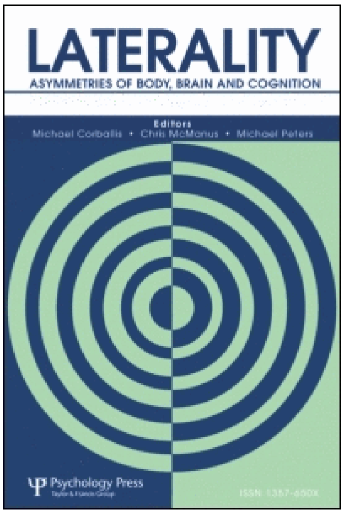

Laterality: Asymmetries of Body, Brain and Cognition
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713683105

Lateral biases in lighting of abstract artwork

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First published on: 09 June 2010

To cite this Article McDine, David A. , Livingston, Ian J. , Thomas, Nicole A. and Elias, Lorin J.(2010) 'Lateral biases in lighting of abstract artwork', Laterality: Asymmetries of Body, Brain and Cognition,, First published on: 09 June 2010 (iFirst)

To link to this Article: DOI: 10.1080/13576500903548382
URL: http://dx.doi.org/10.1080/13576500903548382

LATERALITY, 0000, 00 (00), 1–12

Psychology Press
Taylor & Francis Group

Lateral biases in lighting of abstract artwork

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Previous studies examining perceptual biases in art have revealed that paintings tend to be lit from above and to the left. Abstract images provide a way of testing for the left-light bias while controlling for cues such as posing biases, ground line, shadows, and reflections. A total of 42 participants completed a task that required moving a "virtual flashlight" across the surface of abstract images presented on a computer screen: 20 images (presented both right-side-up and upside down) were used in the study. The participant's only instruction was to "light the painting in a way that is most aesthetically pleasing to you". As predicted, participants on average focused the "virtual flashlight" in the top left quadrant. This study reveals that lateral lighting biases in artwork are not dependent on perception of local light source or interactions with discrete, concrete visual representations in the artwork.

Keywords: Abstract; Art; Flashlight; lighting; lateral bias.

The human perceptual system utilises several implicit assumptions that allow us to see the world the way we do. One such assumption, which was originally noted by Gmelin at the Royal Society of London in 1744, is that light tends to come from above (Elias & Robinson, 2005). The sun is the most common light source. Aside from a sunset viewed from the top of a

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Thank you to all of the individuals in both the Psychology and Computer Science departments at the University of Saskatchewan for providing much-needed feedback and support for the entirety of the project.

http://www.psypress.com/laterality DOI: 10.1080/13576500903548382

mountain or the reflection off water or snow, light is consistently positioned above us (McManus, Buckman, & Woolley, 2004).

This "light-from-above" prior impacts to how we interpret convexities and concavities. Berbaum, Bever, and Chung's (1983) study in which participants were asked to determine whether a muffin tray was presented with the protuberances or indentations facing them provided evidence that people's interpretation of depth cues (i.e., shadows) is reliant on implicit assumptions about light source position. Further evidence is provided by studies involving target detection and shape judgement tasks, including Ramachandran (1988), Sun and Perona (1998), Mamassian and Goutcher (2001), and Adams (2007). More specifically, these studies demonstrated that people interpret dents as concave when light is positioned below and convex when light is positioned above.

It has also been suggested that humans do not assume light to be positioned directly above, but rather slightly left of overhead. This was first noted by Wolfgang Metzger (1936) using a photograph of a fossil ammonite. It was found that, by reversing the photograph, the convexities of the original now appeared as concavities, and vice-versa, providing evidence that light from the left is not perceptually equivalent to light from the right. Furthermore, Mamassian, Jentzsch, Bacon, and Schweinberger (2003), examining event-related potentials during a task in which participants were forced to decide whether the presented stimulus contained narrow or wide relief strips, found that the assumption that light is coming from the above left, which influences how we infer shape from shading, is represented early on in the visual system.

A left-light bias has also been observed in paintings and advertisements. Sun and Perona (1998) found that 77% of 225 master paintings were lit from the left. In addition, McManus (1979) found a similar leftward lighting bias for Byzantine and Italian Renaissance paintings. Regarding advertisements, an experiment conducted by Thomas, Burkitt, Patrick, and Elias (2008) sampled 2801 full-page advertisements from seven different magazines, and coded posing and lighting direction. Overall, they found that images tend to be lit from the top left corner and that the two factors of posing and lighting seem to interact. Left-lit images had more leftward poses than rightward and the opposite effect was seen for right-lit images.

