A leftward bias for the arrangement of consumer items that differ in attractiveness

Paul Rodway* and Astrid Schepman

* Corresponding author

School of Psychology, University of Chester, Parkgate Road, Chester, Cheshire, CH1 4BJ, United Kingdom. Email: p.rodway@chester.ac.uk; a.schepman@chester.ac.uk

Telephone: 01244 511412

Abstract

People are frequently biased to use left side information more than right side information to inform their perceptual judgements. This research examined whether the leftward bias also applied to preferences for the arrangement of everyday consumer items. Pairs of consumer items were created where one item was more attractive than the other item. Using a two-alternative forced choice task, Experiment 1 found a robust preference for arrangements with the more attractive consumer item on the left side rather than the right side of a pair. Experiment 2 reversed the judgement decision, with participants asked to choose the arrangement they least preferred, and a bias for arrangements with the more attractive item on the right side emerged. Experiment 3 failed to find an effect of the 'attractive left' preference on participants' purchasing intentions. The preference for attractive left arrangements has implications for the display of consumer products and for the aesthetic arrangement of objects in general. The findings are discussed in relation to hemispheric asymmetries in processing and the role of left to right scanning.

Key words: Aesthetics; asymmetry; chimeric; lateralised; pseudoneglect.

Introduction

It would be reasonable to expect that when people judge an object for a particular visual attribute, such as its brightness or size, they use information from both sides of the object equally. However, this does not seem to be the case, with people often showing a bias to use the left side of the object more than the right side to inform their judgement. This leftward bias (LB) has been found for a range of perceptual judgements of different stimuli, suggesting it might be a general and fundamental aspect of perceptual processing. The aim of the research reported here was to understand the nature and generalisability of the LB, first by examining whether it applied to preferences for the arrangement of consumer items, and second, to test whether it influenced consumer purchasing intentions. It was expected that the findings would be relevant to enhancing the presentation of consumer items and to aesthetic preferences in general. However, while the findings are relevant to theoretical explanations of the LB, it was not the aim of this research to directly test those theories.

The LB is typically measured using a two-alternative forced choice task, where two equivalent (but transposed) versions of a stimulus are presented, with the relevant choice feature more prominent on the left side in one version and on the right side in the other version. Participants demonstrate a LB when they select the item with the choice feature strongest on the left side rather than the right side. The LB has been obtained with judgements of darkness, brightness, numerosity, size, and with letter cancellation and line bisection tasks where it has been termed pseudoneglect (Bowers & Heilman, 1980; Bradshaw, Nathan, Nettleton, Wilson, & Pierson, 1987; Charles, Sahraie, & McGeorge, 2007; Mattingley, Bradshaw, Nettleton, & Bradshaw, 1994; Nicholls & Roberts, 2002; Nicholls, Bradshaw, & Mattingley, 1999; Nicholls, Hobson, Petty, Churches, & Thomas,

2017; Worley & Boles, 2016). It has also frequently been obtained with chimeric emotional faces, which typically consist of a face with an emotional expression on one side and a neutral expression on the other side. A face with left side emotion is often perceived as expressing an emotion more strongly than a face with right side emotion (Bourne, 2010; Coolican, Eskes, McMullen, & Lecky, 2008; Innes, Burt, Birch, & Hausmann, 2016; Workman, Chilvers, Yeomans, & Taylor, 2006; Workman, Peters, & Taylor, 2000; Luh, Rueckert, & Levy, 1991).

Two leading explanations of the LB have been proposed, which are not necessarily mutually exclusive (Rinaldi, Di Luca, Henik, & Girelli, 2014; Smith, Duerksena, Gutwinb & Elias, 2019). The first is that the LB reflects hemispheric asymmetries in different aspects of perceptual processing. It is suggested that when the right hemisphere (RH) is specialised for a perceptual task it becomes more active, causing attention to be biased to the left hemifield, which results in the left side of an item, or left side of space, having greater importance in the perceptual judgement (Kinsbourne, 1970; Luh et al., 1991; Mattingley et al., 1994; Nicholls et al., 2017; Reuter-Lorenz, Kinsbourne, & Moscovitch, 1990; Spencer & Banich, 2005). This account is consistent with the substantial evidence pointing to the greater role of the RH in emotion perception (see Gainotti, 2019 for a review) and the size of the LB has been interpreted as a measure of the degree of RH specialization for perceiving an emotion (e.g. Coolican et al., 2008), although this reasoning is somewhat circular. In addition, the RH may be more specialised than the LH for other perceptual processes, such as symmetry and configuration (Boles & Karner, 1996; Bradshaw & Nettleton, 1981; Wright, Makin, & Bertamini, 2017). For this reason the hemispheric account could explain why a LB has been found for other perceptual judgements (Burt & Perrett, 1997; Chahboun et al., 2017; Luh et al., 1991; Worley & Boles, 2016).

A second explanation of the LB is that it is caused by a left to right (LTR) scanning direction, acquired from reading experience and present in populations who read left to right. Scanning LTR will cause left sided information to have priority during the judgement decision, potentially enabling participants to reach a judgement without scanning to the right side (Nicholls et al., 1999; Nicholls & Roberts, 2002). A number of studies have found that reading direction can determine the side bias, with LTR readers showing a LB and right to left (RTL) readers showing a right ward bias (RB) in a variety tasks (Chokron et al., 1998; Chokron and De Agostini 2000; Heath, Rouhana, & Abi Ghanem, 2005; Jewell & McCourt, 2000; Maass, Pagani, & Berta, 2007). However, a slight LB has also been found in illiterate participants (Heath et al., 2005) and in participants who habitually scan RTL if the direction of attention is controlled (Nicholls & Roberts, 2002).

Other research suggests that left-right asymmetries are a fundamental property of all species (Rogers, 2017) and originate from the lateralization of brain function (MacNeilage, Rogers, & Vallortigara, 2009; Ocklenburg & Gunturkun, 2012; Rogers & Vallortigara, 2015). For example, a leftward bias in the allocation of attention, similar to pseudoneglect in humans, is present in two-week old chicks and adult pigeons during food detection (Diekamp et al. 2005; Rugani, Vallortigara & Regolin, 2016), and rhesus monkeys and domestic dogs show a left looking bias for human faces (Guo, Meints, Hall, Hall, & Mills, 2008). Similarly, toads show left-right asymmetries, with a right side/hemifield bias during predatory behaviour and left side/hemifield bias during agonistic behaviour to conspecifics (Vallortigara, Rogers, Bisazza, Lippolis & Robins, 1998). Even left-right asymmetries that have been viewed as culturally acquired and specific to humans who read LTR, such as the mental number line (Zebian, 2005), have been found in RTL readers (Zohar-Shai, Tzelgov, Karni, & Rubinsten, 2017).

