.32) and avoidant images averaged a rating of 2.07 (*SD* = 0.37), $t(8) = 15.43$, $p < .001$, $d = 16.02$. In an attempt to use images with the most extreme possible valence ratings, approach (*M* = 5.40, *SD* = 1.51) and avoidance (*M* = 7.64, *SD* = 1.38) images differed on levels of arousal, $t(8) = 3.73$, $p = .006$, $d = 1.55$. The images were displayed in the centre of the screen and were 3.8° wide by 2.7° tall visual angle.

Figure 22. Example of an approach image.

Star-field.

The star-field stimulus was identical to Experiment 1

Procedure

Although participants were forewarned of the graphic nature of the avoidant stimuli, participants were shown an example image (not presented in the actual experiment) before experimental procedures began. This was done to give participants the opportunity to discontinue if they believed the graphic images would make them too uncomfortable[14]. Participants were also free to discontinue the experiment at any time.

The experiment was completed in a single session that lasted approximately 35 minutes. The task was presented with a black background, to match the star-field stimuli. A blank black screen of 200 ms duration began the experiment. This was followed by a white fixation in the centre of the screen that participants focussed on, which was

[14] Two participants decided to discontinue the experiment after seeing the example image. These participants are not included in the total number of participants as they did not begin the experiment proper.

presented for a random duration between 500 and 2000 ms. An image was then presented until the participant classified the image as ‘approach’ or ‘avoidance’, or for a maximum of 2000 ms.

Trials were presented in 3 blocks, based on vection condition (forwards, backwards, and no vection), of 168 trials each, making a total of 504 trials. The order of which the participants viewed the blocks was counterbalanced. Participants were given a 2 minute break between each block. Within each block, trials were presented in random order and trials that were not responded to were repeated at the end of each block. At the completion of the experiment, participants were asked whether or not they had experienced any perception of self-motion and were then debriefed and allowed to leave.

Analyses

Data were collapsed across participants who self-reported feeling vection and those who did not, as no differences were found between the two groups, $F(1,23) = 0.31$, $p = .582$, $\eta_P^2 = 0.01$. A Shapiro-Wilk test indicated the data were normally distributed ($p = .104$). Mauchly’s Test of Sphericity indicated sphericity for all data ($p > .464$ for all). Bonferroni corrections were applied to *p* values where multiple within-subjects comparisons were made.

Results

Data from 25 participants were analysed with a 2 (motivation: approach, avoidance) x 3 (vection direction: forward, backwards, control) repeated-measures ANOVA. Approach (*M* = 619.74, *SD* = 88.62) and avoidance (*M* = 610.26, *SD* = 92.77) images did not elicit differential response times, $F(1, 24) = 2.76$, $p = .110$, $\eta_P^2 = 0.10$. No main effect of vection was found, $F(2, 48) = 0.15$, $p = .862$, $\eta_P^2 = 0.01$, nor was the motivation by vection interaction significant, $F(2, 48) = 0.76$, $p = .471$, $\eta_P^2 = 0.03$ (see *Figure 23*).

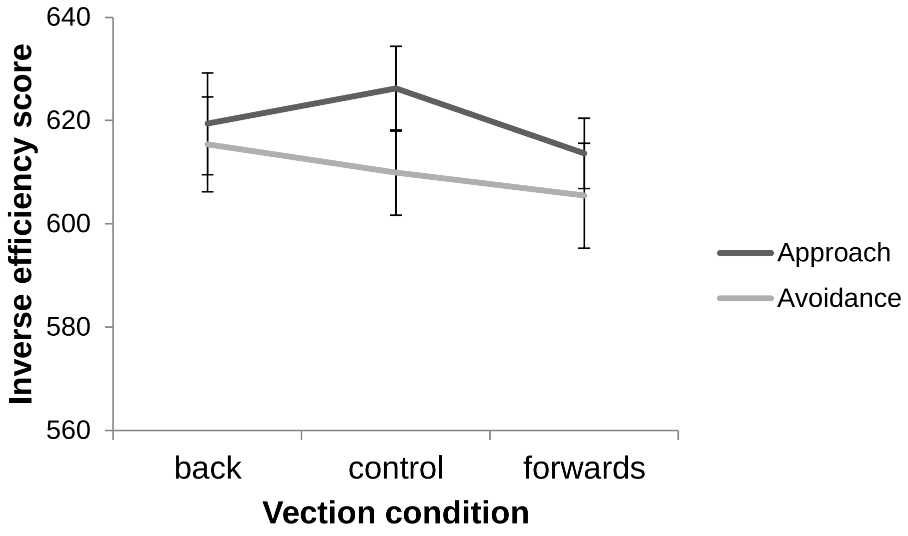

Figure 23. Inverse efficiency scores by motivation and vection conditions. Error bars denote within-subjects standard error from the mean

Discussion

The current experiment found no advantage for classifying images as approach or avoidance during forwards or backwards vection. This was despite using images with very high positive and negative valences. These results, along with those of Experiment 1, indicate that vection does not differentially affect approach and avoidance judgments.

Past research has resulted in mixed results when using images to elicit motivational states. Furl et al. (2012) presented positive and negative stimuli side by side, with positive stimuli sometimes on the left and sometimes on the right, and asked participants to pick a 'winning' stimulus[15]. They found that, when the stimuli consisted of happy and angry faces, participants' responses were biased to the left when a happy face was on the left and to the right when an angry face was on the right. However, no response biases were observed when positive and negative stimuli consisted of valenced images or words. Furl et al. (2012) concluded that faces specifically influence motivational states, because they possess an inherent social dimension. In contrast, Dru and Cretenet (2008) found that approach and avoidance actions (i.e., arm extension and arm flexion) were facilitated by both happy and angry faces as well as valenced images. The results of the current

[15] Left and right stimuli were randomly given a 60% or 40% chance of being the 'winning' stimuli at the beginning of each block.

experiment suggest, similar to the results of Furl et al. (2012), that faces are better able to affect motivational judgments than images. This is illustrated by the faster classification of approach stimuli in Experiment 1, when stimuli were faces, and the lack of an effect in Experiment 2, when stimuli were images.

It also seems likely that the experience of forwards and backwards vection did not affect the spatial representation of stimuli, such that stimuli did not appear to move closer, or further away, during vection presentation. Although previous research has shown that looming and receding stimuli can appear to be closer or further away (Longo, Lourenco & Francisco, 2012), in an effort to control for effects of stimulus size, stimulus properties were not physically changed in the current experiment. Instead, vection was used to create the illusion of stimuli moving closer or further away, when compared to the ‘moving’ background. However, it is possible that the perceived distance of the motivational stimuli remained constant, even during perceptions of self-motion. This might explain why no performance differences were found, in either Experiments 1 or 2, between those who did and did not report experiences of vection. If perceived image distance was constant across vection conditions, no facilitation of approach or avoidance judgments would be expected. As such, both Experiments 1 and 2 suggest that vection does not affect near and far space representations, at least not enough to facilitate approach or avoidance judgments.

An alternate, more convincing manipulation to vection might be looming and receding stimuli. Longo et al. (2012) presented participants with two numbers, side by side. Number pairs were presented in two font sizes (small, medium or large) in rapid succession, such that the numbers appeared to move towards (i.e., small to medium font) or move back from (i.e., large to medium font) participants. Critically, each trial concluded with numbers being displayed in medium font, regardless of whether the number had appeared to move forwards or backwards. When participants were asked to quickly report a number which even bisected the two presented numbers, they found that looming number pairs were bisected more leftward than receding number pairs. Longo et al. (2012) concluded that looming and receding numbers were allocated near and far spatial representations, respectively, despite stimuli being the same physical size and displayed at the same physical distance. In agreeance with this conclusion, Van der Biest, Legrain, Paepe and Crombez (2015) recently found that looming stimuli elicit an ‘action ready’ state, such that body parts that are exposed to looming stimuli have greater tactile sensitivity. These studies suggest that looming and receding stimuli are processed as occupying near and far space, respectively, and that looming stimuli facilitates tactile functions.

Study 5: Experiment 3

Rather than rapidly changing the presentation size of stimuli, the current experiment used 3D facial stimuli to create the illusion of near and far depths. Similar to Longo et al. (2012), the physical size of stimuli was constant between near and far conditions; however, participants perceived the faces as ‘popping out of’, or ‘receding in to’, the screen. Given that the Longo et al. (2012) have previously shown that illusory depth can facilitate near and far space attentional processing, the current experiment explored whether illusory depth can facilitate approach and avoidance mechanisms. Similar to Experiments 1 and 2, it was predicted that the classification of approach stimuli would be facilitated when stimuli appeared to move towards, compared to away from, participants and the classification of avoidance stimuli would be facilitated when stimuli appeared to move away, compared to towards, participants.

Method

Participants

Twenty-four Flinders University psychology students (14 female) completed the experiment in exchange for course credit. Participants were aged between 18 and 43 years (*M* = 22.61, *SD* = 7.63), had normal or corrected-to-normal vision and were right-handed (*M* = 98.70, *SD* = 3.44) according to the FLANDERS (Nicholls et al., 2013). Informed consent was obtained prior to the experiment, which was conducted with the ethical approval of the Social and Behavioural Research Ethics Committee of Flinders University.

Apparatus

Stimuli were presented on an Intel Core 2 Duo PC, with a 19” monitor running at a resolution of 1024 x 768 pixels. E-prime 2.0 software (Psychology Software Tools, Inc.; www.pstnet.com/E-prime/e-prime.htm) was used to present stimuli and record responses. Stimuli were created using OpenGL and red/cyan anaglyph glasses were used to view the 3D stimuli. Responses were made on a model 200A PST Serial Response Box, with five horizontally placed buttons. A printed 'A' for angry and 'H' for happy were stuck above the far right and left buttons (placement counterbalanced between participants). A chin rest kept participants 500 mm from the screen, to maintain the visual angle of the stimuli and reduce head movements. Participants were video monitored so as to motivate them to attend to the task.

Stimuli

Three-dimensional happy or angry schematic faces (9.6° x 11.2° visual angle) were displayed in depth, either at a near (130 mm forward of screen) or a far (130 mm behind screen) distance[16]. Pilot testing determined that distances greater than 130 mm resulted in participants self-reporting that stimuli became difficult to focus on. Stimuli were displayed in front of a background plane, which was textured with non-repeatable white noise. The background plane provided a point of reference for perceiving the depth of the stimuli. Four contextual anchors (5.2° x 4° visual angle rectangles), at screen depth, were displayed at the top and bottom corners of the face, 11.4° from the horizontal centre and 5.7° from the vertical centre (see Figure 24). These anchors served to accentuate the illusory depth of facial stimuli.

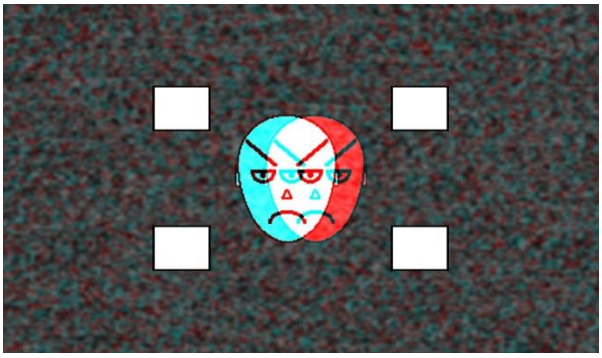

Figure 24. Example of angry stimulus presentation.

The 3D scene was modelled with respect to an observer with an inter-pupillary distance of 63 mm. The stereo images (background and faces) were generated by rendering the

[16] Special thanks to John Bastian (University of Adelaide, School of Computer Science) for his generous time and expertise in creating the 3D stimuli.

greyscale image for each eye using virtual cameras. These images were then converted to anaglyph images by modifying either the red or both the green and cyan channels, for the left or right eye respectively. This procedure was completed with custom OpenGL software.

Procedure

The white-noise background was displayed for 500 ms, followed by the contextual anchors for 100 ms. A blank face, without emotion, was displayed for a random time between 1500 and 2500 ms, to give the participant enough time to focus on the face in the relative depth plane. The emotive face was then displayed and participants were asked to classify the facial stimulus as ‘happy’ or ‘angry’, as quickly as possible. If no response was given in 2000 ms the trial was repeated at the end of the block (see *Figure 25*). The experiment consisted of 2 blocks of 150 trials each, with a short break between blocks.

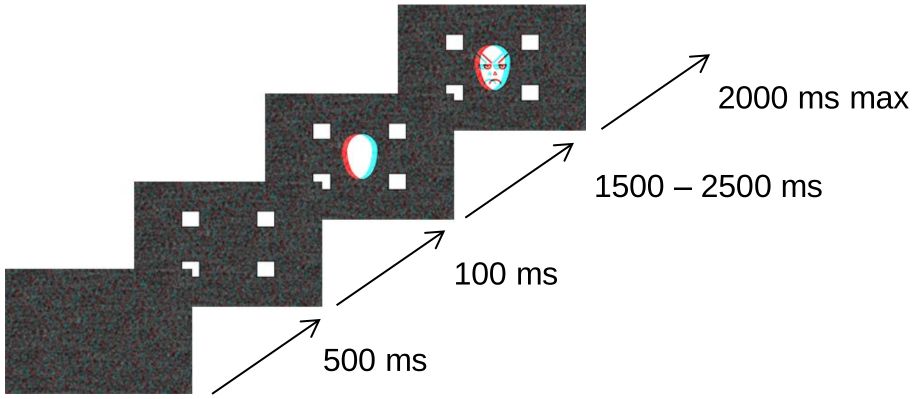

Figure 25. Trial procedure

Analyses

A Shapiro-Wilk test indicated the data were normally distributed ($p > .05$). Sphericity can be assumed as there were only two experimental conditions.

Results

Data were analysed using a 2 (emotion: angry, happy) x 2 (distance: near, far) repeated-measures ANOVA, which found no main effects of either emotion or distance,

$F(1,22) = 0.01$, $p = .991$, $\eta_P^2 = 0.001$ and $F(1,22) = 0.02$, $p = .883$, $\eta_P^2 = 0.001$, respectively. The interaction between emotion and distance was also non-significant, $F(1,22) = 0.002$, $p = .961$, $\eta_P^2 = 0.001$ (see *Figure 26*). Despite the non-significant interaction, a priori paired-samples *t*-tests were conducted, which found no differences between near and far happy facial stimuli, or near and far angry facial stimuli, $t(22) = 0.07$, $p = .948$, $d = 0.01$ and $t(22) = 0.17$, $p = .867$, $d = 0.01$, respectively.

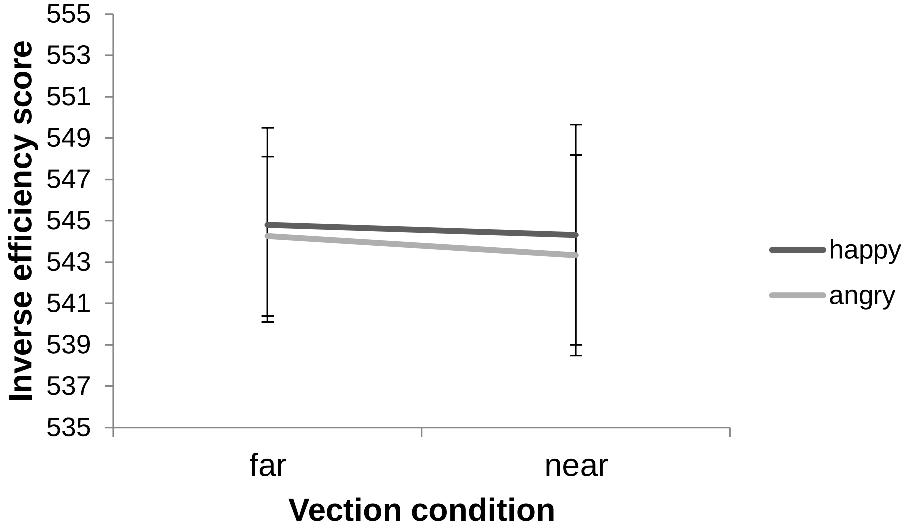

Figure 26. Inverse efficiency scores by emotion and distance conditions. Error bars denote within-subjects standard error from the mean

Discussion

No differences were found between the near and far conditions, either overall or individually for happy or angry facial stimuli. These results suggest that approach and avoidance stimuli are not processed preferentially across near or far distances; however, this is in contradiction to previous research, which has shown that avoidance images expand the boundary near and far space (Coello et al., 2012), looming and receding numbers elicit near and far space representations (Longo et al., 2012) and upwards vection elicits positive mood (Seno et al., 2013). Given the strength of previous research, which suggests that spatial position is closely linked to approach and avoidance processing, it might be more likely that the current methodology contributed to the null effect.