Examining how photographs are compositionally framed has provided further evidence for a left-light bias. Kobayashi, Itoh, Suzuki, Kwee, and Nakada (2007) analysed photographs under three conditions: (1) daytime photographs taken outside without determination of frame composition, (2) daytime photographs taken with determination of frame composition, and (3) photographs taken inside with determination of frame composition. It was found that there was a consistent leftward tilt of 2 to 9 degrees for pictures in categories (2) and (3), but not for (1), thus providing evidence that there is indeed a natural preference for a leftward bias in luminosity for frame composition.

Advertisements, portraits, and photographs present a problem for examining the leftward light bias in that posing biases interact with the lighting bias, as demonstrated by Thomas et al. (2008). Therefore it is difficult to determine whether the preference for one picture over another is due to the positioning of the person in the picture or the fact that it is lit from the left. Landscapes present a different problem when examining left-light biases in that they already supply the ecological backdrop to place the light source in a particular position. The inclusion of a ground line limits where the light source should come from, considering that no reasonable person would place the light source anywhere but the sky. In addition, visual cues such as shadows and reflections provide explicit hints as to whether the light source (sun) should be placed in either the left or right half of the picture.

Examining abstract paintings removes potentially confounding factors associated with portraits and landscape paintings, including interactions with posing biases and the perceptual hints provided by the horizon line and shadows. Furthermore, abstracts have the advantage of not having to render specific forms. Aesthetic preference with portraits and landscapes is often based on some form within the painting. For example, the image of a tree or position of a body may elicit a positive or negative emotional response. Aesthetic preference with abstracts, on the other hand, is based entirely on an image's ability to elicit an emotional response despite a lack of concrete forms. The intended emotional response is not constrained by form and may be tied to the colour, line, or complexity of a painting.

In an interesting study involving the aesthetic value of abstract paintings, Konecni (1984) examined whether an audience was responding perceptually, cognitively, and emotionally in the way that the artist (or critic) expected. Given that the natural orientation is not obvious from the content of the painting, he attempted to determine whether the "message" would be lost if the painting was mirror reversed, or rotated 90 or 180 degrees. Each participant saw a painting only once, in either the correct orientation or the altered orientation. Participants rated the painting's pleasingness, interestingness, balance, and emotional impact, appropriateness of title, and their willingness to buy a reproduction on a 20-cm scale. Interestingly, original orientations were not overwhelmingly preferred, with mirror reversal and alteration of orientation resulting in negligible mean differences.

As in the current study, Konecni (1984) was concerned with choosing abstract images that did not have elements of either portraits or landscapes, considering that the natural orientation of those images would have been obvious. For example, while Willem De Kooning's "Woman V" (1952) is often classified as abstract expressionist, it also contains a human figure and has a ground line, which constrain it to a particular orientation, and thereby fails to eliminate the previously discussed confounds. The 225 master prints examined by Sun and Perona (1998) included both portraits as well as landscapes. While it is certainly interesting that 77% of these paintings were marked by a left-light bias, it cannot be determined whether other factors contributed to this effect.

Evidence for a leftward attentional bias is seen in the greyscales task, originally developed by Mattingley, Bradshaw, Bradshaw, and Nettleton (1994) as a way of assessing spatial biases in right hemisphere patients with neglect. The task requires participants to choose which of two left–right mirror-reversed brightness gradients appear darker overall. As found by both Mattingley et al. (1994) and by Nicholls, Bradshaw, and Mattingley (1999), neurologically normal individuals tend to select the greyscale that is dark on the left side, and this effect remains true when participants are asked to indicate the greyscale that is light on the left side.

The current study examined the left-light bias in a novel way. Participants used a "virtual flashlight" controlled by a computer mouse to explore an abstract painting presented on a computer screen. Using a "virtual flashlight" to test preference for left-lit images offered participants complete freedom to place the light wherever they wished. The investigators aimed to show that the left-light bias observed in previous studies was duplicated using the "virtual flashlight". With consideration of McManus (1979), Sun and Perona (1998), Thomas et al. (2008), and Kobayashi et al. (2007), it was hypothesised that participants would concentrate the light to the left of centre and above the horizon line (top left quadrant of painting). It was also hypothesised that participants would choose the greyscale that is light on the left side, and that there would be a correlation between participant performance in the greyscales task and their lighting of the abstract paintings.