Evidence of a mental number line has also been obtained in 8-9 month old infants (Bulf, de Hevia, & Macchi-Cassia, 2016), one hour old human neonates (Di Giorgio et al., 2019), rhesus monkeys (Drucker & Brannon, 2014) and day old domestic chicks (Rugani, Vallortigara, Priftis, & Regolin, 2015). This research, by showing left-right asymmetries in non-human species, human neonates, and pre-linguistic human infants, where cultural learning and linguistic factors cannot be operating, points to a biological cause. In humans, it is probable that hemispheric specialisation and scanning direction both contribute to the LB (Nicholls & Roberts, 2002; see also Brodie & Pettigrew, 1996; Friedrich & Elias, 2016; Karlsson, Johnstone, & Carey, 2019; Nicholls et al., 2017; Rinaldi et al., 2014; Smith et al., 2019). Given the weight of evidence showing left-right asymmetries across species, it is possible that the LB in humans also has a biological origin. Asymmetries in aesthetic preference, however, such as the arrangement of tall or short persons (Chahboun, Flumini, González, McManus, & Santiago, 2016), may be more likely to be modulated by socio-cultural factors such as reading direction.

The majority of work that first examined the LB involved judgements of chimeric emotional faces or simple perceptual stimuli that varied by one feature. Other evidence now indicates that leftward biases are more widespread than previously identified, appearing for a broader range of decisions, including responses on Likert scales (Nicholls, Orr, Okubo, & Loftus, 2006) and a variety of aesthetic judgements. For example, abstract artworks and wallpaper patterns with a more attractive side and a less attractive side, are viewed as more attractive when the attractive side is on the left rather than the right (Rodway, Schepman, Crossley, & Lee, 2019; see also Calbi, et al., 2019). Moreover, LTR readers show a consistent preference for the lighting of pictures and paintings to be in an upper left position (Smith & Elias, 2019), and for portrait photographs with a left to right directionality (Chahboun, et al., 2016).

Portraits with the highest person on the left and lowest person on the right were preferred by LTR readers whereas RTL readers preferred the opposite arrangement (Chahboun, et al., 2016). Other forms of left to right directionality are also preferred in pictures, with a preference for salient objects in landscapes to be on the left and for movable objects to suggest a left to right movement (Chockron & De Agostini 2000; See Page, McManus, González, & Chahboun, 2017 for a review). Furthermore, goals scored in football are viewed as more beautiful by LTR readers if scored in a left to right direction whereas RTL readers show the opposite aesthetic appreciation (Maass et al. 2007).

In addition to leftward biases influencing aesthetic appreciation other research has obtained an effect on consumer decisions. Across seven studies Romero and Biswas (2016) found that displaying a healthy food option to the left of an unhealthy food option enhanced preference for the healthy option. Moreover, Dallas, Liu and Ubel (2019) found that calorie counts displayed on the left side of food menus were more influential compared to when they were displayed on the right side, causing a change in food choices and reducing calories ordered by 16% in one study. This finding was reversed in Hebrew speakers, indicating the role of scanning direction in causing the effect.

In summary, a body of research shows that information on the left carries more importance when judging facial emotions, visual features, aesthetic attributes, and choosing food options from a menu. Previous research showing a LB in aesthetic preference has been obtained for items that show a leftward directionality (in movement, size, placement, and illumination) or items with two sides of differing levels of attractiveness (Rodway et al, 2019). The current study extended Rodway et al.'s research by using the two-alternative forced choice task to examine, for the first time, whether the LB in attractiveness judgements applied to the

arrangement of two clearly separate and different objects, in this case consumer items. If a LB is present for the arrangement of two consumer items it would counter concerns that the LB in facial emotion perception is caused by the unnaturalness of chimeric stimuli, or the presence of a midline (see Innes et al., 2016). It may also allow the LB to be examined without the need to use specialised chimeric or grey scale stimuli, and have implications for the display of products in retailers and online. Moreover, the attractiveness of consumer items is determined by many cultural factors in addition to the way they look, being strongly influenced by trends in taste and branding (Eckman & Wagner, 1994; Fournier & Alverez, 2019; Spears, Brown, & Dacin, 2006). Consequently, the presence of a LB would strengthen the view that it reflects a judgment concerning the preferred arrangement of consumer items that differ in attractiveness, rather than a response to the basic perceptual attributes of individual items, such as their colour, size, or salience. Based on our previous findings, where abstract patterns were perceived as more attractive when the attractive side was on the left (Rodway et al. 2019), we expected the LB to generalise to preferences for the arrangement of consumer items. It was therefore predicted that for two consumer items, where one consumer item is more attractive than the other, an arrangement with the more attractive item on the left side would be preferred to an arrangement with the more attractive item on the right side.

Experiment 1

Method

Participants

G*Power was used to perform an a priori required sample size estimation for $\alpha = .05$, $1 - \beta = .95$, and $d = .8$, based on an expectation of a large effect size from Rodway et al. (2019) Experiment 3 (where $d = 1$), as that experiment bore the greatest resemblance to the current studies. This calculation yielded a sample size of 19, which we aimed to exceed slightly to account for the possibility of a minor discrepancy in actual effect size. We applied this same sample size estimation to all three studies reported here.

Twenty eight participants (26 females, 2 males), with a mean age of 21.43 (*SD* = 6.19, range 18 - 48), one of which was left handed (by self-report), were recruited from the student population at the University of Chester. They were recruited by opportunity sampling or by use of the department's "Participant Pool" (in the latter case, participation credit was awarded). All participants had normal, or corrected to normal vision. Ethical approval for the experiment, and subsequent experiments, was provided by the University of Chester psychology ethics committee and the researchers complied with British Psychological Society ethical guidelines.

Materials and Task

The two authors collated pictures of consumer items, belonging to particular categories, from a variety of online sources. These pictures were selected using the criteria that the items belonging to each category should vary in subjective attractiveness. During the selection some categories of consumer item were discounted (e.g. bicycles) because it was felt that the items did not have a sufficient range of attractiveness. This process resulted in a total of 42 colour pictures of consumer items, consisting of 15 chairs, 6 kettles, 12 training shoes, and 9 lampshades. These were then displayed in an online survey where participants rated the attractiveness of each consumer item on a 7 point Likert scale (where 1 = unattractive and 7 =

attractive). Thirty four participants (24 females, 9 males, and 1 non binary), with a mean age 26.5 years (*SD* = 13.94, range 18 - 69) completed the attractiveness rating survey. Two other participants withdrew before completing the survey and their data were not included.