Another explanation for the current null result might be due to the nature of the 3D stimuli. Although presenting stimuli in 3D was a novel way of controlling for the physical size of stimuli, this presentation method did have limitations. During pilot testing, some participants found that stimuli which were displaced more than 130 mm, either ‘embedded in to’ or ‘popping out of’ the screen, were difficult to bring in to focus. Thus, in order for stimuli to be suitably perceived by all participants, no displacements exceeded 130 mm from screen depth. This resulted in near space stimuli appearing to be displayed at a distance of 370 mm from participants and far space stimuli being displayed at a perceived distance of 630 mm from participants. Stimuli within both of these distance conditions were likely perceived as being within arm’s reach, thus the far space condition might have failed to elicit far space processing. Although Longo and Lourenco (2006) have found that changes from near to far space representations are gradual, the 260 mm between near and far stimuli might not have been a large enough distance to elicit differential spatial processing, especially because near and far conditions were both within near space.

Study 5 Summary

One overall limitation of the current study is the type of vection used. Previous experiments which have linked positive valence to perceived self-motion have used upwards and downwards vection (Seno et al., 2012). The current study used forwards and backwards vection, assuming that approach and avoidance motivation would be accentuated by the perception of moving closer or further away from stimuli. Although forwards and backwards vection has not previously been used with approach and avoidance stimuli, star-field stimuli has previously been shown to elicit strong perceptions of self-motion (Palmisano, Gillam & Blackburn, 2000). However, it is possible that vection across the proximal plane differs from vection in the vertical plane. ‘Up’ and ‘down’ have previously been shown to have special implicit meaning, such that ‘up’ is associated with good and ‘down’ is associated with bad (Casasanto & Dijkstra, 2010; Seno et al., 2013). This implicit association can be seen in many traditional adages, such as ‘lifting your mood’ or ‘feeling down in the dumps’. Findings of a link between vection and valence might then be specific to vertical vection, and not transfer over to the proximal dimension.

Future research might consider presenting stimuli at physically near or far positions, which could possibly elicit stronger differential effects for approach and avoidance stimuli. Such a paradigm would also need to control for stimulus size, either through stimulus properties themselves or during statistical analysis. By physically presenting stimuli at near or far locations, many of the design limitations of the current study could be overcome and a clearer view of how spatial proximity affects motivational judgment might be gained.

Overall, the current study failed to find evidence to suggest that motivational judgments are facilitated by near or far spatial representations. These results are in contrast to previous research, which has linked positive and negative valence to near and far space stimuli, respectively (Coello et al., 2012; Longo et al., 2012; Sasaki et al., 2012; Seno et al., 2013). Several methodological limitations of the research design were highlighted, with further research being needed to determine whether approach and avoidance judgments can be facilitated by near and far spatial representations.

Chapter 6: Research Practices in Psychological Science

Thus far, the current thesis has provided very little positive evidence for the modulation of visuospatial attention by motivational processes, even though the lateralisation of approach and avoidance motivation is well established in both neuroimaging (see Spielberg et al., 2012 for a review) and behavioural paradigms (Armaghani et al., 2014; Carlson et al., 2009; Chen & Bargh, 1999; Dru & Cretenet, 2008; Duckworth et al., 2002; Elliot & Covington, 2001; Fetterman et al., 2013; Nash et al., 2010). With so many examples of approach and avoidance effects in the literature, one might assume that the motivational effect is robust and easily replicated; however, the current work does not support this assumption. In fact, the current thesis suggests that the motivational effect is, at best, a weak effect that is difficult to observe behaviourally. Amongst the positive results are hints that these motivational effects might not influence behaviour in such a straightforward way (Cattaneo et al., 2014; Furl et al., 2012); however, only one registered report has presented entirely null findings, to date (Rotteveel et al., 2015). The null findings of the current experiment, in contrast to the robust effects presented in the literature, highlight a growing concern within experimental psychology: experimental design and data analysis techniques are flawed (Wagenmakers et al., 2011).

Perhaps the most obvious examples of sub-optimal research practices are cases of fraudulent research. A well-known case is that of Diederik Stapel, who admitted to publishing data that were completely manufactured in 30 of his publications. Stapel stated, “everyone leaves things out, or does a little selective ‘cleaning’ of their data. We’re under pressure [to publish]” (Brown & Stapel, 2013, p.163). The case of Stapel highlights how easy, and perhaps how tempting, it is for researchers to manufacture data in order to publish more and with greater frequency (Leggett et al., 2013). Another case of fraudulent research, of particular relevance to the current thesis, is that of Jens Förster, a social psychologist who has published ten articles investigating approach and avoidance effects (Förster, 2004; Förster, Epstude & Ozelsel, 2009; Förster et al., 2006; Förster & Higgins, 2005; Förster et al., 2008; Förster, Özelsel & Epstude, 2010). Förster has been the subject of two inquiries, with one finding that “… the conclusion that manipulation of the research data has taken place is unavoidable….” (www.retractionwatch.com, 2014). As of November 17, 2015, Förster continues to deny charges of data fabrication but has agreed to retract two papers in order to settle one investigation by the German Society of Psychology (www.retractionwatch.com, 2015).

Experimental research often takes place in isolation, with a single researcher running and analysing a study. Stapel and Förster are two examples of why this procedure is problematic, in that fraudulent research is possible and, most often, undetectable. Although the manufacturing of data is an extreme example, the case of Förster perhaps illustrates a grey area within psychological research. Where the line between reasonable data cleaning and data manipulation is positioned is left up to individual researchers, who are not held accountable for these decisions. Although it could be argued that the effects of fraudulent research will eventually be nullified by subsequent replication attempts, the publication of null-results is often a difficult procedure (Wagenmakers et al., 2011), not-withstanding the wasted time and effort to replicate an effect which was not real in the first place. Furthermore, fraudulent research tarnishes the name of psychological science, which in turn leads to a reduction of faith in all published effects and a reduction in the allocation of funding.

Of course, cases of manufacturing data are extreme examples of the issues facing psychological science. Most often, published work consists of methodologically sound, honest research (Wagenmakers, 2007). However, evidence suggests that the ‘publish or perish’ creed of psychological science has resulted in various publication biases (Masicampo & Lalande, 2012). Seemingly inconsequential decisions made by researchers, such as when to stop collecting data or how to classify data as outliers, might unintentionally affect degrees of freedom and thus significance values (Wagenmakers, 2007; Wagenmakers et al., 2011). Such publication biases can be used to, purposely or inadvertently, push non-significant effects over the significance threshold. This can result in marginally significant, weak effects that are difficult to replicate. Additionally, these weak effects are often portrayed as being robust and replicable, as evidence against such effects comes in the form of null findings, which are notoriously difficult to publish (Wagenmakers et al., 2011).

The so-called “file drawer problem” refers to the problem that it is impossible to know how many studies have been conducted, but not published. Rosenthal (1979, p. 638) states that “the extreme view of the ‘file drawer problem’ is that journals are filled with the

5% of studies that show Type I errors, while file drawers are filled with the 95% of the studies that show non-significant results". Although Rosenthal was being hyperbolic, it is inevitable that some published psychological effects are Type I errors which are yet to be corrected (Wagenmakers et al., 2011). A study by Masicampo and Lalande (2012) examined distributions of *p* values from three prominent psychological journals (*Psychological Science, Quarterly Journal of Experimental Psychology: General, Journal of Personality and Social Psychology*) and found that *p* values just under the significance threshold were grossly over-represented. Masicampo and Lalande (2012) postulated that this publication bias is likely caused by an overemphasis on statistical significance. Authors assume, perhaps not incorrectly, that they must produce positive results in order to publish. This in turn makes it more likely for authors to engage in sub-optimal research procedures, such as continually checking data as they test and stopping when their effect reaches significance, or excluding participants based on the data that is produced rather than a priori parameters (Masicampo & Lalande, 2012).

Recently, psychological science has come under increasing scrutiny, in regards to the reproducibility of published effects and the soundness of the analytical methods used (Nosek et al., 2015). One study, which undoubtedly contributed to such scrutiny, was a paper published in the *Journal of Personality and Social Psychology*, which investigated the phenomenon of 'psi' or 'psychic effects' (Bem, 2011). The paper described how some participants were better able to recall words if they studied those words *after* the recall task (Bem, 2011). To be clear, Bem argued for an effect of pre-cognition, otherwise referred to as telepathy. Understandably, these findings were met with scepticism. Wagenmakers and colleagues (2011) suggested that, rather than evidence for an effect of psi, Bem's study highlighted many of the problems within experimental psychology.

The exploratory nature of Bem's (2011) research is an example of how statistics can be misused to mislead readers. Although there is nothing inherently wrong with running multiple, exploratory analyses, the chances of finding a significant effect increase as more analyses are run, from a strictly statistical viewpoint. As such, proper corrections much be made to the significance level, to account for these multiple comparisons (Wagenmakers et al., 2011). In several of Bem's experiments, numerous conditions were explored but only the best results were reported. For example, Bem tested whether various categories of images (i.e., erotic, neutral, negative, positive and romantic) elicited precognition but only reported the results of the erotic condition, as presumably the results of the other conditions were non-significant. In this example, readers are misled in to thinking that an effect of erotic images was expected all along, when in fact, the erotic images condition is most likely just a false positive, the result of multiple comparisons without a corrected *p* value (Wagenmakers et al., 2011).

Related to exploratory analyses are post-hoc analyses, analyses which are run despite lacking a theoretical reason to do so. In his fifth experiment, Bem (2011) splits subjects by gender and finds that only women displayed an effect of precognition. However, Bem had no reason to split subjects by gender. No prior literature suggests that psi affects males and female differently, nor did Bem hypothesis that it would. Such analyses are problematic, as they suggest that other factors could also have been analysed and, being found to be non-significant, not reported. This in turn suggests that the *p* values reported are incorrect, as they are not correct for multiple comparisons.

Wagenmakers and colleagues (2011) also provided a Bayesian reanalysis of Bem's (2011) data and found evidence in favour of the null hypothesis. Although it might seem obvious that pre-cognition is highly unlikely, Wagenmakers et al. (2011) highlighted the fact that "Bem played by the implicit rules that guide academic publishing" (p. 10), and that the research on 'phi' should be seen as an indication that experimental procedures in psychology are deeply flawed.

Results of a recent collaborative project align with this line of thought (Nosek et al., 2015). The 'Reproducibility Project: Psychology' included just over 40 collaborators and attempted to replicate 100 published effects (Nosek et al., 2015). Results indicated only 36 percent of the effects were reproduced and many were much weaker than originally reported. The generalizability of the results of this project is unclear, as studies that were selected for replication had to be run in a standard psychological lab[17]. However, results indicate that many published effects within the psychological literature might not be replicable.

Questionable research practices are likely contributors to the problem with replicability which psychological science now faces (John, Loewenstein & Prelec, 2012; Masicampo &

[17] The project therefore did not include neuroimaging studies or studies that required specific equipment.

Lalande, 2012; Sacket, 1979; Wagenmakers, 2007). As technology advances, it becomes easier to engage in biases such as the ‘repeated peaks’ bias, where researchers immediately cease data collection when significance results are reached, and the ‘optional stopping’ bias, where researchers continue to test participants past a pre-determined stopping point, in order to push a result over the significance threshold (John et al., 2012; Sacket, 1979). ‘Optional stopping’ and ‘repeated peaks’ are both methods of data selection, which artificially increase the chance of obtaining a statistically significant result. For example, by if an effect becomes significant after testing one additional participant, it is equally likely that an additional participant will render the effect non-significant again.

Although recent research illustrates some serious problems within experimental psychology, it also sparks discussion about psychological methods and analyses which could instigate change. The current study was inspired by research by Masicampo and Lalande (2012), who found an inflation of ‘just significant’ *p* values within published research. The aims of the current study were two-fold: to investigate whether the inflation of ‘just significant’ *p* values could be replicated in a different year, and whether this issue of over-represented *p* values had worsened over the last forty years.

The following experiment was published in *The Quarterly Journal of Experimental Psychology*, and is entitled “The life of *p*: ‘Just significant’ results are on the rise”. The publication is presented here unchanged (Leggett et al., 2013). The current author designed, conducted and analysed the experiment, and is first author on the publication.

Study 6: Experiment 1

Introduction

Null-hypothesis significance testing is the dominant statistical method currently employed by researchers in psychological science to determine whether an effect can be considered reliable or not (Kline, 2004). This approach of hypothesis testing uses the seemingly arbitrary significance cut-off value of .05 to determine whether the probability of an effect occurring by chance is less than 5%. As such, at a *p* value of .05, the null hypothesis is rejected and the effect is considered statistically significant—with the assumption that it is reliable and reproducible (Nickerson, 2000).

Anomalies in significance testing have been reported in a range of fields, including psychology (Wicherts, Kievit, Bakker & Borsboom, 2012). Masicampo and Lalande (2012) surveyed a large number of articles published in prominent psychology journals between 2007 and 2008 and plotted the frequency of reported *p* values. The data showed the expected exponential function (Cumming, 2008; Masicampo & Lalande, 2012) where the frequency of *p* values was increased for lower values. What was remarkable, however, was a spike in values close to the level of statistical significance (.05). This spike marked a significant departure from the expected distribution and suggests a bias towards reporting 'just' significant results. The bias most likely reflects the fact that researchers and reviewers believe that results must be statistically significant in order to be published (Rosenthal, 1979). This emphasis on critical *p* values could, in turn, encourage problematic research practices, where researchers engage a number of 'researcher degrees of freedom' to achieve significant results (John et al., 2012; Simmons, Nelson & Simonsohn, 2011).

Irregularities in the use of significance testing could be driven by the current academic climate of 'publish or perish'. Kyvik (2003) reported that the number of published works per author had risen 30% between 1980 and 2000. It has been speculated that this increased pressure to publish has impinged upon the integrity and objectivity of academic research (Fanelli, 2007; John et al., 2012; Song, Eastwood, Gilbody, Duley & Sutton, 2000), resulting in a possible misuse of significance testing (Masicampo & Lalande, 2012).

Another feature of modern research is the use of computers to carry out statistical analyses, which produces precise *p* values. Prior to the development of computers and statistical software, researchers were required to analyse their data manually and compare their statistics with those in tables containing the critical ranges of *p* values (thus producing less than, or greater than, *p* values rather than precise figures). Modern statistical software now allows for simple and instantaneous calculations, permitting researchers to monitor their data continuously while collecting it. The ease with which data can be analysed may have rendered practices such as "optional stopping" (Wagenmakers, 2007), selective exclusion of outliers, or the use of post hoc covariates (Sacket, 1979) easier to engage in. All of these practices can be used to manipulate *p* values and potentially drive them towards significance (John et al., 2012).

This study explored whether the spike in *p* values at .05 reported by Masicampo and

Lalande (2012) is a recent phenomenon. An increase over time could be due to an increased pressure to publish (Kyvik, 2003), coupled with modern statistical procedures, which potentially facilitates the selection of favourable *p* values. To obtain samples where different research practices were used, we compared *p* values from journals published in 1965 and 2005. If a misuse of null-hypothesis testing (Masicampo & Lalande, 2012) and an increasing pressure to publish exists (Kyvik, 2003), the current study should show a greater over-representation of *p* values at and just below .05 for 2005 articles compared to 1965.

Method

The methodology of Masicampo and Lalande (2012) was employed as a framework for the current study. Values of *p* were collected for all articles published in 1965 and 2005 from the *Journal of Experimental Psychology: General* (JEPG) and the *Journal of Personality and Social Psychology* (JPSP). Although these journals were the same as those used by Masicampo and Lalande (2012), we were not able to sample *Psychological Science* as it was not established in 1965. All articles from volumes 69, 70 and 134 of JEPG and volumes 1, 2, 88 and 89 of JPSP were examined.

A single researcher recorded all *p* values presented in each article. A research assistant, who was blind to the experimental aims, recorded *p* values from a single random volume (12.9% of total *p* values) to assess inter-rater reliability. The ratings from each researcher were strongly correlated, $r(410) = .800$, $p < .001$. While the purpose of this paper was to analyse the pattern of reported *p* values, accurate analysis required exact *p* values. As such, values of *p* that were inexactly reported, such as '$p < .05$', '$p < .01$' or values reported to only 2 decimal places (typically $p = .05$) were recalculated to an accuracy of 6 decimal places. Where insufficient information was available to determine exact *p* values, the data were excluded from analyses. Overall, 15020 *p* values were recorded. As the aim was to examine the distributions of *p* values around the significance cut-off point of .05, values between .01 and .10 (including values of exactly .01) were of particular interest and values outside of this range were excluded. Consequently, for articles published in 1965, 23% (435/1908) of the total number of JEPG *p* values, and 25% (970/3935) of the total number of JPSP *p* values were analysed. Similarly, for articles published in 2005, 28% (362/1302) of the total number of JEPG *p* values, and 25% (1934/7875) of the total number of JPSP *p* values were included.