METHOD

Participants

A total of 42 participants (24 males) were recruited using the University of Saskatchewan Psychology participant pool ($M = 20.95$, $SD = 3.58$). Participants received one research credit in exchange for their participation. There were 36 right-handed, and 6 left-handed participants, determined using the Waterloo Handedness Questionnaire-Revised (Elias, Bryden, & Bulman-Fleming, 1998). All participants were experienced with the use of a mouse and keyboard for computer interaction. Also, participants had no previous experience with laterality studies. The Department of Psychology Ethics Committee at the University of Saskatchewan approved all procedures.

Apparatus

Participants were tested individually in a small, windowless room. Stimuli (abstract images) were presented on a 17-inch (43-cm) flat screen monitor. The lights were turned off to prevent glare and eliminate any potential distraction. Participants sat approximately 24 inches (61 cm) from the monitor and were positioned so that their eyes were parallel with the centre of the screen (see Figure 1).

The experiment was performed on a personal computer running Windows XP Professional, with an ATI Radeon HD 2400 XT video card, and 2.0 Gigabytes of RAM. The virtual flashlight application was custom developed, designed, and implemented in the department of computer science at the University of Saskatchewan. The application was developed using the C+ + programming language and the GLSL shader language (shaders). By using a shader, the virtual flashlight provides a greater level of realistic visual detail than other digital methods. The software uses a high-resolution digital image to create a replica of the art piece in three dimensions. The replica is presented perfectly parallel to the computer display on an unreflective black background in a soft ambient light. This makes the replica appear as though

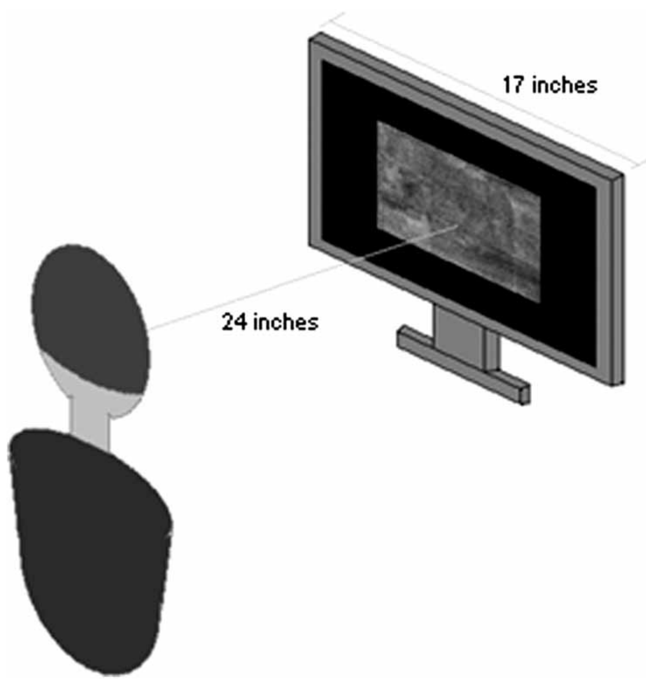

Figure 1. The participant's position during the experiment.

presented in a dark room, allowing the features to be visible, but insufficiently lit. A video screen capture can be found at http://homepage.usask.ca/~lje125/artflashlight.wmv. The participant is able to shine additional light onto the replica by using the virtual flashlight, controlled via the mouse. The virtual flashlight mimics a real flashlight shining on the work, remaining perpendicular to the art at all times so the flashlight maintains the size (10 cm) and shape of the light in all positions. The "virtual flashlight" is never angular to the image and therefore does not cast a shadow. By using the left click participants are able to lock the flashlight in position, using the right click unlocks the flashlight, and pressing the space bar while the light is locked will advance the participant to the next replica.

The primary advantage offered by the "virtual flashlight" program is the ability to collect precise data during the experiment while maintaining a high level of realism. The software is capable of collecting many different facets of data. A new log file is created for each participant, which contains an entry for each of the 40 trials completed. Information related to the flashlight position was most important to collect. Among other things, the current quadrant, exact position, and replica dimensions were logged for each participant. The screen was divided into top left, top right, bottom left, and bottom right; defined using standard Euclidean coordinates, setting (0,0) as the centre point of the replica. The exact positional information was also defined using Euclidean coordinates. The replica dimensions were defined on the same scale but not in the same system (i.e., not on a negative-positive scale). All positional information was determined based on the centre of the flashlight. Other information was also logged on a per-trial basis to aid with later analysis.