From these ratings 12 attractive (mean rating = 3.91, range = 2.91 - 5.5) and 11 unattractive consumer items (mean rating = 1.74, range = 1.35 - 2.38) were selected. The attractive items were then paired with unattractive items of the same type, resulting in 32 pairs (9 pairs of chairs, lampshades, training shoes, and 5 pairs of kettles). Each pair was then transposed, creating a further 32 pairs, so that the attractive/unattractive item was equally often on the right and left. Each of the pairs was then combined to form stimuli consisting of 4 consumer items (see Figure 1), which were 16 cm wide and 17 cm high (642 x 685 pixels). Two versions of each combination were created, resulting in 64 stimuli in total, so that the consumer items in each pair were presented in each location equally often across the experiment. The stimuli and their attractiveness ratings can be viewed here: https://figshare.com/s/c8254fda19ad8ed24ef1

Figure 1. Example arrangement of the consumer items. This example does not show actual stimuli used in the experiment, which we are unable to show for copyright reasons. The stimuli are available in the supplementary materials.

Procedure

Each participant was tested individually using a desktop computer running E-prime software. The two-alternative forced choice task that has been used extensively to examine leftward biases was used. Prior to starting the experiment it was explained to each participant that they would be presented with two arrangements of consumer items, one above the other, and that they would be asked to choose the arrangement they preferred. An example arrangement was shown on paper to participants so that they understood how the stimuli would look before they began the experiment.

At the start of the task participants were then presented with the following instructions:
In the centre of the screen there will be a '+' which we would like you to look at. You will then be shown two consumer items side-by-side, in the same way that they might appear next

to each other in a shop or on a website. The consumer items will be arranged so that each item is either on the left or right. We would like to know which of two arrangements you prefer. If you prefer the top arrangement please press the 'k' and 'd' keys at the same time. If you prefer the bottom arrangement please press the 'm' and 'c' keys at the same time. There are no right or wrong answers we are only interested in your preferences.

On each trial a fixation cross (font 32) was presented in the centre of the screen for 1 second. This was then replaced by the two versions of the arrangement of consumer items, one above the other. The stimuli were removed when the participant responded and replaced by a pattern mask for 500 milliseconds, followed by the fixation cross, which signalled the start of the next trial. The order of presentation of the stimuli was randomized. Participants were asked to press both keys as their response, using the index finger of both hands, to control for any potential confound caused by a motor response from one hand. The stimuli were presented centrally and participants sat approximately 50 cm from the screen.

Results

A standard way of calculating the left side bias was used (see Nicholls et al., 1999; Nicholls & Roberts, 2002). First, participants' responses were categorised as either 'Left' or 'Right' depending on whether they selected the arrangement with the more attractive consumer item on the left or the right side, respectively. The measure of bias was then calculated using the following equation: Bias = ((Number of right responses – Number of left responses)/ Total number of responses), multiplied by 100. Negative scores reflected a left side bias and positive scores a right side bias. Bayes Factors (BF_{10}) were also generated using JASP (JASP team, 2019), to express the probability of the data occurring under the experimental

hypothesis relative to the null hypothesis. The data are available via the supplementary materials.

The mean leftward bias was – 45.77 (*SD* = 26.87) with 26 participants showing a leftward bias and 2 showing a rightward bias. A one sample t-test showed a robust leftward bias, $t(27) = -9.01$, $p < 0.001$; $d = 1.7$, $BF_{10} = 9.075e+6$, showing a clear preference for arrangements with the more attractive consumer item on the left side rather than the right, with the Bayes factor showing extreme evidence for the experimental hypothesis over the null hypothesis (Schönbrodt & Wagenmakers, 2018).

We also calculated the mean leftward bias for each attractive item (see Table 1) by calculating the ratio that it was chosen when on the left side. The LB across items ranged from -61 to -34, with the LB being of a similar strength across the different categories of consumer item. Of note is that some of the least colourful items (e.g. training shoe 2, lampshade 2) showed a LB that was equivalent to that of the average LB, indicating that the bias was not a product of item colourfulness.

Table 1. Mean LB for each attractive item and their attractiveness rating. Arranged in order of the size of the LB.

Item	Leftward Bias	Attractiveness
chair 3	-61	4.71
kettle 1	-57	4.50
training shoe 2	-52	4.09
lampshade 2	-51	3.85
kettle 2	-46	3.71
chair 1	-48	5.50

training shoe 1	-44	3.29
lampshade 3	-42	2.92
chair 2	-38	4.50
lampshade 1	-37	2.91
kettle 3	-36	4.06
training shoe 3	-34	2.91

Discussion

The results clearly showed that people prefer arrangements of consumer items with the more attractive item on the left side of a pair (henceforth referred to as the 'attractive left' arrangement). This LB was robust, with the attractive left arrangement chosen 72% of the time, on average. The size of the LB (-45) was similar to that obtained with grey scale stimuli (Nicholls et al., 1999), abstract patterns (Rodway et al., 2019), and facial emotions that have shown a strong LB, such as fear (Bourne, 2010). Moreover, it was larger than the LB obtained for the six basic emotions combined (-17, Innes et al. 2016) and the chimeric dot task (-29, Luh et al., 1991).

Some of the attractive items (e.g. lampshade 2) were not colourful but showed a similar sized LB as other more colourful stimuli. This suggests the LB was not an artefact of the colourfulness or salience of the consumer items when on the left. Rather, it seems to be determined by the subjective judgement of the attractiveness of the two items and their arrangement, with perceived attractiveness largely independent of colourfulness.

Experiment 2

Introduction

The results of Experiment 1 demonstrated a clear preference for attractive left arrangements. It remained possible, however, that the leftward bias was caused by an aspect of the perceptual properties of the stimuli (such as their salience, size, or colour), or by participants automatically selecting an attractive left item, without actually considering the arrangement of the two items together. To examine this question the second experiment reversed the choice decision that the participants were asked to make. Participants were now asked to choose the arrangement they least preferred.

If the LB was caused by a purely perceptual bias to select the pair with the more salient item on the left, then changing the decision task should have no effect and the same bias should emerge for least prefer choices. Similarly, if the LB was caused by participants automatically and unthinkingly selecting attractive items on the left, without judging the arrangement of both items, then the selection of attractive left arrangements should again emerge even though the choice decision was reversed. However, if it is the judgement of the preferred relationship between the two consumer items that causes the LB, there should now be a bias for the unattractive left arrangement, as this is the arrangement they should least prefer. Therefore, with a 'least prefer' decision we now expected the LB to be for the reversed arrangement (unattractive item on the left and attractive item on the right). This would show once again, but this time indirectly via a least prefer decision, that there is a preference for attractive left arrangements rather than attractive right arrangements.