During the calculation of exact *p* values it was found that 36 of the 93 values that were reported as being exactly equal to .05 were, in fact, greater than .05 (all from JPSP). In other words, 38.7% of *p* values reported as being exactly .05 had been rounded down and discussed as being significant. Furthermore, these *p* values were found to be significantly higher than .05 [(*M* = .0545, *SD* = .007), *t*(35) = 3.84, *p* = .001]. To ensure that the possible rounding down of relevant statistics did not unfairly influence calculations, we used relevant statistics to one decimal place greater than reported. For example, for an *F* reported as 2.05, an *F* value of 2.055 was used in the calculation. While the majority of inaccurate *p* values were a product of rounding down to two decimal places, there were also cases of incorrect rounding (rounding down when it was appropriate to round up) and incorrect reporting. Interestingly, the proportion of misleading *p* values increased from 1965 to 2005. In 2005, 42% of probability values reported as exactly .05 were rounded down compared to 19% in 1965. In the context of the present study, these values were coded as exactly .05, as the purpose was to examine distributions of reported *p* values.

Results

For within-year analyses, the statistical procedures were identical to those employed by Masicampo and Lalande (2012). To ensure that any observed deviations from predicted values in the distribution of *p* values were not the product of the way the categories of *p* values were structured, the range of interest (.01 - .10) was divided into four different division sizes: .01, .005, .0025 and .00125. For example, for the .01 division there were 9 intervals, or ‘bins’, in total (.02; .03; .04; .05; .06; .07; .08; .09; .10). The .02 bin encompassed values between .010001 and .020000, including values equal to .020000, and the .03 bin included values between .020001 and .030000, including values equal to .030000. Separate analyses were conducted for each of the four division sizes, with the difference in the number of bins being the only factor that changed between analyses.

For each division size, the frequency of *p* values in each bin was determined to create a distribution of *p* values (see Figure 27). As prior research (Cumming, 2008; Masicampo & Lalande, 2012; Sellke, Bayarri & Berger, 2001) has indicated an exponential model provides the best fit for distributions of *p* values, a regression curve estimation procedure using an exponential model was employed. All R^2 values were significant below the .001 level, indicating that the data conformed to the predicted exponential model (see Table 6). As goodness-of-fit values were of a similar strength between journals, data were collapsed across journals for all remaining within-year analyses.

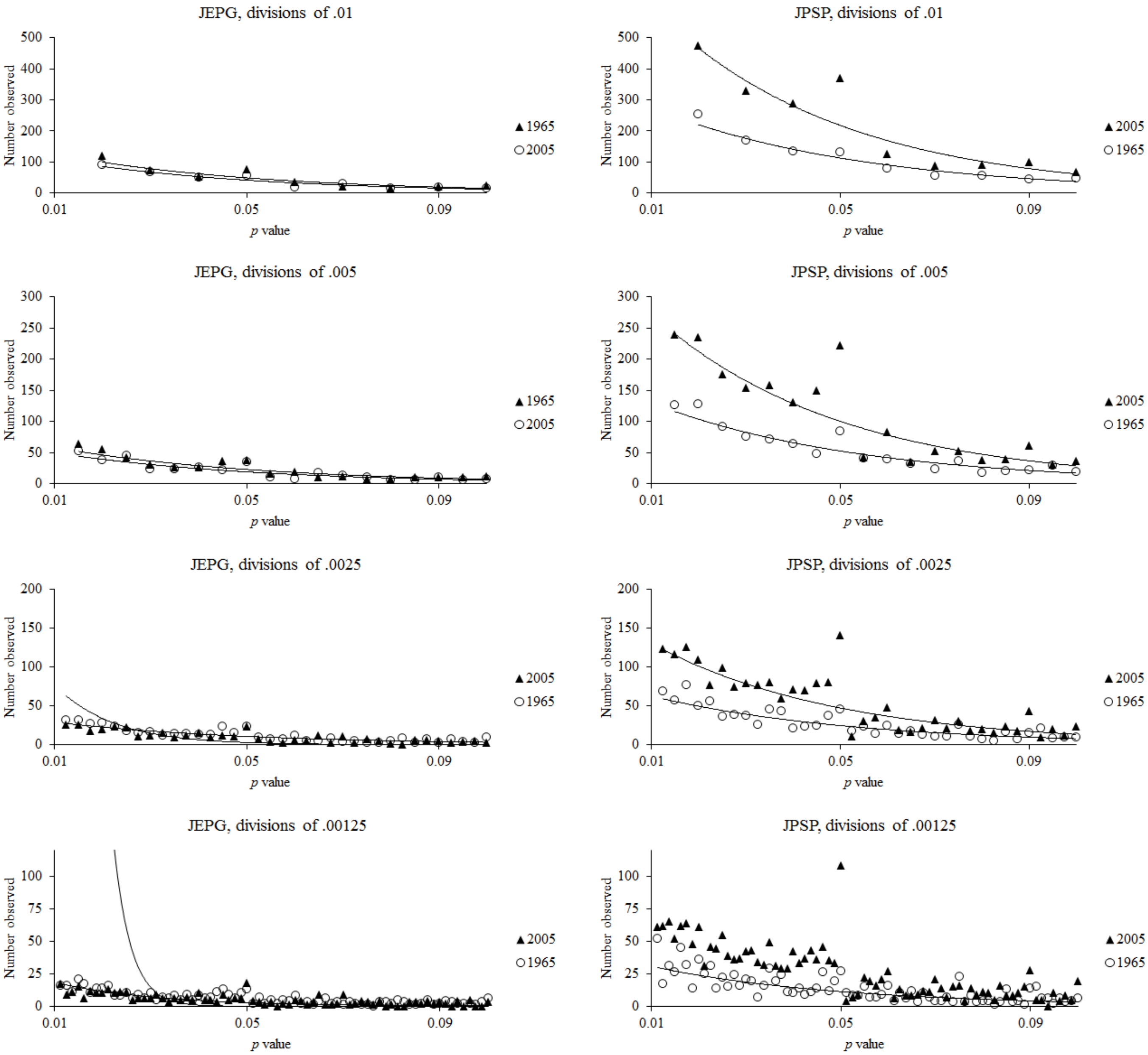

Figure 27. Frequency of p values as a function of year of publication and division size. The line shows the best-fitting exponential function.

Table 6

R2 values for distributions of p fitted to an exponential curve, by publication year, journal and division size

	1965				2005			
Journal	.01	.005	.0025	.00125	.01	.005	.0025	.00125
JEPG	.814	.792	.693	.588	.878	.797	.581	.409
JPSP	.936	.875	.742	.573	.862	.781	.698	.641
Both	.91	.881	.808	.645	.879	.812	.736	.678

Note: All R^2 values were significant ($p < .001$)

To examine the properties of the spike at *p* values of .05, residuals were calculated within each bin, for each year and division size, by taking the absolute difference between the actual frequency of *p* values and the frequency predicted by the model. Descriptive statistics illustrated that the .05 bin, which encompassed values at and just below significance, contained high residual values for both the 1965 and 2005 data. Chi-square contrasts (Cox & Key, 1993) confirmed that residual values in the .05 bin, from both 1965 and 2005, were significantly higher than the mean of the residuals from the other bins (see Table 7).

Table 7

Comparison of residuals between the .05 bin and all others, by publication year, journal and division size.

1965								
	Divisions of .01		Divisions of .005		Divisions of .0025		Divisions of .00125	
Journals	.05	All others	.05	All others	.05	All others	.05	All others
JEPG	26.28**	7.97 (5.58)	15.16*	4.65 (3.60)	12.29*	2.78 (2.27)	7.89	1.92 (1.73)
JPSP	19.57	11.16 (10.01)	31.54***	6.51 (5.61)	21.34**	6.03 (4.88)	15.77*	4.60 (4.66)
Both	45.35**	19.10 (15.06)	46.16***	9.11 (8.43)	32.80***	7.78 (5.37)	23.10**	5.60 (5.04)
2005								
	Divisions of .01		Divisions of .005		Divisions of .0025		Divisions of .00125	
Journals	.05	All others	.05	All others	.05	All others	.05	All others
JEPG	15.79**	4.03 (4.05)	16.06**	3.75 (2.97)	15.17**	2.61 (1.81)	13.45**	1.66 (1.64)
JPSP	153.67***	21.66 (15.68)	121.95***	13.89 (13.75)	93.70***	9.95 (8.45)	85.42***	5.96 (5.24)
Both	168.58***	23.90 (17.83)	137.09***	14.65 (14.51)	108.10***	11.27 (8.10)	98.78***	6.62 (5.49)

Note: The table displays the residuals (i.e., the absolute difference between the *p* values predicted by the exponential model and the actual *p* values) for each division size. The mean residual value of all bins, except.05, are recorded under the “All others” heading (with SDs in parentheses). Chi-square contrasts (Cox & Key, 1993) tested whether residuals at the .05 bin differed from the mean residual value of the other bins. JEPG = *Journal of Experimental Psychology*. JPSP = *Journal of Personality and Social Psychology*.

*p < .05, **p < .01, ***p < .001

The comparison of the 1965 and 2005 *p* value distributions was of critical importance (see *Figure 27*). A 2 (journal: JEPG, JPSP) x 2 (year: 1965, 2005) log linear analysis showed a main effect of both year, $\chi^2(1) = 200.338$, $p < .001$ and journal, $\chi^2(1) = 269.07$, $p < .001$. The interaction between year and journal was also significant, $\chi^2(1) = 58.55$, $p < .001$, such that, for all division sizes, a difference between 1965 and 2005 was only observable within JPSP [.01: $\chi^2(1) = 103.20$; .005: $\chi^2(1) = 52.60$; .0025: $\chi^2(1) = 46.34$; .00125: $\chi^2(1) = 47.14$, all *p*s < .001] and not JEPG [.01: $\chi^2(1) = 2.38$, $p = .123$; .005: $\chi^2(1) = 0.03$, $p = .857$; .0025: $\chi^2(1) = 0.33$, $p = .564$; .00125: $\chi^2(1) = 1.19$, $p = .275$].

Residual values obtained for the .05 bin in this study were compared with Masicampo and Lalande's (2012), to see if the difference between years was consistent across the data sets. Although residual values differed between the current 2005 data and Masicampo and Lalande's 2008 data [.01: $\chi^2(1) = 3.35$, $p = .067$; .005: $\chi^2(1) = 6.12$, $p = .013$; .0025: $\chi^2(1) = 20.43$, $p < .001$; .00125: $\chi^2(1) = 16.11$, $p < .001$], both data sets displayed greater .05 spikes than in 1965 [.01: $\chi^2(1) = 46.51$, $p < .001$; .005: $\chi^2(1) = 19.37$, $p < .001$; .0025: $\chi^2(1) = 3.857$, $p = .050$; .00125: $\chi^2(1) = 9.99$, $p = .002$].

Discussion

The current study demonstrated a clear inflation of *p* values around the margin of statistical significance. The data therefore confirm the pattern observed by Masicampo and Lalande (2012) for journals published in 2007-2008 and demonstrate that the bias generalises to different publication years. While these data indicate some variability across year and journal, overall the magnitude of the spike at .05 is noticeably larger in recently published articles than it was in 1965. This effect, coupled with the finding that the majority of inaccurately rounded *p* values were found in articles published in 2005, suggests a change in research practice over this 40-year period.

Changes in how statistical analyses are carried out, as a result of shifting research climates rather than null hypothesis significance testing itself, might partially account for the larger spike at .05 in recent publications. In 1965, analyses were usually laboriously carried out by hand and statistical significance was checked using a booklet of tables. Card-reading computers running FORTRAN were also available to some fortunate researchers in the early sixties. While it is undeniable that these computers facilitated the analysis of data, the increase in time demands and decrease in flexibility of data analysis in 1965 would have significantly reduced the opportunity (inadvertently or not) to manipulate the collection and analysis of data. In 2005, computer analysis packages allow for the instantaneous monitoring of data, as well as quick and easy analysis. The ease with which data can be analysed may facilitate questionable research practices (John et al., 2012), such as the "repeated peeks bias" (Sacket, 1979), the "optional stopping" bias (Wagenmakers, 2007), selective exclusion of outliers and post hoc inclusion of covariates, to improve the appearance of data.

It was also found that more *p* values were rounded down to .05 (or incorrectly reported) in data published in 2005 compared to 1965. This finding is in line Bakker and Wicherts (2011), who found that 1.5% of reporting errors, within the psychological literature, shifted a non-significant result into significance. These findings highlight the potential escalation of suboptimal research practices in the more recent psychological literature. Interestingly, JEPG had neither misleading *p* values, nor a difference in the *p* value spike between 1965 and 2005, which indicates variability between journals, potentially resulting from differences in research practices.

An established cut-off for statistical significance is important as it allows for a clear distinction to be drawn between effects that are reliable and reproducible and those that are not. Values that fall outside of this cut-off point, no matter how close they might appear to be, should not be presented as statistically significant. Although the decision to round numbers down (e.g., .054 to .05) might appear harmless, and is, in fact, in keeping with the publication guidelines set out by the American Psychological Association (2010), it has the potential to mislead readers. The practice of reporting exact *p* values with an accuracy of three decimal places is recommended, particularly when *p* values approach .05. Adoption of this practice would drastically reduce the likelihood of misinterpretation. Regardless of the number of decimal places that researchers ultimately decide to include, subsequent discussion of these effects should reflect an honest comparison with the criterion for statistical significance, with trends being discussed as such.

A limitation of the current study, similar to Masicampo and Lalande (2012), is that all *p* values were treated as independent entities, although many were taken from the same articles, authors and journals. This lack of independence may have inflated the apparent size of the effects. Given that our data are very similar to that reported by Masicampo and

Lalande (2012), however, we are confident the observed distributions of *p* values are a good reflection of the underlying phenomena.

The current study demonstrates that the over-reporting of *p* values at the margin of significance is not a new thing; researchers in 1965 were also prone to reporting results when they were 'just' statistically significant. That said, there is also a clear increase in the prevalence of *p* values at the margin of significance from 1965 to 2005. This increase may be related to advancements in statistical analysis procedures, which make it easier to engage in suboptimal research practices. If questionable research practices are to blame, reforms to current research practices should result in less inflammatory reporting of *p* values near .05, such as observed for 1965 data. Changes in statistical practice might also explain why *p* values were more likely to be incorrectly rounded down to .05 in 2005 than in 1965. Modern statistical analysis packages typically give exact *p* values to at least three decimal places, whereas in 1965, absolute *p* values were given in bands of significance from tables. The data from 2005 may therefore be more prone to incorrect rounding down of the *p* value than the data from 1965.

The spike of *p* values at the margin of significance and the misreporting of *p* values might reflect increases in the pressure to publish (Kyvik, 2003; National Institute of Health, 2008), coupled with the fact that too much emphasis is placed on *p* values when assessing the merits of research. Values of *p* only provide binary information as to whether the null hypothesis should be accepted or rejected. As such, data should be accompanied by additional statistics, such as confidence intervals and effect sizes (Cumming, 2008; Nickerson, 2000). Confidence intervals give both an estimate of effect size and an indication of the precision of estimates (Nickerson, 2000).

An alternative solution might be the implementation of registered reporting or mandatory methods disclosure. Recent registered reporting schemes, such as those employed by *Cortex* and *Perspectives on Psychological Science*, allow publishing decisions to be made based on the validity of the proposed methodology and hypotheses, prior to the actual data collection process (Chambers, 2013). This method may decrease the preoccupation with significant results by returning the focus to sound research practices and methods (Wicherts et al., 2012). LeBel et al. (2013), who have argued for mandatory methods disclosure, found only 54.7% of surveyed researchers reported all assessed measures and a meagre 11.2% reported their data collection stopping rule. The use of confidence intervals, along with effect sizes, as well as registered reporting and mandatory methods disclosure might decrease the emphasis placed on *p* values. This would, in turn, also encourage the use of optimal research practices. In the absence of additional, complimentary statistics or registered reports, the use of *p* values as an isolated method for determining statistical significance remains vulnerable to human fallibility.

This concludes the current published paper.