Stimuli

Participants viewed 20 abstract expressionist paintings. Images were found using the Google image search engine from January to February 2009 using the keywords "abstract", "expressionist", and "artwork". The works of certain artists were particularly well suited for the study, and therefore multiple works of one artist were often included (e.g., Penelope Billing's paintings). In this case, images were taken from the artists' websites. The only criteria for an image's inclusion in the study was that they be abstract and not have any indication of either proper orientation or provide hints as to where the light source should be positioned. The abstract images were specifically chosen to avoid confounding elements such as posing biases, ground lines, shadows, or reflections. Although not a deliberate choice, only coloured images were used. There was variability between images (see Figure 2 for a representative sample of the images used). Due to copyright law, not all images could be reproduced. All images presented were approximately 30 cm

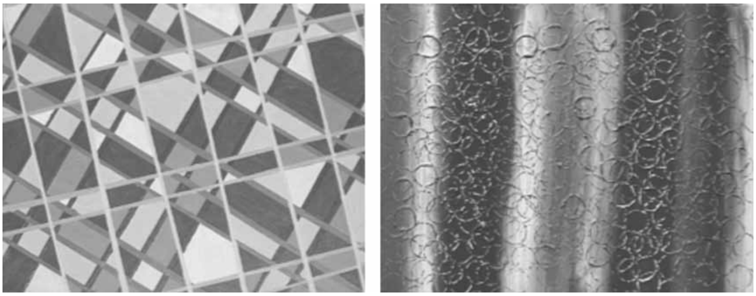

Figure 2. Representative sample of the images used in the study. From left to right, "Red Embers" (Billing, undated), "Ice Tipped Lava" (Billing, undated).

wide by 22 cm long and of similar quality. The images were presented in their native ratio and centred on a black background with no other distracting elements on the screen. Each participant was assigned a percent score indicating how often they chose to light the image from the left side.

Participants also completed the greyscales task (Nicholls et al., 1999). A greyscale is a rectangular bar with a thin black border. Five greyscale lengths were included, ranging from 320 to 720 pixels. The rectangles, referred to as luminance gradients, are black and white at the extremes. Greyscales are presented in mirror-reversed pairs, which are vertically aligned and of equal lengths. Participants viewed 72 pairs of greyscales.

Procedure

After signing the consent form, participants completed the laterality questionnaire (Elias et al., 1998). Participants then completed the greyscales task, for which they were instructed to choose the "lighter" rectangle out of a vertically aligned pair. Following completion of the greyscales task, the experimenter provided instructions for the experiment. The instructions were purposefully minimal as to avoid providing them with external hints regarding placement of the "virtual flashlight". Participants were told, "Position the 'virtual flashlight' in a way that makes the painting most aesthetically pleasing to you." To control for the possibility that artists present the most interesting aspects (e.g., brightest colours, complexity, etc.) in the top left quadrant of the painting, each painting was presented both right side up and in a mirror-reversed upside down position so that the content in the top left quadrant in the right side up orientation was in the bottom-right quadrant for the upside down orientation. Participants first viewed a randomised set of the right side up images followed by a randomised set of the upside down images.

RESULTS

A one-sample *t*-test was performed on the x coordinates, which demonstrated that participants on average placed the "virtual flashlight" in the left half of the painting significantly more often, x: $t(41) = -3.203$, $p = .003$. A one-sample *t*-test was performed on the y coordinates, which demonstrated that participants on average placed the "virtual flashlight" in the top half of the painting significantly more often, y: $t(41) = 8.202$, $p = .000$. See Figure 3 for mean "virtual flashlight" position averaged across participants and images. Paired-samples *t*-tests were performed separately on x and y coordinates for both orientations in order to determine the effect of the orientation of the image and no significant effect was seen, x: $t(19) = -.776$, $p = .447$; y: $t(19) = -1.414$, $p = .173$). A scatterplot was created using each participants average "virtual flashlight" position to demonstrate the robustness of the top left bias across both right side up and up side down versions of the images (see Figure 4).

A 2×2 chi-square analysis indicated a difference in participants' placement of the "virtual flashlight" between the four quadrants for each of the images., $\chi^2(1, N = 40) = 3.352$, $p < .0357$. A scatterplot was created using each participant's average "virtual flashlight" position to demonstrate the robustness of the top left bias across participants (see Figure 5).