Method

Participants

Twenty-five participants (21 females, 4 males), who had not participated in Experiment 1, were recruited from the student and staff population at the University of Chester. They had a mean age of 21.4 (*SD* = 3.81, range 19 - 37) and 3 were left handed (all female). Individuals were recruited by opportunity sampling or by use of the department's "Participant Pool" (in the latter case, participation credit was awarded). All participants had normal, or corrected to normal vision.

Materials and Task

The stimuli and task were the same as in Experiment 1 except that an additional kettle arrangement was used, resulting in 66 trials. One of the attractive kettles had not been paired with one of the unattractive kettles, so this arrangement was added to the experiment.

Procedure

The procedure was the same as Experiment 1 but the instructions were modified:

"We would like to know which of two arrangements you least prefer. If you least prefer the top arrangement please press the 'k' and 'd' keys at the same time. If you least prefer the bottom arrangement please press the 'm' and 'c' keys at the same time. There are no right or wrong answers we are only interested in your preferences."

Results

The side bias was calculated using the same equation as Experiment 1. Responses were now categorised as either 'Left' or 'Right' depending on whether they selected the arrangement with the **least** attractive consumer item on the left side or the right side, respectively. Negative scores reflected a left side bias and positive scores a right side bias.

Twenty four of the 25 participants showed a LB, more frequently choosing the unattractive left/attractive right arrangement as least preferred. The mean LB was -58.67 (SD = 35.61), showing a robust LB for least prefer arrangements. However, the presence of a RB in one participant caused the data not to be normally distributed. We therefore used a Wilcoxon test to analyse the data, which showed a significant leftward bias, $W = 14.5$, $p < 0.001$, $d = 1.65$, $BF_{10} = 1.435e+6$, with participants selecting the unattractive left arrangement as least preferred. The Bayes factor showed extreme evidence for the experimental hypothesis over the null hypothesis.

Discussion

When asked to select the arrangement they least preferred the participants showed a bias to choose the arrangement with the unattractive item on the left and the attractive item on the right. The results therefore indirectly confirmed those of Experiment 1 and show that there is a preference for left attractive arrangements. This result also strengthens the view that the bias was determined by a preference for this arrangement and not by particular visual attributes of the stimuli capturing attention and biasing responses, or by participants unthinkingly selecting attractive items on the left without considering the arrangement of both consumer items in a pair. There is a possibility that participants used a strategy of

identifying the preferred arrangement first and then reported the other least preferred arrangement. However, even if this strategy was used, the experiment still shows there is a preference for attractive left arrangements and that it does not seem to due to an automatic selection of the attractive item on the left.

Experiment 3

Introduction

Research has shown that the LB can influence consumer behaviour, increasing the selection of healthier or lower calorie foods (Romero & Biswas, 2016; Dallas et al., 2018). Experiment 3 examined whether the preference for attractive left arrangements influenced the intention to purchase consumer items. Participants were presented with pairs of consumer items that differed in attractiveness and asked to rate their likelihood of purchasing the more attractive item on a scale of 1 to 9. The more attractive consumer item was presented either on the left or right side of the pair. It was predicted that if the LB influenced purchasing intentions then the intention to purchase would be higher when the more attractive item was on the left side rather than the right side of an arrangement. In the event, however, this study showed support for the null hypothesis. While, in the past, it has been customary not to report null effects, in the context of the replication crisis and file drawer bias (Rosenthal, 1979), we felt it was important to report it, so that other researchers benefit from the information we acquired and to avoid undue distortions of the scientific record.

Method

Participants

Twenty five participants (22 females, 3 males) with a mean age of 21.24 (*SD* = 5.01, range 18 - 37) were recruited from the student and staff population at the University of Chester. Two participants were left handed (both female). Individuals were recruited by opportunity sampling or by use of the department's "Participant Pool" (in the latter case, participation credit was awarded). Two of the participants had previously participated in experiment 2, two and a half months prior to this experiment. All participants had normal, or corrected to normal vision.

Materials and Task

Twenty attractive consumer items (mean attractiveness rating = 3.77, consisting of 7 chairs, 3 kettles, 4 lampshades, and 6 training shoes) and 13 unattractive items (mean attractiveness = 1.91; consisting of 5 chairs, 2 kettles, 3 lampshades, 3 shoes) were selected from the set of pre-rated consumer items based on their levels of attractiveness. Attractive and unattractive items of the same type were then paired together, pseudo-randomly, to form 20 pairs, with some of the unattractive items pairing with more than one attractive item. Each pair was then transposed, forming 40 pairs in total, so that the attractive item was on the left and right side equally often. The pairs were 16 cm wide and 10 cm high (640 x 400 pixels). On each trial a pair of consumer items was presented with a bar marker beneath the attractive consumer item.

Procedure

Each participant was tested individually using a desktop computer running E-prime software. Prior to starting the experiment it was explained to participants that they would be presented with two consumer items side by side and that one consumer item would have a bar marker beneath it. They were told they would be asked to rate their likelihood of purchasing the item with the bar marker if money was not a concern and they had unlimited funds. An example arrangement was shown on paper to participants so that they understood how the stimuli would look before they began the task.

At the start of the task participants were then presented with the following instructions: *In the centre of the screen there will be a '+' which we would like you to look at. You will then be shown two consumer items side-by-side. One of the items will have a bar marker beneath it. We would like to know how likely it is you would purchase that item if the price is not an issue (e.g. if you imagine have unlimited funds). Please rate your likelihood on a scale of 1 to 9 (where 1 = extremely unlikely and 9 = extremely likely)*

On each trial, 1 second after the onset of the stimuli a bar marker appeared beneath the attractive consumer item and 4 cm beneath the bar marker the following instruction was presented: *Please rate your likelihood of purchasing the item on a scale of 1 to 9 (where 1 = extremely unlikely and 9 = extremely likely).* The bar marker always appeared beneath the attractive item of the pair. The participants were asked to use the numeric keypad to give their response to avoid any effects of a number line interacting with the left/right position of the consumer items. The stimuli were presented centrally and participants sat approximately 50 cm from the screen.

Results

The mean intention to purchase items (mean = 2.32) was relatively low on the 9 point scale and was similar when the attractive item was on the left side (mean = 2.29, *SD* = 0.6) or right side (mean = 2.35, *SD* = 0.64), being slightly higher for the right side.

A paired sample t-test showed no significant difference in the intention to purchase attractive items when they were on the left or right side of the pair, $t(24) = -1.25$, $p = 0.22$, $BF_{10} = 0.103$, with the Bayes factor showing moderate (close to strong) evidence for the null hypothesis (see Dienes, 2014, for a discussion on how the Bayes Factor can aid in the interpretations of non-significant results, allowing for disambiguation between type II errors and positive evidence for the null hypothesis).