Study 6: Experiment 2

Although the shortcomings of NHST and publication biases are by no means recent issues (Nickerson, 2000; D. H. Robinson & Wainer, 2002; Wagenmakers, 2007), poor replicability and improper analytical procedures are being openly discussed now more than ever (Cumming, 2013a, 2013b; Lindsay, 2015; S. E. Maxwell, Lau & Howard, 2015; Rotteveel et al., 2015; Wagenmakers et al., 2011). In a recent editorial, which discussed publishing within the prolific journal *Psychological Science*, Interim Editor Steve Lindsay outlined ‘the troubling trio’; three weaknesses within a publication which might be a sign of questionable replicability (Lindsay, 2015). The troubling trio consists of: low statistical power, a surprising result, and a *p* value only slightly below the significance threshold. Lindsay (2015) writes that any study displaying these three issues is unlikely to be replicable. Furthermore, he writes that *Psychological Science* will ask authors to complete high-powered, pre-registered replications of unlikely effects, in an effort to minimise non-replicable papers.

Psychological Science’s new stance on publishable data is only one example of a potential solution to non-replicable publications. Cumming (2008) and Nickerson (2000) have advocated for the inclusion of confidence intervals and effect sizes along with standard inferential statistics. Cumming (2008 p.286) states that “there is an 83% chance that a replication gives a mean that falls within the 95% [confidence interval] from the initial experiment”. As such, confidence intervals give an indication of how replicable results might be (Cumming, 2008; Nickerson, 2000). LeBel et al. (2013) has advocated for mandatory methods disclosure, which would require authors to submit additional methodological details (i.e., excluded subjects, non-reported conditions and measures, and sample size determination). Although the disclosure of these details are not currently required under standard reporting procedures, LeBel et al. (2013) argues that such details are integral to the interpretation and evaluation of research.

Registered reports are another potential solution to the problem of non-replicable data (Chambers, 2013). Registered reports consist of a two stage process: stage 1 involves the submission of a theoretical discussion of a topic, a proposed methodology which details specifically how the topic will be explored, and a description of planned analyses with clear prediction of what results are expected. This proposal is peer-reviewed and eventual publication decisions are based on the theoretical foundation of the research and the soundness of the methodological and analytical procedures. Stage 2 involves collecting and analysing the data, followed by peer revision of the results and discussion sections. In this way, the decision to ultimately publish the research is based on the theoretical background of the study and the soundness of the methodological and analytical procedures which are proposed, rather than whether or not the study produced significant results. Additionally, this procedure ensures that decisions which are supposed to be made before data collection, mainly hypotheses and analyses, are *actually* made before data collection.

The Open Science Framework (www.osf.io) lists 19 journals[18] that have adopted procedures for reviewing registered reports. Of relevance to the current thesis, Rotteveel et al. (2015) published a registered report that attempted to replicate the findings of Chen and Bargh (1999). Chen and Bargh (1999) originally found that participants were quicker to respond to avoidance words when pushing a lever (arm extension) and quicker to respond to approach words when pulling a lever (arm flexion). This effect occurred even when participants did not need to explicitly evaluate the valence of the words. Rotteveel et al. (2015) failed to replicate the original effects reported by Chen and Bargh (1999), instead finding evidence in support of there being no effect. Even though the findings of Rotteveel et al. (2015) were based on null-results, publication was ensured by the registered report procedure. Research that is methodologically and analytically rigorous is essential to the literature, regardless of whether findings are in line with previous research

[18] AIMS Neuroscience; Attention, Perception and Psychophysics; Cognition and Emotion; Comprehensive Results in Social Psychology; Cortex; Drug and Alcohol Dependence; European Journal of Neuroscience; Experimental Psychology; Human Movement Science; Journal of Accounting Research; Journal of Business and Psychology; Journal of Personnel Psychology; Journal of Media Psychology; NFS Journal; Perspectives on Psychological Science; Royal Society Open Science; Social Psychology; Stress & Health; Working, Aging and Retirement

or not. Although a failed replication does not disprove the original results, the inclusion of any methodologically and analytically sound research provides a broader, more comprehensive literature.

The aims of the current experiment were twofold, to explore whether a landmark task could reliably measure approach and avoidance motivation elicited by auditory stimuli and to explore the registered report procedures more generally. The current manuscript received Stage 1 approval as a registered report in *Attention, Perception, & Psychophysics* (AP&P), such that the editorial team committed to the eventual publication of the manuscript based on the introduction, proposed method, and proposed analyses (prior to the experiment being conducted). The paper is presented here, in the form of the current submission, which now includes the obtained results and discussion[19]. It should be noted that, although the complete paper has undergone review, reviewer comments have not yet been addressed as additional experimentation is currently being undertaken.

The current experiment explored whether spoken compliments and insults affect performance on a landmark task. Compliments and insults were given in both positive and negative intonations. Based on previous published research (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010), a main effect of phrase was predicted, such that insults would elicit greater leftward biases on the landmark task than compliments. It was expected that this effect would be moderated by intonation, wherein congruent insults (insults with a negative intonation) would elicit greater leftward biases than congruent compliments (compliments with a positive intonation). No significant differences were expected to occur between the incongruent conditions.

The following registered report has been accepted for publication in *Attention, Perception and Psychophysics*, and is entitled “The effect of spoken compliments and insults on approach and avoidance motivation”. The manuscript is presented here unchanged from the stage 2 submission. The current author designed, conducted and analysed the experiment, and is first author on the publication.

[19] The paper is entitled " The effect of spoken compliments and insults on approach and avoidance motivation” and the author are, in order, Nathan C. Leggett, Nicole A. Thomas and Michael E. R. Nicholls.

Introduction

The lateralization of important cognitive processes allows for quick and automatic processing of the world around us (Vallortigara & Rogers, 2005). Each day, one of the most critical decisions humans make is whether to approach or withdraw from their environment (Hanbury et al., 2013). The cognitive systems responsible for approaching positive stimuli and avoiding negative stimuli have been shown to be left and right lateralised, respectively (Gable & Poole, 2012; Spielberg et al., 2013; Takeuchi et al., 2014). Convincing evidence for such lateralisation has been provided by neuroimaging studies. Several studies have asked participants to complete an emotional-stroop task during magnetic resonance imaging (Davidson et al., 1990; Herrington et al., 2005) or to view pleasant/unpleasant short film clips while electroencephalogram data were recorded (Spielberg et al., 2012). These studies have linked approach behaviours to the left, and avoidance behaviours to the right, dorsolateral prefrontal cortex.

In addition to this neuroimaging research, an extensive number of behavioural studies suggests that approach and avoidance motivation are left and right lateralised, respectively (Chen & Bargh, 1999; Förster, 2004; Friedman & Förster, 2000; Rotteveel & Phaf, 2004). Gestures, such as pulling or pushing, have been shown to influence state approach and avoidance motivation (Rotteveel & Phaf, 2004). Arm flexion is reminiscent of pulling an object towards the body and the sensation of pulling is associated with approach motivation (Friedman & Förster, 2000). In contrast, arm extension is congruent with pushing an object away from the body and the sensation of pushing is congruent with avoidance motivation (Friedman & Förster, 2000). Researchers have utilised the association between pulling and pushing movements and motivational processes to explore the effects of various stimuli on approach and avoidance motivation.

Chen and Bargh (1999) asked participants to classify words as either good or bad by pulling or pushing a lever. Half of the participants pulled the lever for good and pushed the lever for bad, and the other half employed a reversed response mapping. They found that positive words facilitated flexion, whereas extension was quicker for negative words. Chen and Bargh concluded that stimuli are automatically classified as either good or bad, and this directly influences behaviour (see also Duckworth, Bargh, Garcia & Chaiken, 2002).

Using a similar methodology, Lavander and Hommel (2007) asked participants to judge whether an image was good or bad, but instead of using a lever, participants moved a small doll toward or away from the screen. Therefore, the association between motor movements and motivation was reversed, such that extension was congruent with approach motivation and left hemisphere activation, and flexion was congruent with avoidance motivation and right hemisphere activation. They found positive images were classified more quickly during extension, whereas negative images were identified more quickly during flexion. These contrasting results indicate that motor movement methodologies are troublesome, as findings suggest that the cognitive representation of an action, which is context-dependent, is more important than the action itself.

Several recent studies suggest that line bisection (Armaghani et al., 2014; Nash et al., 2010) is a suitable, more straightforward, measure of approach and avoidance lateralization. Generally, line bisection is used to measure asymmetries in visuospatial attention (Bowers & Heilman, 1980). When asked to indicate the midpoint of a horizontal line, participants reliably bisect lines slightly to the left of centre (Jewell & McCourt, 2000). The landmark task is similar to line bisection, with the advantage that it is a perceptual task that does not rely on motor movements (Nicholls & Roberts, 2002). This task consists of a pre-bisected horizontal line, with a transector placed centrally or slightly to the left/right of veridical centre. When asked to indicate whether the line is longer on the left or the right side, participants show a bias toward the left (Greene, Robertson, Gill & Bellgrove, 2010). This leftward bias, which is referred to as pseudoneglect (Bowers & Heilman, 1980), is thought to have the same underlying neural mechanisms as the rightward attentional bias that occurs amongst hemispatial neglect patients (Heilman & Valenstein, 2011). Computerised line bisection and the landmark task have historically been used interchangeably within the literature (Jewell & McCourt, 2000).

Line bisection has been used, with some success, to measure lateral asymmetries associated with state approach and avoidance motivation (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010). Nash et al. (2010) recorded EEG data while participants completed a line bisection task and found that response biases were correlated with left pre-frontal activity, an area reliably linked to approach motivation. Nash et al. also showed that response biases on the line bisection task only shifted rightward during high approach-motivated states. This link has also been shown behaviourally by Armaghani et al. (2014), who found line bisection was more leftward when lines were flanked by sad faces compared to neutral faces. Cattaneo et al. (2014) similarly found that happy face flankers elicited greater rightward bisections than sad or neutral face flankers. This emerging research suggests that line bisection is sufficiently sensitive to approximate the relative brain activation elicited by approach and avoidance motivation.

Of the few studies that have directly examined the link between line bisection and motivation, only emotional faces have been used to manipulate motivational states (Armaghani et al., 2014; Nash et al., 2010), making it unclear whether it is motivation or emotional faces that affect line bisection performance. Research by Furl et al. (2012) suggests that faces have a unique social relevance, compared to other types of stimuli. They found that, within a learning task, angry faces elicited more leftward responses than happy faces. However, biases failed to occur when either words or images were presented in the place of emotional faces. Consistent with this result, research (Lavender & Hommel, 2007), shows that images only influence motivation in affect-relevant tasks, such as classifying stimuli as good or bad. In relation to word stimuli, however, research suggests that valenced words do affect motivational states (Chen & Bargh, 1999). These discrepant findings suggest that word stimuli only affects motivation under specific conditions.

The context in which a motivational stimulus is presented can be as important as the stimulus itself (Lavender & Hommel, 2007). Faces, words and images have all been used to manipulate motivation, but such stimuli have only been presented visually (Chen & Bargh, 1999; Furl et al., 2012; Lavender & Hommel, 2007; Nash et al., 2010). While faces and images are primarily visual aspects of the environment, words are encountered both visually and aurally. Context and meaning are not derived from the literal definition of words, but from the way in which they are spoken (Collier, 1989; Cook, 2002). Prosody, the intonations and patterns that make up spoken language, allows speakers to highlight important information (Vroomen, Collier & Mozziconacci, 1993), as well as their emotions and attitudes (Cook, 2002). Visually-presented words, as used by Chen and Bargh (1999) and Lavender and Hommel (2007), might therefore be contextually ambiguous, potentially explaining the contrasting results of their studies.

It is apparent that written words have produced a mixed effect in relation to approach/avoidance motivational states (Chen & Bargh, 1999; Lavender & Hommel, 2007). It is possible that this lack of consistency is related to the modality in which words were presented and the resulting contextual ambiguity of the words. To address this issue, the current study sought to reduce the contextual ambiguity of stimuli by including prosody through the use of verbal stimuli. It was hypothesised that these phrases, which were directed at participants to create social relevance, would influence lateral biases. Auditory phrases consisted of short audio clips of voiced compliments or insults, e.g., “you are a racist”. Phrases were used, rather than individual words, to allow for compliments and insults to be voiced with both positive and negative intonations. This allowed for contextually compatible (i.e., compliments with a positive intonation and insults with a negative intonation) trials to be compared with incompatible trials (Lavender & Hommel, 2007). The landmark task was used to measure lateral biases. A main effect of phrase was expected, such that insults would elicit greater leftward biases than compliments. It was expected that this effect would be moderated by the intonation of the audio clips, wherein congruent insults would elicit a greater leftward bias than congruent compliments, with no significant differences between incongruent conditions.

Method

Participants

Participants were recruited from Flinders University with the ethical approval of the Social and Behavioural Research Ethics Committee of the Flinders University. All participants had normal or corrected-to-normal vision and were right-handed (M = 9.44, SD = 1.40), as measured by the Flinders Handedness Inventory (FLANDERS) (Nicholls et al., 2013). To maintain a power level of at least 0.9, the program G*Power (Faul et al., 2007) was used to conduct an a priori power analysis for the planned analysis of variance (ANOVA). With a partial eta-squared of 0.4 and critical alpha of .05, a minimum of 23 participants were needed. To ensure proper counterbalancing of conditions, a total of 27 participants (19 females, M_{age} = 23.60, SD_{age} = 6.30) were tested, with usable data for 24 participants.

Apparatus

Stimuli were presented on an Intel Core 2 Duo PC, with a 19” monitor running at a resolution of 1024 x 768 pixels. E-prime 2.0 software (Psychology Software Tools, Inc.; www.pstnet.com/E-prime/e-prime.htm) was used to present stimuli and record responses. Auditory stimuli were presented binaurally through headphones (Sennheiser, model HD 201) and responses were made on a model 200A PST Serial Response Box. A chin rest served to keep the visual angle of the stimuli constant and to reduce head movements. Participants were video monitored to motivate them and ensure they attended to the task.

Stimuli

Landmark Task.

The landmark task is a perceptual line bisection task, on which participants indicate whether a pre-bisected line is longer on the left or right side. Two line lengths were used, 150 mm and 170 mm, to increase task variability and improve attention to task (Nicholls et al., 1999). Two 10 mm vertical lines were located at the end points of the line, with a third vertical line (bisector) located 0.5 mm, 1 mm, or 2 mm to the left or right of veridical centre. The line stimulus was not located in the actual centre of the screen, but instead was jittered 5 mm to the left or right of centre, to minimise the effect of external reference points.

Compliments/Insults.

To reduce the repetitiveness of the stimuli and to increase attention to task, one male and one female actor voiced recordings of compliments or insults. Both compliments and insults were voiced in positive and negative intonations, such that congruent trials were positive/compliment and negative/insult pairs, while incongruent trials were positive/insult and negative/compliment pairs. To avoid a possible confound, the sex of the voice was kept consistent for both positive and negative intonations, i.e., the female voiced “you are a racist” in both the compliment and insult conditions and this sentence was not voiced by the male. Each audio clip was 1500 ms in length and volume was consistent across clips.

Flinders Handedness Survey (FLANDERS).

As left-handers are more likely to show atypical hemispheric lateralisation, such as weaker leftward biases on line bisection (Heilman, 2005), the FLANDERS (Nicholls et al., 2013) was administered to ensure all participants were right-handed. The questionnaire consisted of ten questions that address typical actions, such as writing, and participants indicated their hand preference for each (left, right, or either). Scores can range from -10 to 10, as right responses are scored as 1, left responses as -1 and ‘either’ responses as 0. All participants in the current study scored over +4 on the FLANDERS.

Procedure

All participants provided informed consent prior to the study. The task was presented with a grey background, to reduce the luminance of the screen. A blank grey screen was presented for 200 ms, followed by a cross in the centre of the screen for 500 ms, on which participants were asked hold a steady gaze. The compliment or insult audio clip was played for 1500 ms, followed by a blank grey screen for 500 ms. The line stimulus was then presented for 500 ms (see *Figure 28*). Participants then indicated whether the left or the right side of the line was longer, using the far left and far right keys of the response box, respectively. Response mapping was not reversed, as it was intuitive in nature and participants might have responded incorrectly if left responses were mapped to the right key (and vice versa). Participants were instructed to respond within 2000 ms of the stimulus disappearing, although accuracy was stressed. Trials on which participants failed to respond within 2000 ms were repeated at the end of the block.