A one-sample *t*-test was used to analyse bias scores from the greyscales task, $t(41) = -3.135$, $p = .003$. Results from the greyscales task revealed that

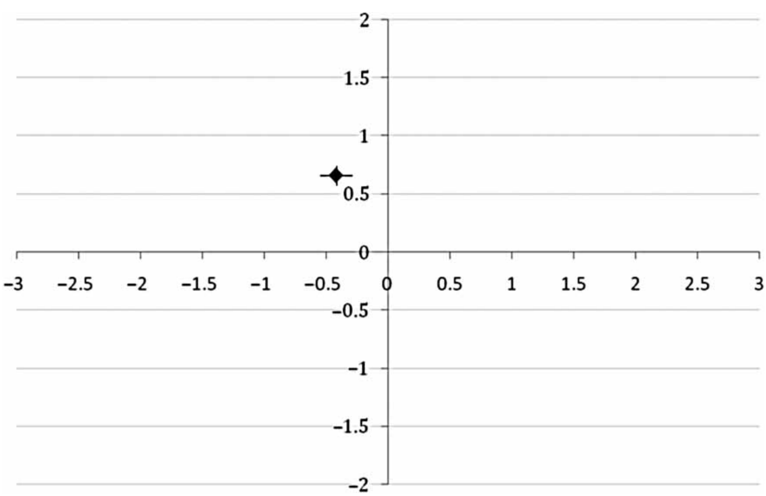

Figure 3. Scatterplot showing the average position of the virtual flashlight for all participants and across all images. The cross hairs show the standard error of the average participant's x and y coordinates across images. Scale of graph increased for clarity.

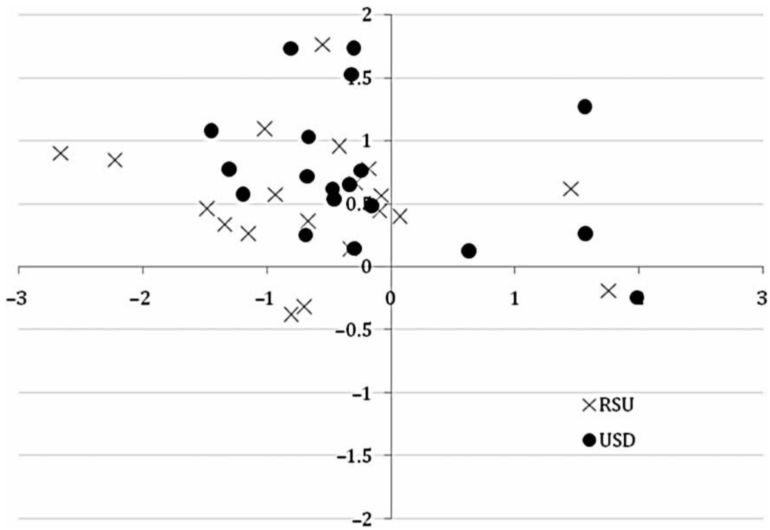

Figure 4. Scatterplot showing the average position of the "virtual flashlight" for each image. Each data point represents either the right side up or upside down presentation of a painting. Scale of each graph increased for clarity.

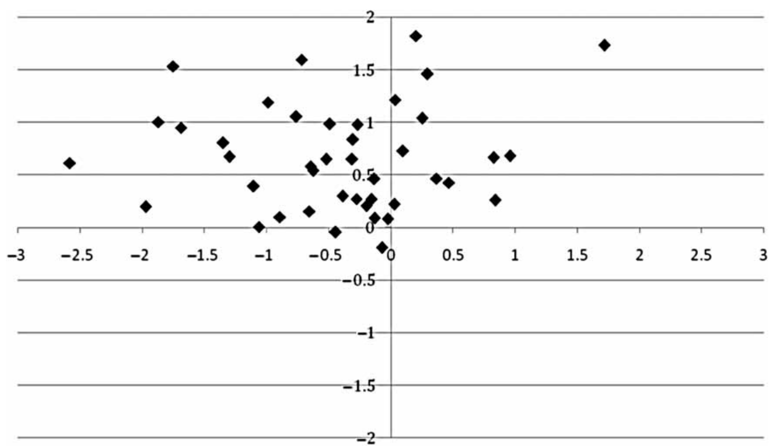

Figure 5. Scatterplot showing the average position of the "virtual flashlight" across the 40 images for each participant. Each data point represents one participant's average "virtual flashlight" position. Scale of graph increased for clarity.

participants chose the left side 63.1% of the time, indicating a significant leftward bias. A bivariate Pearson product-moment correlation was conducted to determine the degree to which the bias in performance during the greyscales task was related to an individual's bias in performance during the "virtual flashlight" task. No correlation was found between participants' performance during the greyscales task and the "virtual flashlight" task, $r = .151$, $p = .339$.