Each consumer item that participants rated was presented twice, once on the left side and once on the right side, and it was possible that the participants' second response was strongly influenced by their first response, which eliminated any overall effect of side. Therefore, a paired samples t-test was conducted to examine whether there was a difference between sides for the first presentation of the consumer items. However, the mean intention to purchase items presented first on the left side did not differ significantly from those items presented first on the right side, $t(24) = .41$, $p = .34$, $BF_{10} = 0.296$ (one tailed) (mean left side first = 2.39, mean right side first = 2.31). Again, there was no evidence that the side influenced purchasing intentions.

Discussion

There was no evidence that the LB, obtained in Experiments 1 and 2, influenced the intention to purchase the consumer items in this task. Other studies have found an effect of a LB on consumer choices, particularly for food, and it remains to be seen whether a LB influences consumer behaviour in other contexts.

There are several possible reasons why the LB did not affect purchasing intentions. It was apparent that, on average, purchasing intentions were generally low, suggesting that the items were not particularly desirable to participants, even though they had previously been rated as attractive. Occasionally, during debrief, participants reported that they had liked an item but would not have purchase it because they did not need it. The LB may influence purchasing behaviour when the intention to purchase is much stronger, such as when people are choosing food from a menu that they are going to eat and when a comparison is being made between possible options (e.g. Romero & Biswas, 2016). Another possibility is that the forced choice preference task used in Experiments 1 and 2, with two options, is a more sensitive measure of underlying biases when they exist. In that task, the only difference between the two options is the arrangement, which could focus attention on it and influence the choice. In contrast, ratings of purchasing intentions will be strongly influenced by the desirability of the item, which could overshadow any effect of a leftward arrangement (see Chahboun et al., 2017 for a similar interpretation of their results).

General Discussion

This research set out to explore whether the LB was a pervasive phenomenon that generalised to the arrangement of everyday consumer items that differed in attractiveness. The results of Experiments 1 and 2 confirmed that this was the case, showing for the first time that there is a

robust preference for arrangements with the more attractive consumer item on the left side. The preference was present for different types of consumer item and the findings add to the growing body of work showing that LBs are present for a broad range of perceptual judgements. Moreover, a novel aspect of the current research is the finding that a strong LB can be obtained with pictures of pairs of consumer items, rather than carefully constructed chimeric stimuli. This finding potentially makes it easier to study the LB and to manipulate the properties of each item in a pair (e.g. attractiveness, intensity, colour, value, size, etc.), so that leftward biases for other judgement features can be examined. Consequently, the use of pairs of items might enable a deeper understanding of the LB.

The results are also consistent with other work showing a LB for aesthetic judgements (e.g. Calbi, et al., 2019; Chahboun et al., 2017; Smith & Elias, 2019; Smith et al., 2019). In the present study the participants were asked to make a preference judgement rather than an attractiveness judgement and item attractiveness was not directly referred to. However, as item attractiveness and the arrangement determined choice, participants appear to be demonstrating an aesthetic preference for attractive left arrangements. The findings therefore suggest that even when participants are not explicitly asked to consider attractiveness, aesthetic biases concerning the arrangement of items can determine preferences. Based on the current findings we expect the attractive left preference to generalise to many other stimuli that can differ in attractiveness, including objects, buildings, and the judgement of people.

While many studies have attempted to identify the cause of the LB (Mattingley et al., 1994; Nicholls et al., 2017), this question has not been definitively resolved, and it is probable that both hemispheric and scanning direction processes are involved (see Friedrich & Elias, 2016 for an interactive explanation incorporating hemispheric and reading processes). Leftward

biases for aesthetic judgements have sometimes been interpreted as evidence of the RH's greater specialisation in perceptual and aesthetic processing (e.g. Calbi et al., 2019; see also Rodway et al., 2019). Other studies, that have tested leftward biases for aesthetic preferences in participants with different reading directions, have found that in RTL readers the LB is either eliminated or reverses to become a rightward bias (Chahboun, et al., 2017; Friedrich & Elias, 2016; Rinaldi, et al., 2014; Smith, & Elias, 2019; Smith et al., 2019). This influence of reading direction suggests that it may be an important underlying cause of the LB in aesthetic preferences.

Left to right scanning on its own, however, does not explain why there should be a preference for attractive left arrangements. To explain left to right directionality preferences in photographs Chahboun et al. (2017) suggested that it could be due to perceptual fluency, which is the ease with which a picture is processed (Reber et al., 2004), with easier processing leading to enhanced aesthetic appreciation (Khaw, Nichols, & Freedberg, 2019). Chahboun et al. proposed that left to right compositions may be more congruent with typical scanning patterns and therefore have greater perceptual fluency and aesthetic appeal. A similar aesthetic preference could also occur for pictures that depict movement (e.g. Chokron & De Agousti, 2000), and for moving images (Maass et al., 2007), with left to right scanning being congruent with the left to right directionality of the picture or moving image.

For the current findings, a perceptual fluency explanation does not seem to apply because it is not clear why an attractive left arrangement should be more perceptually fluent than the alternative arrangement. One possibility is that the preference is caused by an effect of item order, when scanning sequentially from LTR, and the importance of the first item (Carney & Banaji, 2012). Evidence indicates that there is a heuristic bias for the first item in a sequence

to be regarded as the best option (Carney & Banaji, 2012). If this is the case, scanning the attractive consumer item first and an unattractive item second may be compatible with a pre-existing 'first is best' preference whereas scanning an unattractive item first, and an attractive item second, may be incongruent with that preference. Therefore a LTR scanning account, in conjunction with a 'first is best' bias, could explain why the attractive left /unattractive right arrangement is preferred (Experiment 1), whereas an unattractive left / attractive right arrangement is least preferred (Experiment 2). This explanation, by emphasising the sequential nature of reaching a choice, is also compatible with research showing that leftward biases can occur with sequentially presented stimuli (Li, Li, Wang, & Cao, 2018; see also Mitsuda, Luo, & Wang, 2019, for the effects of touch on sequential choice).