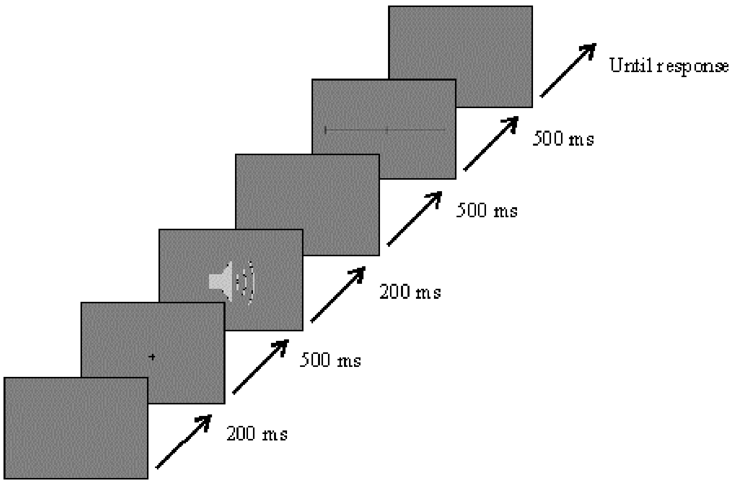

Figure 28. Trial sequence.

Experimental variables included phrase intonation (positive, negative), phrase message (compliment, insult) and bisection side (left, right), with control variables of line length (150 mm, 170 mm), bisection distance (0.5 mm, 1 mm, 2 mm) and jitter (left, right). Compliments and insults were presented in separate blocks; the unique combination of line length, bisection side, bisection distance, and intonation resulted in a total of 144 trials for each block.

Analyses

The variables of line length, bisection distance and jitter were included as controls and were therefore not analysed. Response biases on the landmark task were calculated, for each phrase type, using the following formula:

$$Response\ Bias = 100\left(\frac{Right\ responses - Left\ responses}{Total\ responses}\right)$$

Right responses indicate that the right side of the line was perceived as longer, whereas left responses indicate that the left side was perceived as longer. Possible scores could therefore range from -100 (left responses on all trials) to +100 (right responses on all trials).

All raw data is available for download from www.sites.google.com/site/ncleggettpsychology/downloads.

Results

Outliers were selected based on participant accuracy (*M* = 69.64%, *SD* = 13.00%), resulting in 3 participants, with accuracy scores below 50%, being excluded. One-sample *t*-tests on the remaining 24 participants confirmed biases were significantly leftward for compliments with positive intonation, *t*(23) = 3.07, *p* = .005, *d* = 0.89, compliments with negative intonation, *t*(23) = 2.14, *p* = 0.43, *d* = 0.62 and insults with positive intonation *t*(23) = 3.81, *p* = .001, *d* = 1.10. Insults with negative intonation produced a mean leftward biases, although this failed to reach significance, *t*(23) = 2.01, *p* = .057, *d* = 0.58 (see *Figure 29*). A 2 (message: insult, compliment) x 2 (intonation: positive, negative) repeated-measures ANOVA, with response bias as the dependent variable did not find a main effect of message, *F*(1, 23) = 0.13, *p* = .726, η_p^2 = 0.01. Although not hypothesised, the significant main effect of intonation showed that phrases voiced in a positive intonation elicited a greater mean leftward response bias (*M* = -17.36, *SD* = 24.62) than those voiced in a negative intonation (*M* = -11.34, *SD* = 26.53), *F*(1, 23) = 9.68, *p* = .005, η_p^2 = 0.30. The interaction between message and intonation failed to reach significance, *F*(1,23) = 0.55, *p*

= .465, η_p^2 = 0.02. Despite the interaction being non-significant, a priori planned comparisons were carried out due to their theoretical importance to the current study (see *Figure 29*). Congruent insults did not differ from congruent compliments, $t(23) = 1.55$, p = .136, nor did incongruent insults differ from incongruent compliments, $t(23) = 1.86$, p = .075.

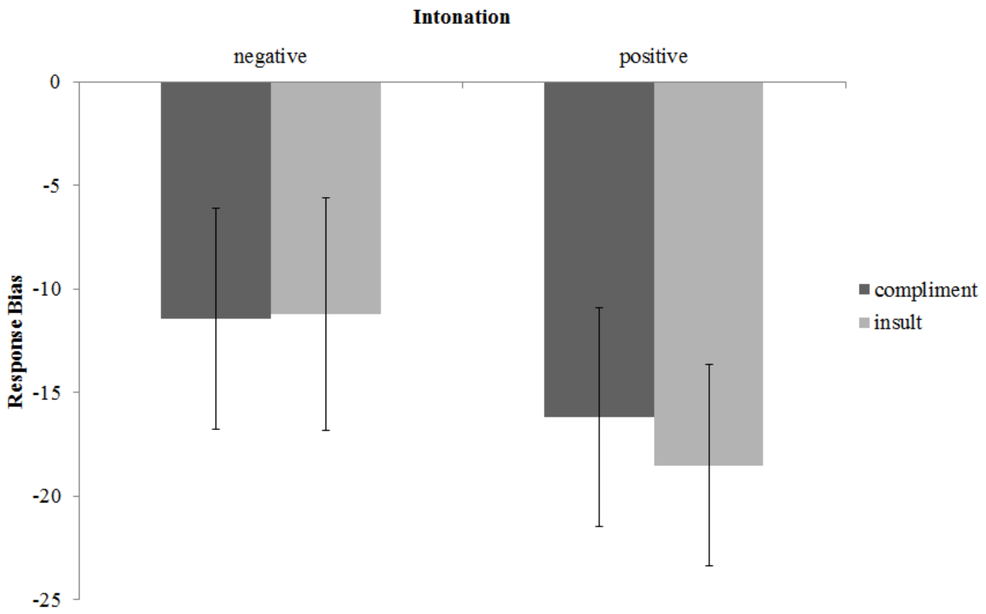

Figure 29. Response biases for compliments and insults, by positive and negative intonations. Error bars denote standard error from the mean and negative biases represent biases leftwards from centre.

Discussion

The present study found that only the prosody of compliments and insults affected participants' motivation, such that phrases delivered in a positive intonation, regardless of whether they were compliments or insults, resulted in greater leftward biases than phrases in a negative intonation. Prosody is processed by low-level cognitive pathways (Bach et al., 2008; Bachorowski & Owren, 2003), whereas word recognition and semantic meaning are processed by higher-level pathways (Markman & Brendl, 2005). Specifically, semantic processes are associated with superior and middle temporal gyrus activation (Friederici & Alter, 2004), and have also been correlated with the N400 event-related potential, which has a centro-parietal distribution (Kutas & Federmeier, 2000; Kutas & Hillyard, 1980). In comparison, prosodic processes have been shown to be associated with right prefrontal and right superior temporal cortices (Friederici & Alter, 2004). Damage to the right hemisphere has been linked to deficits in prosodic comprehension, which are not present following left hemisphere damage (Pell & Baum, 1997).

Similar to prosody, approach and avoidance responses derive from low-level pathways (Norbury, Kurth-Nelson, Winston, Roiser & Husain, 2015). This level of processing allows for quick, automatic reactions to stimuli based on their evolutionary significance, be it dangerous or advantageous (Lang et al., 1990). As both prosody and motivation rely on similar low-level pathways (LeDoux, 1996), it is possible that prosody affects motivation. As suggested by the current results, positive intonations affect approach motivation to produce strong leftward biases. These biases are more leftward than those produced by negative intonations, which affect avoidance motivation.

Higher and lower levels of processing might also explain why compliments and insults, as well as other word stimuli from previous studies, failed to affect motivation. Neumann and Strack (2000) asked participants to classify adjectives as ‘good’ or ‘bad’, while performing arm flexion (associated with approach) or extension (associated with avoidance) and found that arm extension facilitated the classification of negative adjectives as ‘bad’; however, no facilitation effect occurred during arm flexion (p = .057, one-tailed). In a slightly different paradigm, Markman and Brendl (2005) asked participants to classify words by physically moving them either toward or away from a card displaying their own names. Participants were faster to move positive, compared to negative, words toward their name, regardless of whether the movement required arm flexion or extension. Interestingly, participants were faster overall to push positive words away from their body and (non-significantly) faster to pull negative words towards their bodies. A recent straight replication of Chen and Bargh’s (1999) original study (Rotteveel et al., 2015) also found no effect of valenced words on motivation (see also Furl et al., 2012). Instead, their Bayesian analyses found anecdotal evidence in favour of the null hypothesis. The processing of semantic meaning, which was present in the aforementioned studies, is a high-level process (Zhuang, Randall, Stamatakis, Marslen-Wilson & Tyler, 2011). The results of the current experiment suggest that this higher-order processing may operate separately from lower-level processes, such as those associated with prosody and motivation.

The counter-intuitive direction of the intonation effect might best be explained from a neuronal fatigue account (Benwell, Harvey, et al., 2013; Newman et al., 2014). Presumably, positive and negative intonations should elicit approach and avoidance motivational states, respectively. One would expect that the increased right hemispheric activation, associated with avoidance motivation, would result in greater leftwards response biases, and vice versa for approach motivation. However, we found the opposite pattern of results, such that participants' response biases were more leftward for positive, compared to negative, intonations. Positive intonation activates the left hemisphere, whereas the right hemisphere is activated by the landmark task. In contrast, the right hemisphere is activated by both negative intonation and the landmark task. It is plausible that this simultaneous activation of the right hemisphere caused neuronal fatigue to occur in only the negative intonation condition (Benwell, Harvey, et al., 2013). As such, negative intonations could have resulted in weaker leftward biases, relative to positive intonations.

It appears that the effect of language on motivation is more complicated than initially proposed by Chen and Bargh (1999). The present study illustrates that prosody affects motivation more so than the message alone. These results, together with previous studies (Furl et al., 2012; Markman & Brendl, 2005; Neumann & Strack, 2000; Rotteveel et al., 2015), indicate that language interacts with motivation only at lower-level pathways. The pattern of results also supports a neuronal fatigue account consistent with the findings of Benwell et al. (2013). Language consists of many components, such as semantic, syntactic and prosodic elements. It is important that future research consider that these components are often processed separately, and effects reliant on lower or higher-levels of processing might present differently based on which cognitive process is salient.

This concludes the current manuscript.

Discussion of the registered report experience

Registered reports are designed to combat the increasing problem of 'repeated peaks' and 'optional stopping' biases by ensuring that publication decisions are made prior to data collection. In other words, the decision to publish an eventual dataset is no longer dependent on returning significant results, but is instead based on the development of a sound methodology and the use of appropriate statistical analyses. Registered reports undergo a two stage process: Stage 1 involves the submission of a proposal, which includes a theoretical discussion of the topic, hypotheses based on this theory, a proposed methodology that addresses specifically how the topic will be explored, and planned analyses which sufficiently address the hypotheses. The decision of whether or not the manuscript will eventually be published is based on this proposal, with the journal committing to publication based on the theoretical foundation and the methodological and analytical procedures of the research. Following approval, Stage 2 can be undertaken, which involves data collection and analysis. Once the results and discussion have been written, the manuscript is once again sent out for peer revision of these final two sections.

In theory, registered reports should result in the publication of fewer false positives. Factors that contribute to the publication of false positives, such as optional stopping and low statistical power, should be reduced by the peer review procedure that is undergone prior to experimentation. Additionally, post-hoc analyses should be reduced, as hypotheses are clearly stated and planned analyses are outlined before data collection (Chambers, 2013). The following is a discussion of the author's personal experience with submitting a registered report, and explores both the positives and negatives of the procedure.

In a traditional publication process, there is no single standardised procedure; individual journals have slight variations in formatting, reviewing and editorial decision-making. Unfortunately, the process for Stage 1 registered reports appears to differ rather widely, depending on the journal[20]. This wide variability in procedure is likely due to the infancy of the registered report procedure itself. Over time, registered report procedures will hopefully become more standardised across journals, which will make registered reports a more attractive option for authors. As a result of this lack of standardisation, the current author's experience with registered reports may differ greatly from the experience of others. The current paper was not a straight replication of earlier research, which would have excluded it from publication under the registered report procedures of some journals (such as *Cognition and Emotion*). However, the sound methodology and appropriateness of the planned analyses, which were based on previous research, were sufficient to gain Stage 1 approval with AP&P. The acceptance of the proposal allowed for data collection to

[20] Some journals only accept straight replications of prior published work, whereas others accept novel research. Some journals require raw data to be made available, as well as an experimenter log, whereas others do not.

commence, and for these data to be analysed and added to the Stage 1 approved manuscript.

Given the theoretical background and methodology for the experiment had been pre-approved, the most surprising aspect of the registered report procedure was the Stage 2 reviewer comments. Interestingly, after submitting the completed manuscript (i.e., post-data collection), the reviewer comments were not restricted to the results and discussion sections, but also included comments relating to the methods and data analysis procedures. Although these comments provided valuable feedback on how the introduction and analysis sections could be improved, one could argue that these comments came rather late in the process – particularly given that the goal of registered reports is to have the methods and proposed analyses pre-approved. Theoretically, authors should be held accountable to their proposed research design, original approved analyses and the original predictions they made when a paper is published as a registered report. The modification of any of these, post-data collection, could re-introduce many of the problems that traditional publication processes face, such as post-hoc analyses and post-hoc hypotheses. Additionally, readers need to be able to trust that registered reports adhere to the pre-approved methods and analyses; without this trust, registered reports will be unable to present as the pinnacle of research practice. For registered reports to impact psychological research in a positive way, methods and analyses must not be altered after Stage 1 acceptance.

An additional issue with the current registered report arose when a main effect unexpectedly reached statistical significance. More traditional publication procedures might have seen the introduction rewritten to suit the unexpected result; however, even if the authors of the current registered report had been of a mind to engage in sub-par research procedures, the registered report procedure meant that this was not possible.The effect of intonation was hypothesised to be nonsignificant, as prior research suggests the valence of prosody does not affect lateralised processes (Grimshaw, Séguin & Godfrey, 2009). As an interaction effect between intonation and phrase was predicted, the analysis of variance was conducted and the main effect of intonation turned out to be significant. There are no strict guidelines (to the author's knowledge) that suggest how an unpredicted effect should be discussed in a registered report. Initially, there seem to be two acceptable ways of handling an unexpected finding: firstly, one could argue that the effect should not be discussed at all, past the point of reporting its significance. This option seems reasonable, as registered reports are not supposed to include exploratory research. The second option is to openly admit that the effect was unpredicted, but to argue that the effect is still meaningful. The author took the second option with the current manuscript.

Although it initially seemed reasonable to discuss the unpredicted effect of intonation as meaningful, given that it arose from a study with sufficient statistical power, no evidence exists in prior research to suggest that an effect of intonation should have occurred. Two prior studies, which have investigated the effects of emotional prosody on visual attention, actually suggest that emotional prosody, in general, rarely affect visual attention (Godfrey & Grimshaw, 2012; Grimshaw et al., 2009). Specifically, no evidence has been found to suggest that happy and angry prosody affect visual attention (Grimshaw et al., 2009). In lieu of discussing this unexpected effect, not simply because it was unexpected, but because it was also in the opposite direction to what might be expected should this unlikely effect emerge, a third option was deemed more appropriate. It was decided that further experimentation should be conducted, with greater statistical power, to determine whether the effect of intonation was indeed meaningful or was a false positive. For this reason, the reviewers' comments were not addressed in this thesis, and further experimentation is currently taking place. This way of looking at unexpected results, as possible false positives, might be a suitable template for future registered reports. The occurrence of unexpected effects suggests there is a lack of prior evidence indicating such effects could exist. Therefore, in keeping with the main goal of registered reports, which is a reduction of non-replicable data in the literature, such unexpected effects should, at the very least, be self-replicated before being considered meaningful.

Overall, the author's first experience with registered reports has been positive. Registered reports seem like an appropriate solution to publication biases, as they should reduce false positives and uphold a higher standard of research than previous publication processes. Although there is a long way to go before registered reports are widely used and procedures are standardised across journals, this author is hopeful that an emphasis on sound methodological and analytical procedures can be maintain within psychological science through the use of registered reports.

Chapter 7: General Discussion

The current thesis explored three main research questions relating to approach and avoidance motivation. The first line of research sought to confirm and elaborate on prior claims that line bisection provides a reliable measure of motivational asymmetries (Armaghani et al., 2014; Cattaneo et al., 2014). Had line bisection been found to reliably measure motivational asymmetries, a more convenient methodological procedure would have been available for motivational research. Unfortunately, and in contrast to previous research (Armaghani et al., 2014; Cattaneo et al., 2014), both the landmark and greyscales tasks were found to be unreliable in measuring motivational lateralisation.