DISCUSSION

As hypothesised, participants placed the "virtual flashlight" in the top left quadrant most often, providing evidence that the top left-light bias previously observed (e.g., McManus, 1979; Sun & Perona, 1998; Thomas et al., 2008) may be driven by individual aesthetic preferences. The participants' positioning of the "virtual flashlight" was similar across the majority of the paintings, showing that it was not merely a few extreme scores on a small number of paintings that was driving the top left bias across the entire set of images. In addition, participants were not merely focusing the light on the most interesting aspect of the painting, as evidenced by participants focusing the "virtual flashlight" in the top left quadrant for both the right side up and the upside down mirror-reversed versions of the image.

The "virtual flashlight" illuminated specific aspects of the painting with light gradually becoming less bright as it radiated outwards. However, all aspects of the painting could be seen at all times, regardless of the flashlight position. The "virtual flashlight" merely allowed individuals to apply additional illumination to specific aspects of the paintings. However, there still exists the possibility that the observed effect could be due to the spotlight creating an attentional window. If this is the case, the results may have nothing to do with lighting, but rather may be indicative of an attentional bias.

By using abstract paintings to examine the left-light bias we were able to control for a number of confounds presented by previous studies. Unlike the portrait and landscape paintings examined by both McManus (1979) and Sun and Perona (1998), the abstract paintings used in the current study do not contain elements such as ground lines, shadows, reflections, or human or animal figures. Therefore participants were provided with no hints as to where light is supposed to come from or even proper orientation of the image.

The current study also differed from previous studies by allowing participants to actively create the left-light bias. Participants had full control of the placement of the "virtual flashlight" and were provided with minimal instructions. The use of the "virtual flashlight" to create a left-light bias provides evidence that lighting biases are the result of an internal cognitive bias rather than external elements (e.g., posing biases, ground line).

The goal of the current paper was to extend the finding of a left-light bias in art to include abstract works. To this end, the authors were successful. However, images were selected without consideration of the seminal works of Arnheim (2004) and Kanizsa (1979). Abstract artwork is notoriously variable (e.g., consider the images "Red Embers" and "Ice-Tipped Lava" used in the current study). As correctly suggested by Noguchi (2003), the perceptual structure of an image can inform aesthetic judgements. For example, Arnheim (2004) outlines a number of perceptual elements that may influence aesthetic judgement including balance, shape, form, colour, movement, dynamics, and expression. Arnheim argues that perception is the result of experiencing the dynamic qualities within an image. The extent to which these elements may have influenced the positioning of the "virtual flashlight" cannot be gleaned from the results. Future work should consider the potential interaction between illumination and the internal elements of artwork when selecting an image set.

An issue worth commenting on is whether the manipulation of lighting used in the current study is comparable to that of the artists and photographers in Thomas et al.'s (2008), McManus's (1979), and Sun and Perona's (1998) studies. There is indeed a difference between the internal luminance within an image and the external lighting of an image using the "virtual flashlight". Participants actively demonstrated a left-light bias when given control of the light source. Furthermore, a left-light bias was found independent of image orientation. If the internal luminance of a painting was driving the left-light bias, a significant difference in "virtual flashlight" position would have been found between right side up and upside down images. The robust results of the current study suggest continuity between Thomas et al.'s (2008), McManus's (1979), and Sun and Perona's (1998) findings and those of the current investigation, despite different methodologies.

Performance on the greyscales task revealed that participants chose the left side as lighter 63.1% of the time. This is in line with the previous findings regarding the left bias on the greyscales task (i.e., Nicholls et al., 1999). No correlation was found between performance during the greyscales task and the "virtual flashlight" task. However, laterality indices often fail to correlate with one another, as evidenced by a number of previous studies (e.g., Jewell & McCourt, 1999; Nicholls et al., 1999).

The results of the current study demonstrate a robust top left bias in the lighting of abstract paintings. Although methodological differences exist between internal and external lighting of paintings, the results suggest that the left-light bias observed in portraits, landscapes, and advertisements can be broadened to include abstract artwork. The relative lack of confounding elements in the images used in the current study and the participants' active creation of a left-light bias using the "virtual flashlight" suggest that aesthetic lighting is not dependent on the images themselves, but rather representative of an internal cognitive bias.

Manuscript received 8 September 2009
Revised manuscript received 7 December 2009
First published online day/month/year

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