A hemispheric specialisation account could also explain the current findings and is compatible with biologically determined left-right asymmetries in other species. This theory would propose that the process of making a perceptual preference judgement activates the RH and biases attention to the left side of space / left consumer item (Mattingley et al., 1994; Nicholls et al., 2017; Spencer & Banich, 2005). The same process would occur for both prefer and least prefer choices and cause the left item to bias the choice. For example, if attention is preferentially directed to the two leftward consumer items of each pair, and the judgement decision is 'which arrangement do you prefer', this leftward focus may bias the participant to select the more attractive item, and the pair that the attractive item belongs to. Similarly, if the judgement decision is for the least preferred arrangement, a leftward attentional focus could bias participants to select the least attractive item on the left, and the arrangement that it belongs to. An equivalent process could also occur because of LTR scanning, rather than for hemispheric reasons, with an initial focus on the left items biasing the choice. Therefore, as has been the case with other research into the LB, both accounts are

able to explain these results, and evidence in favour of one explanation may only become available when similar experiments are conducted with right-to-left readers, or if equivalent left-right asymmetries are found with non-human species, as has been the case with the mental number line (Rugani, et al., 2016).

The present study was a preliminary examination into leftward biases for the judgement of everyday items and several questions remain to be investigated. One limitation was the much greater number of female than male participants, suggesting caution before generalising the findings to both sexes. However, we are not aware of any evidence which shows that similar leftward biases are sex specific, and each male participant showed a strong LB in line with the results of each experiment, which indicates that the findings may also apply to males. A further limitation is that the LB may not have influenced purchasing intentions in Experiment 3, because of a floor effect in intentions, or because an actual purchase involving direct comparisons was not being made. In future, the influence of the attractive left preference on consumer behaviour can be examined in more realistic settings, such as when consumers view products in stores or online and when they make real purchases (e.g. Romero & Biswas, 2016; Dallas et al., 2018). Based on the findings of experiments 1 and 2, for arrangements consisting of two consumer items, it would seem to be a good strategy for sellers to place the 'best' consumer item on the left, as this will be preferred by consumers. In other circumstances, where multiple consumer items of similar quality are displayed, items placed centrally tend to be preferred and chosen (Christenfeld, 1995; Rodway, Schepman, & Lambert, 2012; Shaw, Bergen, Brown, & Gallagher, 2000).

A notable difference between the central preference, the LB, and other left-right asymmetries, is that (as far as we are aware) the central preference has only been shown in humans whereas

functional asymmetries are frequently observed in other species (Rogers & Vallortigara, 2015). This could be because the central preference and left-right asymmetries have different causes. The central preference might be caused by a decision heuristic, reflecting the cultural belief that the item in the middle is the best (Kreplin, Thoma, & Rodway, 2014), whereas many left-right functional asymmetries have a biological origin (Rogers, 2017). An important test of the heuristic account of the central preference would be whether it is also present in other species.

In summary, the results show that when two consumer items differ in attractiveness there is a preference for attractive left arrangements. This preference also has widespread implications for the presentation of options and products, both online and in shops, and its influence on consumer behaviour and other forms of choice remain to be fully explored. We expect that similar leftward biases will be discovered for many other objects that differ in attractiveness and for other types of aesthetic judgement.

References

Boles, D. B., & Karner, T. A. (1996). Hemispheric differences in global versus local processing: Still unclear. *Brain and Cognition*, *30*(2), 232-243. https://doi.org/10.1006/brcg.1996.0015

Bourne, V. J. (2010). How are emotions lateralised in the brain? Contrasting existing hypotheses using the chimeric faces test. *Cognition and Emotion*, 24(5), 903–911. https://doi.org/10.1080/02699930903007714

Bowers, D., & Heilman, K. M. (1980). Pseudoneglect: Effects of hemispace on a tactile line bisection task. *Neuropsychologia*, 18(4), 491–498. https://doi.org/10.1016/0028-3932(80)90151-7

Bradshaw, J. L., & Nettleton, N. C. (1981). The nature of hemispheric specialization in man. *Behavioral and Brain Sciences*, 4(01), 51–63. https://doi.org/10.1017/S0140525X00007548

Bradshaw, J. L., Nathan, G., Nettleton, N. C., Wilson, L., & Pierson, J. (1987). Why is there a left side underestimation in rod bisection? *Neuropsychologia*, 25(4), 735–738. https://doi.org/10.1016/0028-3932(87)90067-4

Brodie, E. E., & Pettigrew, L. E. (1996). Is left always right? Directional deviations in visual

line bisection as a function of hand and initial scanning direction. *Neuropsychologia*, 34(5), 467–470. https://doi.org/10.1016/0028-3932(95)00130-1

Bulf, H., de Hevia, M. D., & Macchi Cassia, V. (2016). Small on the left, large on the right: Numbers orient visual attention onto space in preverbal infants. Developmental Science, 19(3), 394-401. https://doi.org/10.1111/desc.12315

Burt, D. M., & Perrett, D. I. (1997). Perceptual asymmetries in judgements of facial attractiveness, age, gender, speech and expression. *Neuropsychologia*, 35, 685–693. https://doi.org/1016/S0028-3932(96)00111-X

Calbi, M., Aldouby, H., Gersht, O., Langiulli, N., Gallese, V., & Umiltà, M. A. (2019). Haptic aesthetics and bodily properties of Ori Gersht's digital art: a behavioral and eye-tracking study. *Frontiers in Psychology*, *10*, 2520. https://doi.org/10.3389/fpsyg.2019.02520

Carney, D. R., & Banaji, M. R. (2012). First is best. *PloS one*, *7*(6), e35088. https://doi.org/10.1371/journal.pone.0035088

Chahboun, S., Flumini, A., Pérez González, C., McManus, I. C., & Santiago, J. (2017). Reading and writing direction effects on the aesthetic appreciation of photographs. *Laterality: Asymmetries of Body, Brain and Cognition*, *22*(3), 313-339. https://doi.org/10.1080/1357650X.2016.1196214

Charles, J., Sahraie, A., & McGeorge, P. (2007). Hemispatial asymmetries in judgment of

stimulus size. *Perception & Psychophysics*, 69(5), 687–698. https://doi.org/10.3758/BF03193771

Chokron, S., Bartolomeo, P., Perenin, M. T., Helft, G., & Imbert, M. (1998). Scanning direction and line bisection: A study of normal subjects and unilateral neglect patients with opposite reading habits. *Cognitive Brain Research*, 7(2), 173–178. https://doi.org/10.1016/S0926-6410(98)00022-6

Chokron, S., & De Agostini, M. (2000). Reading habits influence aesthetic preference. *Cognitive Brain Research*, 10(1-2), 45-49. https://doi.org/10.1016/S0926-6410(00)00021-5

Christenfeld, N. (1995). Choices from identical options. *Psychological Science*, 6, 50–55. https://doi.org/10.1111/j.1467-9280.1995.tb00304.x

Coolican, J., Eskes, G. A., McMullen, P. A., & Lecky, E. (2008). Perceptual biases in processing facial identity and emotion. *Brain and Cognition*, *66*(2), 176-187. https://doi.org/10.1016/j.bandc.2007.07.001