The second line of questioning explored whether the vertical position of stimuli interacted with motivational lateralisation. Given that information in the upper visual field and approach stimuli both elicit rightward biases, and lower visual field information and avoidance stimuli elicit leftward biases (Armaghani et al., 2014; Cattaneo et al., 2014; Loughnane et al., 2015), motivational stimuli could be attended to differently depending on their elevation. This effect of elevation would have methodological implications for motivation research, as well as highlight a potential confound for studies that have used upper and lower response button placements (Krieglmeyer et al., 2010; Rotteveel & Phaf, 2004). However, no difference between upper and lower visual fields was found between approach and avoidance stimuli, suggesting that the directional biases that are elicited within each visual field are not directly related to motivation.

The third research question was related to the proximal position of motivational stimuli, and explored whether moving toward or away from stimuli facilitated approach or avoidance judgments. Additionally, the potential effect of near and far stimuli on motivational judgements was explored. Previous research has linked near and far space representations with stimulus valence, such that positive stimuli bring the near space boundary closer to the body and negative stimuli push the near space boundary away from the body (Coello et al., 2012; Iachini, Pagliaro & Ruggiero, 2015). Additionally, research has shown that positive stimuli elicits forwards postural sway and negative stimuli elicits backwards postural sway (Brunyé et al., 2013; Eerland et al., 2012). Given that stimulus valence affects distance perception and body posture, it is plausible that the reverse might also be true; that spatial representations (i.e., near or far) facilitate approach/avoidance motivation. Most prior research that has manipulated stimulus spatial position has controlled for either the stimulus size or visual angle, but has failed to consider the combined influence of both factors. The current thesis employed novel methods to adequately control for both stimulus size and visual angle, providing an important methodological contribution to the literature. Contrary to expectation, no evidence was found to suggest spatial representations facilitate approach and avoidance judgments.

A series of null results and non-replications led to a broader exploration of psychological science itself, and more specifically, the issue of replicability. Recently, a great deal of psychological research has explored publication biases and found many published effects cannot be reproduced (Nosek et al., 2015). Indeed, some research suggests that sub-optimal research practices, as well as an overemphasis on statistical significance, has led to an inflation of *p* values just below the significance threshold (Masicampo & Lalande, 2012). These data highlight a problem with null hypothesis significance testing, and further, highlight the fact that significant but weak effects are often unable to be reproduced. In Chapter 6, distributions of published *p* values were analysed and the frequency of *p* values just under the significance threshold was found to be inflated. This inflation increased from 1965 to 2005, suggesting publication biases and sub-optimal research practices have increased over this forty-year period. Potential solutions to this issue were discussed, with registered reporting, in particular, being explored in detail.

Overall, the current thesis explored the lateralisation of approach and avoidance motivation, and also investigated the issue of replication within psychology. Each research question, as outlined above, is discussed here in detail. Conceptual implications, as well as potential limitations, of the current findings are discussed. Recommendations are also made for future research.

Visuospatial tasks and motivational lateralisation

The initial aim of this thesis was to expand on previous research showing that line bisection reliably reflects approach motivation (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010). Several approach-related constructs, such as positive affect (Drake & Myers, 2006), writing about cherished values (Shrira & Martin, 2005) and narrowed attention (Förster et al., 2008) have been found to push line bisection biases rightward. Nash et al. (2010) found that line bisection performance was significantly correlated with left pre-frontal brain activation, a brain region which has previous been linked to approach motivation (Spielberg et al., 2013). Additionally, during a challenging task, participants with high self-esteem bisected lines more rightwards than those with low self-esteem. Given that high self-esteem individuals have previously been found to display high levels of approach motivation during challenging situations (McGregor et al., 2007; McGregor et al., 2009), Nash et al. (2010) concluded that approach motivation elicits rightward line bisections. More recently, studies have found that approach-related faces elicit more rightward response biases than avoidance-related faces (Armaghani et al., 2014; Cattaneo et al., 2014). These studies suggest line bisection might be a reliable, low cost alternative to neuroimaging and motor congruency studies, for measuring motivational lateralisation.

Although Experiment 1 of Study 2 found avoidance stimuli elicited greater leftwards biases than approach stimuli, four additional studies (including a straight replication of Experiment 1) were unable to reproduce this effect. Further experimentation using the greyscales task produced similar results, in that motivation was found to affect attentional biases in Experiment 1 of Study 3 (albeit in the opposite direction to that hypothesised), but a straight replication did not reproduce this effect. Overall, despite limited evidence of a motivational effect, the data strongly suggest neither task can *reliably* measure asymmetries in approach and avoidance motivation.

More broadly, the current data highlight the importance of replication. Recent data has shown that effects with small effect sizes are less likely to be replicated than those with large effect sizes (Nosek et al., 2015). The current data support this, as Experiment 1 of Study 2 found small but significant effects of motivation which were later unable to be reproduced. Additionally, Experiment 1 of Study 3 found an effect in an unexpected direction, which also failed to be replicated. Therefore, replication seems to be particularly important when evidence of an effect is relatively weak (Rotteveel et al., 2015) or an effect is unpredicted (Wagenmakers et al., 2011).

The inconsistent results produced by the landmark and greyscales tasks was likely due to the inherent variability of both tasks (Manning et al., 1990). For example, in Experiment 1 of Study 2, angry faces elicited a significant leftward bias on the landmark task; however, the exact replication of this experiment (Experiment 5 of Study 2) found that angry faces elicited biases slightly *right* of centre. Similar variability was evident in Study 3, which used the greyscales task. Experiment 1 of Study 3 found that angry face stimuli elicited no response bias, whereas the straight replication (Experiment 2 of Study 3) found that angry face stimuli elicited a strong leftwards bias. A wide range of response biases were also observed across all five experiments within Study 2 and 3, evidenced by the large standard deviations of each condition. Although this could be the product of slight methodological changes between experiments, the failed replication attempts suggest this is unlikely.

Manning et al. (1990) suggests the variability on visuospatial tasks is likely caused by both scanning direction and error types. Participants commonly use both leftward and a rightward scanning directions during visuospatial tasks, as well as both anticipatory errors (i.e., stopping before the line's middle) and perseverative errors (i.e., stopping after the line's middle; Manning et al., 1990). Given this, any individual trial can result in a leftward or rightward bias, depending on the combination of scanning direction and error type used (Manning et al., 1990). Although this variability is less problematic for coarse, baseline measures of attentional asymmetry, influences of smaller effects on attentional allocation (e.g., motivation) can be difficult to observe through this variability.

The variability within the current research, particularly inter-participant variability, potentially highlights the possibility of observer subtypes. Although an overall leftward attentional bias is reliably found in typically developed populations (Jewell & McCourt, 2000), several studies have indicated that both leftward and rightward observer subtypes exist (Benwell, Thut, Learmonth & Harvey, 2013; Braun & Kirk, 1999; Cowie & Hamill, 1998; Manning et al., 1990; Newman et al., 2014). Benwell, Thut, et al. (2013) found that 61% of their right-handed participants initially bisected a landmark task to the left, 18% bisected to the right and 21% showed no bias[21]. Newman et al. (2014) also found evidence of pseudoneglect subtypes, as they observed that 67% of their sample presented with a mean left response bias and 33% presented with a mean rightward response bias. Although the exact cause of observer subtypes are not altogether clear, some research

[21] Benwell, Thut, et al. (2013) also found that, over time, initial leftward bisectors shifted their bisections to the right and initial rightward bisectors shifted their bisections to the left; however, Newman et al. (2014) argued that these data were simply portraying a regression to the mean.

suggests that inter-participant variability on visuospatial tasks might be related to dopamine receptor genotypes (Bellgrove, Hawi, Kirley, Gill & Robertson, 2005). Regardless of the possible underlying mechanisms of observer subtypes, future research might consider initially classifying participants as leftward or rightward observers and exploring whether approach and avoidance stimuli affect these participants' biases differently. Indeed, if observer subtypes were found to mediate the effects of approach and avoidance motivation on attention, this could have important methodological implications for future research.

The variability within the current data resulted in statistically significant effects, with small effect sizes. Interestingly, the only two previous studies reporting an influence of approach- and avoidance-related faces on response biases also have small effect sizes. The main effect of motivation reported by Cattaneo et al. (2014) was slightly weaker (η_p^2 = 0.13) than the effect in Experiment 1 of Study 2 (η_p^2 = 0.16). Although Armaghani et al. (2014) concluded that negatively valenced faces elicit more leftward biases than positively valenced faces, they did not test this assumption statistically[22]. Given the current results, it appears the conclusions drawn by Cattaneo et al. (2014) and Armaghani et al. (2014), that line bisection can *reliably* measure approach and avoidance motivation, might have been premature. Instead, the small effect sizes reported in the past and the current studies, as well as the high variability across the eight current experiments, strongly suggest traditional visuospatial tasks cannot reliably measure approach and avoidance lateralisation.

Vertical Dimension

Previous research exploring the behavioural consequences of approach and avoidance motivation has not incorporated the possible influence of vertical position (Armaghani et al., 2014; Cattaneo et al., 2014; Nash et al., 2010). Attentional allocation has been shown to be affected by the vertical position of stimuli (Barrett et al., 2000; Loughnane et al., 2015; Previc, 1990; Thomas & Elias, 2010), which could in turn mean that approach and avoidance motivation might differentially affect attention to the upper and lower visual fields. The current thesis explored whether approach or avoidance motivation predisposed

[22] Although the current author could not statistically test whether happy and sad faces elicited significantly different biases from the available data provided by Armaghani et al. (2014), a *d* of 0.35 (medium-large) was calculated from means, standard deviations and group sizes.

attention towards the upper or lower visual fields.

Typically developed populations allocate attention differently to the upper and lower visual fields (Barrett et al., 2000; Loughnane et al., 2015; Previc, 1990; Thomas & Elias, 2010). Loughnane et al. (2015) found, using a visual search task, that greater relative right hemisphere activation was associated with lower visual field targets, whereas greater relative left hemisphere activation had no association with task performance. In addition, participants displayed more efficient searches for targets that appeared in the lower-left portion of the array and also tended to show a search advantage for upper-right targets. This result is in line with previous research, which has found that lower visual field stimuli elicit stronger leftward biases (Barrett et al., 2000; Thomas & Elias, 2010).

Previc (1990) argues that attentional biases are more leftward in the lower visual field due to a functional association between lower visual field and near space processing. Stimuli that are encountered in the lower portion of our visual field are most often within arm's reach (e.g., a keyboard, food, mobile phone, etc.) and are processed in terms of how such stimuli can be physically interacted with. Conversely, stimuli found in the upper visual field (e.g., a bird, a plane, superman, etc.) are most often outside of arm's reach and are processed in terms of identifying *what* a stimulus is. Previc (1990) further posits that dorsal stream processing, which is specialised in planning physical interactions, is dominant for both near space and lower visual field stimuli, whereas ventral steam processing, which is specialised in recognising what an object is, is dominant for far space and upper visual field stimuli. Some experimental research similarly suggests that leftwards biases are stronger for lower visual field stimuli due to increased dorsal, compared to ventral, stream processing (Corbetta & Shulman, 2011; Loughnane et al., 2015; McCourt & Olafson, 1997; Thomas, Schneider, Gutwin & Elias, 2012).

Attentional biases towards either the top-right or bottom-left regions of space could be facilitated by congruent biases elicited by approach and avoidance motivation, respectively. Participants were given a visual search task that involved searching for a happy or and angry face target amongst neutral face distractors. It was predicted that actively searching for an angry face would result in more efficient searches for lower-left stimuli, whereas actively searching for happy faces would facilitate searches for upper-right targets. Although the results revealed overall search efficiency was greater for angry face targets compared to happy face targets; actively searching for happy or angry face targets did not facilitate searches to any specific region of space. It is possible that the relatively large search advantage for angry faces (η_P^2 = 0.80) outweighed any motivational effect which might have occurred; however, the lack of a motivational effect might also be due to the nature of the distracter stimuli used.

Previous studies have consistently found that happy faces elicit stronger rightward biases than sad and angry faces; however, results have been less clear when comparing these emotional faces to neutral faces (Armaghani et al., 2014; Cattaneo et al., 2014). Neutral faces have previously been found to elicit more rightwards biases than both happy and sad faces (Armaghani et al., 2014), or to elicit more leftwards biases compared to happy faces but not sad faces (Cattaneo et al., 2014). Given these mixed results, it is difficult to predict how neutral face stimuli might have affected lateral asymmetries in search efficiency. Future research might consider using alternate distracter stimuli to neutral faces, such as blank circles.

Facial stimuli were also schematic rather than photographic. Schematic faces were used in an attempt to reduce emotionally irrelevant perceptual features, as previous research suggested such features influence visual search (Craig et al., 2014). However, motivational lateralisation has only previously been explored by using photographic faces (Armaghani et al., 2014; Cattaneo et al., 2014). Although it is possible that schematic faces do not possess sufficient emotional content to elicit approach or avoidance motivation, the overall advantage for angry face searches suggests that this is unlikely. If schematic faces were unable to elicit emotional representations, no advantage for angry faces should have occurred. Despite this, future research might consider confirming that schematic faces elicit similar attentional biases to photographic faces. Alternatively, the use of photographic facial stimuli, rather than schematic stimuli, might be considered; although, irrelevant perceptual features (e.g., hair, makeup, jewellery, etc.) would need to be removed (Craig et al., 2014).

One final note can be made regarding the methodology of Study 4. Although Loughnane et al. (2015) found upper and lower visual field differences using a visual search task, their arrays were double the height of the current arrays. The fact that Loughnane et al. (2015) found elevational differences, whereas the current thesis did not, might indicate that upper and lower visual field differences are more pronounced for tall stimuli. Future research might consider increasing the distance between upper and lower visual field stimuli, in order to accentuate elevational effects. Overall, the current thesis suggests that happy and angry schematic faces do not facilitate the allocation of attention to one region of visual space over another.

Proximal Dimension

Although Study 4 did not find evidence that approach and avoidance motivation interact with attentional asymmetries in the upper or lower visual fields, the proximal position of stimuli could be more functionally linked to motivation. Previous research has found, in both animals and humans, that psychological responses (e.g., fear) increase as the distance to stimuli decreases (Blanchard & Blanchard, 2003; Fanselow, 1994; Lang, Bradley & Cuthbert, 1997; Teghtsoonian & Frost, 1982). For example, in a study with phobic participants, as the presentation distance of a snake stimuli decreased, self-reported fear, heart rate and skin conductance increased (Teghtsoonian & Frost, 1982). More generally, people reduce feelings of fear by literally increasing the distance between them and the fear inducing stimuli (Kreitler, 2003).

Some studies have shown approach and avoidance stimuli also affect the perceived distance of stimuli. Coello et al. (2012) presented participants with threatening images and found that participants' near space boundaries were enlarged, such that objects seemed further away, when threatening images were orientated towards them compared to away from them. Similarly, Iachini et al. (2015) used virtual reality to present participants with realistic human models. These models were given a positive or negative moral association (e.g., John steals his neighbour's newspapers) and either walked towards the participants or participants were instructed to walk towards the model. Iachini et al. (2015) found participants began feeling uncomfortable at further distances from negative stimuli than positive stimuli. Additionally, participants reported that they could reach negative stimuli at further distances than positive stimuli. These data suggest that the boundary of near space is expanded by negative stimuli. Conversely, near space boundaries have been found to reduce in response to positive stimuli. Tajadura-Jiménez et al. (2011) found that participants felt more comfortable having an experimenter sit close to them when they were listening to positive, compared to negative, music. It therefore seems that positive stimuli afford a near space context and negative stimuli afford a far space context.

In a related vein of research, approaching stimuli have been shown to facilitate tactile sensitivity (Van der Biest et al., 2015). On 75% of trials, Van der Biest et al. (2015) administered vibrotactile[23] stimulation to participants' left, right or both hands. Concurrently, an experimenter approached the participant's left or right hand with a pencil. Van der Biest et al. (2015) found that detection accuracy was higher for the hand that had been approached by the pencil, suggesting that tactile sensitivity can be facilitated by approaching visual stimuli. Additionally, some research suggests that positive and negative stimuli elicit forwards and backwards postural sway, respectively (Brunyé et al., 2013; Eerland et al., 2012). These studies suggest a link between approach/avoidance motivation and approaching/withdrawing stimuli.

Study 5 of the current thesis explored whether approaching or withdrawing from stimuli would facilitate approach/avoidance judgments. Given that both stimulus size and viewing angle have previously been shown to affect attentional allocation (Benwell, Harvey, et al., 2013; D. Wilkinson & Halligan, 2003), both methodologies used in Study 5 controlled for these factors using two novel methodologies. Vection was the first of two methods used to create an approaching/receding illusion. Vection is the subjective feeling of self-motion, in the absence of actual motion, and is induced by visual input. For example, many people have experienced vection while sitting in a stationary train at a train station. When a train outside the window begins to move, it might feel as if your train, rather than the outside train, is moving. This is because visual information in this situation could be consistent with either train beginning to move.

Some evidence exists to suggest that vection can elicit positive affect (Seno et al., 2013; Seno et al., 2012). Seno et al. (2013) elicited upwards and downwards vection in participants and asked them to concurrently recall memories based on keywords. Upwards vection, compared to downwards vection, facilitated the recollection of positive memories as well increasing positive mood in general. Conversely, Sasaki and colleagues (2012) induced upwards vection in participants while they listened to positive or neutral valenced auditory stimuli. Participants reported more intense and longer lasting upwards vection when they listened to the positive, compared to the negative, auditory stimuli. These studies demonstrate that vection is linked to valence.

[23] The intensities of the vibrotactile stimuli were near the perceptual threshold, which was individually determined using an adaptive procedure.

Experiment 1 of Study 5 used forwards and backwards star-field displays (such as ‘warp speed’ in star trek) to induce feelings of backwards and forwards self-motion, respectively. Concurrently, happy and angry facial stimuli were displayed on top of the star-field display. In this way, participants would feel like they were moving towards or away from stimuli. It was predicted that forwards vection would facilitate responses to approach stimuli, whereas backwards vection would facilitate responses to avoidance stimuli (Coello et al., 2012; Iachini et al., 2015).

A secondary aim of Experiment 1 was to explore whether participants needed to explicitly evaluate stimuli valence in order to elicit approach and avoidance motivation, or whether such motivational asymmetries were automatically and unconsciously elicited. Some prior research suggests valenced stimuli automatically elicit approach and withdrawal behaviours (Chen & Bargh, 1999; Duckworth et al., 2002), whereas others argue that behavioural reactions to valenced stimuli are not automatic, but are instead dependent on contextual information (Lavender & Hommel, 2007; Markman & Brendl, 2005). In order to examine this factor directly, participants were split into two groups: one group indicated whether faces were happy or angry (explicit group) and the other group indicated whether faces were male or female (implicit group). It was predicted that explicit judgments, compared to implicit judgments, would elicit greater approach and avoidance motivation, such that differences between approach and avoidance conditions would be more pronounced for the explicit, compared to the implicit, group.

Happy facial stimuli elicited higher inverse efficiency scores (reflecting both faster and more accurate responses) compared to angry facial stimuli. This happy face advantage was not significantly different between explicit and implicit groups, suggesting that explicit judgements of valenced stimuli are not required to elicit approach or avoidance motivation (Chen & Bargh, 1999; Duckworth et al., 2002). Approach and avoidance judgments were not facilitated by forwards or backwards vection, which could suggest three things: that vection did not affect the judgments of motivational stimuli, that vection conditions did not elicit forwards or backwards vection as intended, or that happy and angry facial stimuli did not sufficiently elicit approach and avoidance motivation.

To rule out the possibility that facial stimuli did not elicit approach and avoidance motivation, Experiment 2 of Study 5 used valenced images in lieu of happy and angry faces. Thus far, the data have provided very little evidence to suggest that happy and angry faces elicit significant approach or avoidance behavioural responses. This contrasts with previous research by Furl et al. (2012), who argued that approach and avoidance motivation are most strongly elicited by faces, compared to valenced words or images. However, previous experiments that have used valenced images, including those by Furl et al. (2012), have not used the most extreme positive and negative images (Dru & Cretenet, 2008; Suri, Sheppes & Gross, 2012). Experiment 2 of Study 5 used extremely valenced images, such that approach and avoidance motivation had the best possible chance of being elicited. Negative images included graphic depictions of injuries, famine and war and positive images included cute baby animals and nice food. Experiment 2 utilised a similar methodology to Experiment 1; however, only an explicit condition was used, as no difference was found between explicit and implicit groups in Experiment 1.

Despite the strong valence of images, no facilitation of approach or avoidance judgments was found for either vection condition. It seems unlikely that stimuli in both Experiments 1 and 2 failed to elicit approach and avoidance motivation, as both facial stimuli (Armaghani et al., 2014; Cattaneo et al., 2014; Furl et al., 2012) and valenced images (Dru & Cretenet, 2008; Suri et al., 2012) have previously been shown to elicit approach and avoidance motivation. The pattern of results seem to agree with research by Furl et al. (2012) as only facial stimuli, and not valenced images, elicited an overall performance difference between approach and avoidance conditions. The fact that approach and avoidance images did not elicit significant overall performance differences could also be indicative of a limitation with the stimuli set of Experiment 2. The current stimuli set included the most negatively valenced images in the IAPS database but not the most positively valenced. Erotic images have previously been shown to elicit extremely strong positive valence (van Lankveld & Smulders, 2008); however, erotic images were not used in Experiment 2[24]. Future research might consider using erotic images in order to maximise the chance of eliciting approach motivation. Overall, it seems unlikely that approach and avoidance stimuli, both face and images, are wholly to blame for the null findings of Study 5. Instead, it is possible that forwards and backwards vection conditions were unrelated to approach and avoidance motivation.

[24] Erotic images were not used for two main reasons: firstly, the IAPS database was released in 1999 and depicted pornographic images that were relevant to that time period; secondly, eroticism is to some degree subjective and the current author did not want to exclude participants based on gender or sexuality (or both).

Previous research which has linked positive affect to feelings of self-motion has used upwards vection (Sasaki et al., 2012; Seno et al., 2013), rather than the forwards or backwards vection used in the current experiments. Forwards and backwards vection, rather than upwards or downwards vection, were used in Study 5 as previous research has found that positive stimuli elicit forwards postural sway and negative stimuli elicit backwards postural sway (Brunyé et al., 2013; Eerland et al., 2012). As such, it seemed plausible that illusory forwards and backwards self-motion might be functionally linked to approach and avoidance motivation, more so than upwards or downwards vection. However, overall performance did not differ between participants who did or did not report feelings of vection. This, along with the fact that approach and avoidance judgments were not affected by vection conditions, likely suggests that forwards and backwards vection are not linked to motivational processes.

Given that forwards and backwards vection were unable to facilitate approach or avoidance motivation, Experiment 3 of Study 5 used 3D technology to create the illusion of stimuli being embedded in, or ‘popping out’ of, the screen. Facial stimuli were used, as faces appear to elicit the strongest motivational effects (Furl et al., 2012). Participants categorised facial stimuli as happy or angry and it was predicted that faces which ‘popped out’ of the screen would be allocated a near space representation and as such would facilitate happy responses. Faces that appeared to be embedded in to the screen were predicted to be allocated a far space representation and would therefore facilitate angry responses.

No facilitation effects were found for happy or angry faces. It is possible that this occurred due to an insufficient difference in perceived depth between the near and far conditions. During pilot testing of the 3D stimuli, participants reported that stimuli which exceeded a screen displacement (‘popping out’ or ‘receding in to’ the screen) of 130mm were difficult to focus on. Given that participants were seated 500 mm from the screen during the task, this resulted in near space stimuli appearing to be displayed at a distance of 370 mm from participants and far space stimuli being displayed at a perceived distance of 630 mm from participants. As such, the far space condition might have failed to allocate a sufficient far space context, as stimuli were on the edge of reachable space for the majority of participants. However, Longo and Lourenco (2006) found that line bisection performance[25] differed between presentation distances of 300 mm and 600 mm. Longo and Lourenco (2006) had a difference of 300 mm between their distance conditions, whereas the current experiment had a difference of 260 mm. It therefore seems altogether possible that the near and far space conditions of Experiment 3 succeeded in allocating near and far space contexts to facial stimuli, which would in turn suggest that near and far space contexts do not affect motivation judgments.

Study 5 was unable to provide positive evidence to suggest that near and far space stimuli facilitate approach or avoidance judgments. Neither illusory self-motion nor presenting stimuli in 3D, such that stimuli ‘popped out’ or ‘receded into’ the screen, resulted in dissociable responses to approach or avoidance stimuli. Although both methodologies used in Study 5 had the advantage of controlling for both visual angle and stimulus size, illusory manipulations of distance are limited as stimuli physically occupy the same space. Future research might consider physically changing the presentation of approach and avoidance stimuli to further investigate whether distance affects motivational judgments. Overall, Study 5 indicated that presentation distance does not facilitate approach or avoidance judgments.

Replicability

Although the lateralisation of motivation is well covered in the literature (Carver & White, 1994; Chen & Bargh, 1999; Elliot & Covington, 2001; Fetterman et al., 2013; Gable & Poole, 2012; Nash et al., 2010; Spielberg et al., 2012), only two studies have directly investigated the effects of motivational stimuli on visuospatial attentional biases (Armaghani et al., 2014; Cattaneo et al., 2014). The current thesis sought to replicate and expand on the results of both Armaghani et al. (2014) and Cattaneo et al. (2014) by showing that avoidance stimuli elicited greater leftward biases of attention than approach stimuli; however, very little evidence for such an effect could be found. Although the current null results are by no means evidence against the findings of previous research, this thesis might suggest that the effect of motivation on attentional asymmetries is weaker and less replicable than originally thought.

Armaghani et al. (2014) concluded that sad faces elicit stronger leftward biases than happy faces; however, happy and sad faces were only directly compared to neutral face

[25] $t(59) = 3.24$, $p = .008$, bonferroni corrected.

stimuli and not to each other. Additionally, Armaghani et al. (2014) did not apply a correction to their significance threshold after running multiple *t*-tests, which likely resulted in an inflation of positive results (Wagenmakers et al., 2011). Furthermore, the motivational effect reported by Cattaneo et al. (2014) was small. Small effect sizes have recently been found to replicate much less often than effects with large effect sizes (Nosek et al., 2015). Indeed, Cattaneo et al. (2014) were unable to replicate their motivational effect when motivational conditions were mixed, rather than blocked. Given that the current thesis provided very little evidence in favour of a motivational effect, it appears that the results of both Cattaneo et al. (2014) and Armaghani et al. (2014) are more difficult to replicate than initially thought.

Two publications have recently failed to replicate a motivational effect (Leggett et al., 2015; Rotteveel et al., 2015) and both are likely indicative of a broader problem within psychological science – publication biases. Publication biases result from sub-optimal research practices, which can potentially be used to coax *p* values towards significance (John et al., 2012). Sub-optimal research practices include ‘optional stopping’ and ‘repeated peaks’ biases, which refer to the continual monitoring of data as they are being collected and the cessation of data collection when a significant result is reached. Post-hoc outlier classification and post-hoc covariate inclusion are also examples of sub-optimal research practices. These practices inflate the likelihood of finding a significant result by selectively including or excluding data points across multiple analyses (John et al., 2012; Simmons et al., 2011).

Experimental evidence has been found to suggest that publication biases have resulted in an inflation of *p* values just below the significance threshold. Masicampo and Lalande (2012) examined the distributions of *p* value frequencies published in *Psychological Science, Journal of Personality and Social Psychology* and *Journal of Experimental Psychology: General* and found that *p* values just under the significance threshold were greatly overrepresented. They argued that this might be caused by an assumption that data must be significant in order to publish, an assumption which some data suggest that both researchers and reviewers hold (Chambers, 2014; Rosenthal, 1979). In fact, some data suggest that researchers are facing even greater pressure to publish in recent times, with the number of publications per researcher having risen 30% from 1990 to 2000 (Kyvik, 2003). This increased pressure to publish, coupled with an emphasis on significant *p* values, likely encourages researchers to engage in sub-optimal research practices to achieve publishable results (John et al., 2012; Simmons et al., 2011).

Although publication biases have likely existed through the history of psychological science, modern technology has plausibly made it easier to engage in sub-optimal research practices. Prior to the wide spread use of computers and statistical software, researchers had to analyse their data by hand, comparing their critical statistics to tables of *p* values. Nowadays, computerised statistical packages facilitate quick and easy data analysis, which allows researchers to continually monitor their data as they collect it, and also facilitates small changes to inclusion or exclusion criteria, in order to obtain significant results. Therefore, modern day researchers could be more likely to (inadvertently or not) manipulate the collection and analysis of data, such that a positive result is more likely.

The current thesis presented evidence in support of the notion that sub-optimal research practices are more common in modern research, compared to research conducted 40 years prior. Similarly to Masicampo and Lalande (2012), *p* value distributions, which were collected from the *Journal of Personality and Social Psychology* and the *Journal of Experimental Psychology: General*, were analysed to explore whether *p* values just under the significance threshold were over-represented. *P* values published in both 1965 and 2005 were collected to explore whether the over-representation of *p* values just under .05 had increased over the forty-year period. Although an over-representation of *p* values just below .05 was found in the 1965 data, the '.05 spike' was significantly larger in 2005 compared to 1965. Additionally, values that were reported as exactly .05 were more likely to be incorrectly rounded down (i.e., to achieve statistical significance) in 2005 than in 1965. This result is in agreement with Bakker and Wicherts (2011) who found that 18% of psychological results are reported incorrectly, 15% of which change a non-significant result to a significant result. Overall, these data suggest that publication biases in relation to the importance of statistical significance have increased from 1965 to 2005.

There are several factors that potentially contribute to the increasing problem of publication biases within psychological research. Technological advances have made data analysis faster and easier, potentially increasing sub-optimal research practices. These research practices increase the likelihood returning a positive result, as researchers are likely to cease data analyses when a result that confirms the hypothesis is returned

(Chambers, 2014). Additionally, researchers might feel like they are under pressure to produce significant, publishable data from the experiments they conduct[26]. This pressure to publish may in turn make researchers more likely to engage in sub-optimal research practices (Kyvik, 2003; Wagenmakers et al., 2011). In fact, the current data suggest sub-optimal research practices are more likely to be found in recent research, as *p* values inaccurately rounded down to .05 occurred more frequently in recent papers, even though technological advances should make such rounding errors *less* likely.

Several recent publications have put forward potential solutions to the increasing problem of publication biases (Cumming, 2013a, 2013b; Lindsay, 2015; S. E. Maxwell et al., 2015; Rotteveel et al., 2015; Wagenmakers et al., 2011). Lindsay (2015) suggests that editors and reviewers should be on the lookout for papers that present the 'troubling trio': low statistical power, a surprising result, and a *p* value only slightly below the significance threshold, as such papers are likely to present non-replicable effects. Others have advocated for the inclusion of effect size measures and confidence intervals, as these measures supply additional information about the replicability of an effect, whereas *p* values and descriptive statistics do not (Cumming, 2008; Nickerson, 2000). LeBel et al. (2013) have advocated for mandatory methods disclosure, a scheme where researchers detail which subjects were excluded, what conditions and measures were not reported, and how sample size was determined. LeBel et al. (2013) correctly argues this information is integral to the accurate interpretation of experimental findings, and although some journals do require this information, it should become part of the standardised reporting procedure.

The current thesis explored another potential solution to publication biases – registered reports (Chambers, 2013). Registered reports break the publication procedure into two stages: the first stage is a proposal of the research to be conducted and includes a theoretical introduction to the topic, the proposed methodology, the hypotheses, and the planned analytical procedures. Registered reports are peer-reviewed after stage one and the decision to accept (or reject) the manuscript for publication occurs prior to data

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[26] Although there is no direct data to support a link between significant results and grant funding/job opportunities, which the author is aware of, it seems likely that researchers who produce more significant, publishable results are at an advantage when applying for jobs or grant money. This could perhaps be the largest incentive for researchers to engage in sub-par research practices, although no research empirically tests these assumptions.

collection. As such, the research merit is assessed on the theoretical importance of the work, as well as the soundness of the methodological and analytical procedures. In other words, significant results are not of primary importance. Stage two of the registered report involves the collection and analysis of data, as well as a conceptual discussion of the results. The second stage of a registered report is also peer reviewed before the manuscript is published; however, the journal is bound by their original decision to publish the results, as long as the approved methodological and analytical procedures were followed. Given that methodological and analytical procedures are clearly presented, and publication decisions are made, prior to data collection, researchers are less able and less likely to engage in sub-optimal research practices.

A registered report was thought to be a fitting medium for the current research, given that much of the current thesis consisted of null findings. Although five experiments, consisting of mostly null findings, were published (Leggett et al., 2015), null results are notoriously difficult to publish on their own (Rosenthal, 1979). Indeed, the current thesis includes experiments which would be difficult to publish in highly ranked journals, at least in part because they resulted in null findings. Chambers (2014, p. 1) writes that “interesting results can be junk and dull results could be vital”, which alludes to the fact that the importance of scientific exploration should not be gauged by *what* is found, but instead by *how* it is found.