Dallas, S. K., Liu, P. J., & Ubel, P. A. (2019). Don't count calorie labeling out: Calorie counts on the left side of menu items lead to lower calorie food choices. *Journal of Consumer Psychology*, *29*(1), 60-69. https://doi.org/10.1002/jcpy.1053

Diekamp, B., Regolin, L., Güntürkün, O., & Vallortigara, G. (2005). A left-sided visuospatial bias in birds. *Current Biology*, *15*(10), R372-R373. https://doi:10.1016/j.cub.2005.05.017

Dienes, Z. (2014). Using Bayes to get the most out of non-significant results. *Frontiers in Psychology*, *5*, 781. https://doi.org/10.3389/fpsyg.2014.00781

Di Giorgio, E., Lunghi, M., Rugani, R., Regolin, L., Dalla Barba, B., Vallortigara, G., & Simion, F. (2019). A mental number line in human newborns. *Developmental science*, *22*(6), e12801. https://doi.org/10.1111/desc.12801

Drucker, C. B., & Brannon, E. M. (2014). Rhesus monkeys (Macaca mulatta) map number onto space. *Cognition*, *132*(1), 57-67. https://doi.org/10.1016/j.cognition.2014.03.011

Eckman, M., & Wagner, J. (1994). Judging the attractiveness of product design: the effect of visual attributes and consumer characteristics. In: Allen, Chris T, John, Deborah Roedder (Eds.), NA - *Advances in Consumer Research* Volume 21. Association for Consumer Research, Provo, UT, pp. 560–564.

Fournier, S., & Alvarez, C. (2019). How Brands Acquire Cultural Meaning. *Journal of Consumer Psychology*, *29*(3), 519-534. https://doi.org/10.1002/jcpy.1119

Friedrich, T. E., & Elias, L. J. (2016). The write bias: The influence of native writing direction on aesthetic preference biases. *Psychology of Aesthetics, Creativity, and the Arts*, *10*(2), 128. https://doi.org/10.1037/aca0000055

Guo, K., Meints, K., Hall, C., Hall, S., & Mills, D. (2009). Left gaze bias in humans, rhesus monkeys and domestic dogs. *Animal cognition*, *12*(3), 409-418. https://doi.org/10.1007/s10071-008-0199-3

Gainotti, G. (2019). Emotions and the right hemisphere: can new data clarify old models? *The Neuroscientist*, *25*(3), 258-270. https://doi.org/10.1177/1073858418785342

Heath, R., Rouhana, A., & Abi Ghanem, D. (2005). Asymmetric bias in perception of facial affect among Roman and Arabic script readers. *Laterality: Asymmetries of Body, Brain and Cognition*, 10(1), 51–64. https://doi.org/10.1080/13576500342000293

Innes, B., Burt, D. M., Birch, Y. K., & Hausmann, M. (2016). A leftward bias however you look at it: Revisiting the emotional chimeric face task as a tool for measuring emotion lateralization. *Laterality: Asymmetries of Body, Brain and Cognition*, 21(4-6), 643-661. https://doi:10.1080/1357650X.2015.1117095

JASP Team (2019). JASP (Version 0.11.1) [Computer software]. https://jasp-stats.org/

Jewell, G., & McCourt, M. E. (2000). Pseudoneglect: a review and meta-analysis of performance factors in line bisection tasks. *Neuropsychologia*, *38*(1), 93-110. https://doi.org/10.1016/S0028-3932(99)00045-7

Karlsson, E. M., Johnstone, L. T., & Carey, D. P. (2019). The depth and breadth of multiple perceptual asymmetries in right handers and non-right handers. *Laterality: Asymmetries of Body, Brain and Cognition*, *24*(6), 707-739. https://doi.org/10.1080/1357650X.2019.1652308

Khaw, M. W., Nichols, P., & Freedberg, D. (2019). Speed of person perception affects immediate and ongoing aesthetic evaluation. *Acta psychologica*, *197*, 166-176. https://doi.org/10.1016/j.actpsy.2019.05.006

Kinsbourne, M. (1970). The cerebral basis of lateral asymmetries in attention. *Acta Psychologica*, 33, 193–201. https://doi.org/10.1016/0001-6918(70)90132-0

Kreplin, U., Thoma, V., & Rodway, P. (2014). Looking behaviour and preference for artworks: The role of emotional valence and location. *Acta psychologica*, *152*, 100-108. https://doi.org/10.1016/j.actpsy.2014.08.003

Li, C., Li, Q., Wang, J., & Cao, X. (2018). Left-side bias is observed in sequential matching paradigm for face processing. *Frontiers in psychology*, *9*, 2005. https://doi.org/10.3389/fpsyg.2018.02005

Luh, K. E., Rueckert, L. M., & Levy, J. (1991). Perceptual asymmetries for free viewing of several types of chimeric stimuli. *Brain and Cognition*, 16(1), 83–103. https://doi.org/10.1016/0278-2626(91)90087-O

Maass, A., Pagani, D., & Berta, E. (2007). How beautiful is the goal and how violent is the fistfight? Spatial bias in the interpretation of human behavior. *Social Cognition*, *25*(6), 833-852. https://doi.org/10.1521/soco.2007.25.6.833

MacNeilage, P. F., Rogers, L. J., & Vallortigara, G. (2009). Origins of the left & right brain. *Scientific American*, *301*(1), 60-67.

Mattingley, J. B., Bradshaw, J. L., Nettleton, N. C., & Bradshaw, J. A. (1994). Can task specific perceptual bias be distinguished from unilateral neglect?. *Neuropsychologia*, *32*(7), 805-817. https://doi.org/10.1016/0028-3932(94)90019-1

Mitsuda, T., Luo, J., & Wang, Q. (2019). Exploratory Hand Movements Enhance the Liking Effect in Haptics. *Perception*, 48(9), 850-861. https://doi.org/10.1177/0301006619864483

Nicholls, M. E., Bradshaw, J. L., & Mattingley, J. B. (1999). Free-viewing perceptual asymmetries for the judgement of brightness, numerosity and size. *Neuropsychologia*, 37(3), 307–314. https://doi.org/10.1016/S0028-3932(98)00074-8

Nicholls, M. E., Orr, C. A., Okubo, M., & Loftus, A. (2006). Satisfaction guaranteed: the effect of spatial biases on responses to Likert scales. *Psychological Science*. https://doi.org/10.1111/j.1467-9280.2006.01822.x

Nicholls, M. E., Hobson, A., Petty, J., Churches, O., & Thomas, N. A. (2017). The effect of cerebral asymmetries and eye scanning on pseudoneglect for a visual search task. *Brain and Cognition*, 111, 134–143. https://doi.org/10.1016/j.bandc.2016.11.006