Rotteveel et al. (2015) recently published a registered replication (of Chen & Bargh, 1990) showing evidence that positive and negatively valenced words do not facilitate arm flexion or extension. The registered report procedure was likely pivotal for publishing such research, as registered reports facilitate the publication of results which might not be particularly ground breaking or ‘flashy’, but nevertheless contribute critical information about the reliability of an effect. The publication of this research is important for two reasons: firstly, due to the nature of registered reports, the paper focusses on correct and appropriate analytical procedures. The in-depth explanation of these procedures, including Bayesian analyses, might prove to be valuable examples for future researchers. Additionally, such research might encourage researchers and reviewers to conduct and publish more methodological/analytical focussed papers. Secondly, the results of the study suggest that further research, specifically pre-registered research, is needed to clarify under what specific circumstances valenced words can affect arm flexion and extension.

Registered report procedures allow research with sound methods and analyses, such as that of Rotteveel et al. (2015), to be seen by the psychological community.

The current thesis concluded with a registered report, which had two primary aims: firstly, to explore whether approach and avoidance auditory stimuli could affect the allocation of attention and secondly, to explore registered report procedures more broadly. Although some studies have suggested that both positive and negative auditory stimuli are right lateralised (Carmon & Nachshon, 1973; King & Kimura, 1972; Rodway & Schepman, 2007), others have found that positive and negative stimuli elicit left and right hemisphere activation, respectively (Bryden & MacRae, 1988; Erhan, Borod, Tenke & Bruder, 1998; Grimshaw et al., 2009; Schepman et al., 2012). Additionally, Cattaneo et al. (2014) recently found that happy auditory stimuli elicited stronger leftward biases, on a tactile rod bisection task, than sad auditory stimuli. The current registered report therefore presented participants with an auditory phrase (compliment or insult), which was spoken with a positive or negative intonation. It was predicted that participants would show stronger leftward biases on a landmark task after hearing insults compared to compliments. Additionally, it was predicted that this effect would be modulated by the intonation of the phrase, such that an effect of phrase would only be found for congruent stimuli (positive compliments/negative insults). Although previous research suggests that happy and angry auditory stimuli should push attention rightward and leftward, respectively (Cattaneo et al., 2014), previous approach/avoidance experimentation within the current thesis has suggested that a motivational effect can be difficult to find. As such, a registered report would ensure that the results of the study, regardless of whether they were significant or not, would be made available to the psychological community.

The second, and arguably the primary, aim of the current registered report was to explore the registered reporting procedure more generally. Registered reports are a relatively new initiative and, as such, are an unexplored frontier for many researchers. However, given the possible advantages of registered reports (i.e., reduction in publication biases), a first-hand exploration of whether the theoretical advantages of registered reports hold true in actuality could prove useful.

The registered report presented here was accepted for publication in *AP&P* after stage one, which meant that the results of the study would be published following data collection, regardless of statistical significance. Only one significant effect was found, an effect of intonation, such that positive intonation elicited greater leftward biases than negative intonation. The main effect of phrase and the interaction between phrase and intonation were non-significant. The effect of intonation was problematic, as no such effect was hypothesised and the direction of the effect was opposite to what one might predict (Armaghani et al., 2014; Cattaneo et al., 2014). This did highlight one advantage of the registered report procedure, as hypotheses cannot be changed after data collection and effects must be discussed in the context of the original predications. Within traditional publication procedures, there are no procedures to stop authors changing the introduction and hypotheses to suit their results. Therefore, only two options were available to the authors, to not discuss conceptual implications of the effect, as the effect was not predicted, or to admit that the effect was unpredicted and in the opposite direction, but to discuss possible implications of this.

The authors chose to discuss the effect of intonation as conceptually meaningful, because the methodology and analysis were sound and the result was statistically significant. Although admittedly post-hoc, neuronal fatigue was offered as a possible explanation for the direction of the effect, such that both the negative intonation condition as well as the landmark task elicited right hemisphere activation, which resulted in neuronal fatigue in the right hemisphere (Benwell, Harvey, et al., 2013). This, in turn, resulted in greater left hemisphere activation following the positive intonation condition, compared to the negative intonation condition. However, this explanation was a difficult sell and the absence of any measures of neural activation makes this possible explanation rather presumptuous. This sentiment was confirmed by reviewer comments during stage two of the registered report process. In fact, previous literature has found no evidence for an effect of happy or angry intonation on visual attention (Godfrey & Grimshaw, 2012; Grimshaw et al., 2009), making the current finding even more puzzling. It was therefore decided that further experimentation provided the best option to determine whether the effect of intonation was replicable, and not a false positive.

The unpredicted effect of intonation raised an important point about registered reports. Registered reports have been introduced as a means of reducing false positives in published literature by “gently but firmly compel[ing researchers] to stick to the scientific method” Chambers (2014, p. 1). However, it is important to realise that false positive can still occur in pre-registered research. The current registered report might be an example of this, given that the effect of intonation was unprecedented (Godfrey & Grimshaw, 2012; Grimshaw et al., 2009). The only way to instil confidence that an effect is indeed robust, reliable, and replicable, is for an effect to be replicated many times, via registered reports (Rotteveel et al., 2015).

Although registered reports certainly seem like they will be able to positively contribute to the future of psychological science, one aspect of the current procedure was particularly worrying. Given that the theoretical background, methodology, and analytical procedures of the current registered report had been approved in stage one, it was surprising that reviewers' comments during stage two were not restricted to the results and discussion sections. Although suggestions for changes to the methodology and analytical procedures were insightful and would undoubtedly improve the manuscript overall, they should been received and implemented prior to data collection. One could argue that such comments came too late in the registered report procedure, as the methodology had already been approved and reviewers had already seen the results.

The temptation might be to allow changes to the introduction, methods and analysis sections, only if such changes do not impinge on the integrity of the study. Indeed, the vast majority of the comments received for the current registered reports were sensible suggestions that would improve the quality of the manuscript, without affecting the results. However, any amendments made after data collection potentially introduce publication biases that registered reports are specifically designed to avoid. If authors and reviewers are not held to the originally approved methods and analyses, the advantages of registered reports over traditional publications become less clear. The registered report procedure is based on the fact that readers can trust that the methods and analyses they read in the final paper do not differ from the original methods and analyses approved prior to data collection. For registered reports to positively affect psychological science, this trust cannot be broken.

For registered reports to positively affect the scientific method within psychology, registered report procedures must be standardised across journals. The process for stage one of registered reports appears to differ widely depending on the journal. Some journals will only accept replications of previous experiments (such as *Cognition and Emotion*), while others require experimenters to keep a laboratory log of when experimentation takes place (such as *Cortex*). Although this variability between journals is likely a symptom of the infancy of the procedure, such variability reduces the accessibility of registered reports, as researchers must familiarise themselves with different procedures each time they submit a report to a different journal.

Overall, registered reports seem to be gaining influence within experimental psychology, as “the list of journals taking on registration is steadily growing, submissions from authors are rising, and funding agencies are taking notice” (Chambers, 2014, p. 1); however, only time will tell how the psychological community ultimately receives registered reports. The success of registered reports will likely be determined by, unfortunately, the popularity of the registered report articles themselves – how often these articles are cited and whether such research attracts as much funding as more traditional, exploratory research. If registered reports can achieve as much prestige as more traditionally published articles, the current author believes that they may go a long way in safeguarding psychological science.

Concluding comments

The current thesis sought to expand on previous research, which has found that approach and avoidance motivational processes can affect how one allocates attention in visual space. A lack of significant results made it difficult to significantly expand existing theoretical models of approach and avoidance lateralisation; however, several key points relating to psychological science as a whole were explored. The current thesis provided evidence that suggests publication biases are inflating the number of significant findings that are reported in published works and that this problem is worse now than it was fifty years ago. The unofficial ‘publish or perish’ creed of experimental psychology has shifted the focus away from sound science and towards the quick and continuous publication of ‘novel and interesting’ results. Such a shift in focus has encouraged researchers to engage in (inadvertently or not) sub-par research practices, which massage data towards the significance threshold. Despite this, the psychological community has recently begun to openly discuss changes that might be implemented to reduce publication biases and increase the validity and replicability of published work. The current thesis explored one promising solution to publication biases – registered reports. Registered reports were found to have many advantages over more traditional publication procedures, such that the soundness of methodological and analytical procedures could be insured before data collection even began. Although only time will tell whether registered reports can affect positive change on psychological science, it appears that the future of experimental psychology rests in the hands of the experimenters themselves.

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Appendix 1

Visual search generator

```
close all
clear all
%% User input
%Set values for columns and rows
prompt = {'Enter trial type','Enter number of columns','Enter number of rows','Enter matrix density','Enter the size of the gap between objects','Enter number of catch trials'};
dlgTitle = 'Set Variables';
numLines = 1;
default = {'','20','6','0.7','0.01','24'};
uInput = inputdlg(prompt,dlgTitle,numLines,default);
if isempty(uInput) %user pressed cancel
   return
end

%Convert input to numbers
directory = cell2mat(uInput(1));
xWide = str2num(cell2mat(uInput(2)));
yHigh = str2num(cell2mat(uInput(3)));
density = str2num(cell2mat(uInput(4)));
gap = str2num(cell2mat(uInput(5)));
nCatchTrials = str2num(cell2mat(uInput(6)));

%Select target and distracter images
[targetName, targetPathName] = uigetfile({'*.jpg;*.tif;*.png;*.gif', 'Image Files'},'Select the target image');
if ~targetName %user pressed cancel
   return
end
[distracterName, distracterPathName] = uigetfile({'*.jpg;*.tif;*.png;*.gif', 'Image Files'},'Select the distracter image');
if ~distracterName %user pressed cancel
   return
end

%Set image files
imgTarget = imread(fullfile(targetPathName,targetName));
imgDistract = imread(fullfile(distracterPathName,distracterName));
```

```
%Get image dimentions (in pixels)
imageDim = size(imgTarget);
imageWide = imageDim(1);
imageHigh = imageDim(2);

%Calc figure dimentions
figX = (imageWide*xWide)+((xWide-1)*gap);
figY = (imageHigh*yHigh)+((yHigh-1)*gap);

%Define how many faces in the matrix, based on width, height and density
totNFaces = round((xWide*yHigh)*density);
%% Target arrays
%{
Define matrices to track where targets have been placed
0s define no target placed in that position
1s define target placed in that position
%}
trackTargets = zeros(yHigh,xWide);

%Calculate how many faces in each column
facesPerColumn = round(totNFaces/xWide);

wbHandle = waitbar(1,'Creating target arrays');
waitbar(0/100)

for array = 1:(xWide*yHigh)
   tPresent = false; %if true, target has been placed in the current array
   curFaceCount = 0; %count of how many faces currently in the array
   rowCount = 0; %tracks which row the face is being placed in
   columnCount = 1; %tracks which column the face is being placed in
   trackColumn = zeros(1,xWide); %matrix counting how many faces in each column

   %{
   Keeps track of where faces have been placed in each array
   0s define no face
   1s define distracter
   2 defines target
   %}
   trackFaces = zeros(yHigh,xWide);

   while curFaceCount < (facesPerColumn*xWide)     %While there are still spaces for faces
      for i = 1:(yHigh*xWide)                    %For each possible location in the array
```

```
            rowCount = rowCount + 1;                %Faces are placed top to bottom, left to right
            if rowCount > yHigh                     %Reset rowCount after cycling through all rows
                rowCount = 1;
                columnCount = columnCount + 1;      %Move to the next counn, after all rows have been cycled in previous column
                if columnCount > xWide
                    columnCount = 1;                %Once all columns have been cycled through, go back to the first column
                end
            end
            if trackFaces(i) == 0 && trackColumn(columnCount) < facesPerColumn      %If position empty and the max face count not reached in the column, attempt to place a face
                if tPresent == false && trackTargets(i) ~= 1                    %If no target in array yet and there has not been a target in that position in a previous array, place a target
                    tPresent = true;                                %Indicates there is now a target in the array
                    trackFaces(i) = 2;                              %Records position of target in this array
                    trackTargets(i) = 1;                            %Records position of target for future arrays
                    curFaceCount = curFaceCount + 1;                            %Indicates a face has been placed
                    trackColumn(columnCount) = trackColumn(columnCount) + 1;           %Indicates a face has been placed in the current column
                elseif randi(100) <= 50 && tPresent == true                     %50 percent chance of placing a distracter (only after target has been placed, to avoid missing targets)
                    trackFaces(i) = 1;                              %Records position of distracter in this array
                    curFaceCount = curFaceCount + 1;                            %Indicates a face has been placed
                    trackColumn(columnCount) = trackColumn(columnCount) + 1;           %Indicates a face has been placed in the current column
                end
            end
        end
    end

%% Figure Creation
    nCount = 1;
    trackFaces = transpose(trackFaces); %Need to transpose the array, as matrices are read top to bottom, left to right; however subplot places images left to right, top to bottom
    figHandle = figure;
    set(figHandle,'color','w');
    spHandle = tight_subplot(yHigh,xWide,[(gap) (gap)]);
    for i = 1:(yHigh*xWide)           %For every position in the array, look up the value of trackfaces and select the appropriate image (if any)
        if trackFaces(i) ~= 0
            if trackFaces(i) == 1
                face = imgDistract;
            elseif trackFaces(i) == 2
                face = imgTarget;
            end
            if nCount == 1  %For some reason truesize doesn't kick in for the first image, so do it twice
                axes(spHandle(i)),imshow(face), truesize;
                set(spHandle, 'visible', 'off')
                nCount = 0;
            end
```

```
            axes(spHandle(i)),imshow(face), truesize; %Place the image into the figure (using subplot)
            set(spHandle, 'visible', 'off')
            nCount = 0;
        end
    end
    export_fig (strcat((directory),'_array', num2str(array))),'-nocrop';
    close(figHandle);
    waitbar(array/(xWide*yHigh))        %Updates the waitbar
end
delete(wbHandle)
%% Catch arrays

%Calculate how many faces in each column
facesPerColumn = round(totNFaces/xWide);

wbHandle = waitbar(1,'Creating catch arrays');
waitbar(0/100)

for array = 1:nCatchTrials
    curFaceCount = 0; %count of how many faces currently in the array
    rowCount = 0; %tracks which row the face is being placed in
    columnCount = 1; %tracks which column the face is being placed in
    trackColumn = zeros(1,xWide); %matrix counting how many faces in each column

    %{
    Keeps track of where faces have been placed in each array
    0s define no face
    1s define distracter
    %}
    trackFaces = zeros(yHigh,xWide);

    while curFaceCount < (facesPerColumn*xWide)     %While there are still spaces for faces
        for i = 1:(yHigh*xWide)                     %For each possible location in the array
            rowCount = rowCount + 1;                    %Faces are placed top to bottom, left to right
            if rowCount > yHigh                     %Reset rowCount after cycling through all rows
                rowCount = 1;
                columnCount = columnCount + 1;      %Move to the next coumn, after all rows have been cycled in previous column
                if columnCount > xWide
                    columnCount = 1;                %Once all columns have been cycled through, go back to the first column
                end
            end
            if trackFaces(i) == 0 && trackColumn(columnCount) < facesPerColumn        %If position empty and the max face count not reached in the column, attempt to place a face
```

```
            if randi(100) <= 50                                 %50 percent chance of placing a distracter (only after target has been placed, to avoid missing targets)
                trackFaces(i) = 1;                              %Records position of distracter in this array
                curFaceCount = curFaceCount + 1;                            %Indicates a face has been placed
                trackColumn(columnCount) = trackColumn(columnCount) + 1;            %Indicates a face has been placed in the current column
            end
        end
    end
end

%% Figure Creation
    nCount = 1;
    trackFaces = transpose(trackFaces); %Need to transpose the array, as matrices are read top to bottom, left to right; however subplot places images left to right, top to bottom
    figHandle = figure;
    set(figHandle,'color','w');
    spHandle = tight_subplot(yHigh,xWide,[(gap) (gap)]);
    for i = 1:(yHigh*xWide)             %For every position in the array, look up the value of trackfaces and select the appropriate image (if any)
        if trackFaces(i) ~= 0
            if trackFaces(i) == 1
                face = imgDistract;
            elseif trackFaces(i) == 2
                face = imgTarget;
            end
            if nCount == 1  %For some reason truesize doesn't kick in for the first image, so do it twice
                axes(spHandle(i)),imshow(face), truesize;
                set(spHandle, 'visible', 'off')
                nCount = 0;
            end
            axes(spHandle(i)),imshow(face), truesize; %Place the image into the figure (using subplot)
            set(spHandle, 'visible', 'off')
            nCount = 0;
        end
    end
    export_fig (strcat('catch', num2str(array))),'-nocrop';
    close(figHandle);
    waitbar(array/(xWide*yHigh))        %Updates the waitbar
end
delete(wbHandle)
```