Ocklenburg, S., & Gunturkun, O. (2012). Hemispheric asymmetries: the comparative view. *Frontiers in psychology*, *3*, 5. https://doi.org/10.3389/fpsyg.2012.00005

Page, A. G., McManus, C., González, C. P., & Chahboun, S. (2017). Is beauty in the hand of the writer? Influences of aesthetic preferences through script directions, cultural, and

neurological factors: a literature review. *Frontiers in psychology*, *8*, 1325. https://doi.org/10.3389/fpsyg.2017.01325

Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience? *Personality & Social Psychology Review*, 8, 364–382 https://doi.org/10.1207/s15327957pspr0804_3

Reuter-Lorenz, P. A., Kinsbourne, M., & Moscovitch, M. (1990). Hemispheric control of spatial attention. *Brain and Cognition*, 12(2), 240–266. https://doi.org/10.1016/0278-2626(90)90018-J

Rinaldi, L., Di Luca, S., Henik, A., & Girelli, L. (2014). Reading direction shifts visuospatial attention: An Interactive Account of attentional biases. *Acta psychologica*, *151*, 98-105. https://doi.org/10.1016/j.actpsy.2014.05.018

Rodway, P., Schepman, A., & Lambert, J. (2012). Preferring the One in the Middle: Further Evidence for the Centre-stage Effect. *Applied Cognitive Psychology*, *26*(2), 215-222. https://doi.org/10.1002/acp.1812

Rodway, P., Schepman, A., Crossley, B. & Lee, J. (2019) A leftward perceptual asymmetry when judging the attractiveness of visual patterns. *Laterality: Asymmetries of Body, Brain and Cognition*, *24*(1), 1-25. https://doi.org/10.1080/1357650X.2018.1461897

Rogers, L. J. (2017). A matter of degree: Strength of brain asymmetry and behaviour. *Symmetry*, 9(4), 57. https://doi.org/10.3390/sym9040057

Rogers, L. J., & Vallortigara, G. (2015). When and why did brains break symmetry?. Symmetry, 7(4), 2181-2194. https://doi.org/10.3390/sym7042181

Romero, M., & Biswas, D. (2016). Healthy-left, unhealthy-right: can displaying healthy items to the left (versus right) of unhealthy items nudge healthier choices?. *Journal of Consumer Research*, *43*(1), 103-112. https://doi.org/10.1093/jcr/ucw008

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological bulletin*, *86*(3), 638. http://dx.doi.org/10.1037/0033-2909.86.3.638

Rugani, R., Vallortigara, G., Priftis, K., & Regolin, L. (2015). Number-space mapping in the newborn chick resembles humans' mental number line. *Science*, *347*(6221), 534-536. https://DOI:10.1126/science.aaa1379

Rugani, R., Vallortigara, G., & Regolin, L. (2016). Mapping number to space in the two hemispheres of the avian brain. *Neurobiology of learning and memory*, *133*, 13-18. https://doi.org/10.1016/j.nlm.2016.05.010

Schönbrodt, F. D., & Wagenmakers, E. J. (2018). Bayes factor design analysis: Planning for compelling evidence. *Psychonomic bulletin & review*, *25*(1), 128-142. https://doi.org/10.3758/s13423-017-1230-y

Shaw, J. I., Bergen, J. E., Brown, C. A., & Gallagher, M. E. (2000). Centrality preferences in choices among similar options. *The Journal of General Psychology, 127*, 157–164. https://doi.org/10.1080/00221300009598575

Smith, A. K., & Elias, L. J. (2019). Native reading direction modulates eye movements during aesthetic preference and brightness judgments. *Psychology of Aesthetics, Creativity, and the Arts, 13*(4), 482-488. http://dx.doi.org/10.1037/aca0000184

Smith, A. K., Duerksen, K. N., Gutwin, C., & Elias, L. J. (2019). Lateral biases in aesthetic and spatial location judgments: differences between tasks and native reading directions. *Laterality: Asymmetries of Body, Brain and Cognition*, 1-17. https://doi.org/10.1080/1357650X.2019.1577433

Spears, N., Brown, T. J., & Dacin, P. A. (2006). Assessing the corporate brand: The unique corporate association valence (UCAV) approach. *Journal of Brand Management, 14*(1-2), 5-19. https://doi.org/10.1057/palgrave.bm.2550051

Spencer, K. M., & Banich, M. T. (2005). Hemispheric biases and the control of visuospatial attention: An ERP study. *BMC Neuroscience*, 6(1), 51. https://doi.org/10.1186/1471-2202-6-51

Vallortigara, G., Rogers, L. J., Bisazza, A., Lippolis, G., & Robins, A. (1998). Complementary right and left hemifield use for predatory and agonistic behaviour in toads. *NeuroReport*, 9(14), 3341-3344.

Workman, L., Chilvers, L., Yeomans, H., & Taylor, S. (2006). Development of cerebral lateralisation for recognition of emotions in chimeric faces in children aged 5 to 11. *Laterality: Asymmetries of Body, Brain and Cognition*, 11(6), 493–507. https://doi.org/10.1080/13576500600724963

Workman, L., Peters, S., & Taylor, S. (2000). Lateralisation of perceptual processing of pro- and anti-social emotions displayed in chimeric faces. *Laterality: Asymmetries of Body, Brain and Cognition*, 5(3), 237–249. https://doi.org/10.1080/713754378

Worley, M. M., & Boles, D. B. (2016). The face is the thing: Faces, not emotions, are responsible for chimeric perceptual asymmetry. *Laterality: Asymmetries of Body, Brain and Cognition*, 21, 672–688. https://doi.org/10.1080/1357650X.2015.1136319

Wright, D., Makin, A. D., & Bertamini, M. (2017). Electrophysiological responses to symmetry presented in the left or in the right visual hemifield. *Cortex*, *86*, 93-108. https://doi.org/10.1016/j.cortex.2016.11.001

Zebian, S. (2005). Linkages between number concepts, spatial thinking, and directionality of writing: The SNARC effect and the reverse SNARC effect in English and Arabic monoliterates, biliterates, and illiterate Arabic speakers. *Journal of Cognition and Culture*, *5*(1-2), 165-190. https://doi.org/10.1163/1568537054068660

Zohar-Shai, B., Tzelgov, J., Karni, A., & Rubinsten, O. (2017). It does exist! A left-to-right spatial–numerical association of response codes (SNARC) effect among native Hebrew

speakers. *Journal of Experimental Psychology: Human Perception and Performance*, *43*(4), 719. https://doi.org/10.1037/xhp0000336