Effects of Handedness on Affective Lateralization: a Divided Visual-Field Study

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Abstract

The “valence hypothesis” of affective lateralization states that right hemisphere (RH) is specialized for negative affect, and that the left hemisphere (LH) is specialized for positive affect. While the valence hypothesis has been fairly well-established, the vast majority of the relevant studies have been conducted exclusively on right-handed participants; the effects of handedness on affective lateralization have not been as thoroughly investigated. To further investigate the influence of handedness on affective lateralization, a divided-visual field image-discrimination paradigm was used. The experiment consisted of two counterbalanced conditions: threat-detection and positive affect. Within each condition, matched-pair “emotional” and “neutral” stimuli were used. Participants were instructed to indicate whether a presented stimulus was “emotional” or “neutral” by pressing keys on a keyboard. For emotional stimuli, experimental condition (threat vs. positive) resulted in opposing hemispheric task performance advantage in both handedness groups. However, between the handedness groups, the patterns of hemispheric advantage elicited were reversed. Right-handers had a RH/LVF performance advantage in the threat-detection condition, and a LH/RVF advantage in the positive affect condition; the opposite pattern was seen in left-handers. In contrast, neutral stimuli reliably produced a RH/LVF advantage in both handedness groups and conditions. This suggests that handedness may be a predictor for affective lateralization, with the “valence hypothesis” holding true for right- but not left-handers.

Introduction

The “valence hypothesis” of affective lateralization was inspired by the findings of Wada test experiments in the 1930s. The Wada test involves the selective injection of barbiturates into arteries that lead to one hemisphere, and provides for fairly specific lateralized inhibition of neuronal activity (Goldstein 1939). Wada experiments found that left-hemisphere inhibition resulted in a “catastrophic reaction” of depressive symptoms: crying, pessimism, guilt, worthlessness, etc. Conversely, right-hemisphere inhibition was found to result in euphoria (Goldstein 1939; Perria et al. 1961). Thus, it was inferred that the right hemisphere (RH) was specialized for negative affect, and the left hemisphere (LH) specialized for positive affect (Silberman & Weingartner 1986). Similar results were seen in lesion studies; LH lesions were associated with elevated depression scales, while RH lesions were found to correlate with laughter, positive mood change, and even mania (Gasparrini et al. 1978; Sackeim et al. 1982). EEG and ECT studies have shown this pattern of affective lateralization in more anterior regions of the cortex, but not posterior regions (Davidson 1992). Functional neuroimaging has further localized anterior affective laterality effects to the prefrontal corticies (Northoff et al. 2000). Divided-visual field (DVF) and dichotic listening studies on depressed and healthy populations have consistently found similar patterns (Silberman & Weingartner 1986; Shamay-Tsoory et al. 2008).

While the valence hypothesis has been fairly well-established, the vast majority of the relevant studies have been conducted exclusively on right-handed participants (Shamay-Tsoory et al. 2008; Elias et al. 1998). The effects of handedness on affective lateralization have not been as thoroughly investigated. Existing literature has been inconclusive, and the effects of handedness on affective lateralization remain nebulous (Rodway et al. 2003). One of the most consistent findings has been through studies using dichotic-listening paradigms. Handedness-related affective lateralization has been found using music, words, and speech prosody as stimuli (McFarland & Kennison 1989; Bryden et al. 1991; Perry et al. 2001). Furthermore, handedness effects on affective and language lateralization have been found to be dissociable (Bryden et al. 1991; Bulman-Fleming & Bryden 1994). These dichotic listening studies have shown that right-handers' affective lateralization corroborates with the "valence hypothesis" (i.e. RH for negative affect, LH for positive), but that left-handers have opposite lateralization. However, handedness does not appear to have consistent effects on language lateralization.

In contrast to dichotic-listening, studies using DVF paradigms have been inconsistent. Some DVF studies using facial emotion stimuli have found similar results to the dichotic listening studies (Natale et al. 1983; Everhart et al. 1996). These studies also show writing posture as having an effect on lateralization, with left-handed inverted-posture participants showing intermediate lateralization between "normal" right- and left-handers. However, some studies have not found any handedness effects at all (Rodway et al. 2003). One popularly-cited study found footedness, not handedness, to be a predictor of affective lateralization (Elias et al. 1998). However, studies on motivational lateralization—an important aspect of affect—have reliably found opposite patterns between handedness groups (Brookshire & Casasanto 2011).

To further investigate the influence of handedness on affective lateralization, a DVF image-discrimination paradigm was used. Two counterbalanced experimental conditions were used: threat-detection and positive affect. In each condition, participants were asked to decide whether a stimulus was "emotional" (i.e. threatening or positive, respectively), or "neutral." Better task performance was expected when stimuli was presented to participants' dominant hemisphere. "Emotional" stimuli is expected to produce further performance effects. Right-handers are expected to have improved LH/RVF performance for emotional stimuli in the positive-affect condition, and reduced RH/LVF performance for emotional stimuli in the threat-detection condition. Opposite effects are expected for left-handers. Overall handedness-VF interactions were not found, but differential handedness-related, stimuli-specific, and condition-specific effects were found to have marginal statistical significance.

Materials and Methods

Participants

Seventeen participants were recruited from Carnegie Mellon University's undergraduate student body. Participants consisted of ten right-handers and seven left-handers. There were eleven males, and six females. Median age was 21.2 years, with a range of 20 to 24 years. There were eleven "technical" majors (sciences and engineering), along with six "creative" majors (arts and humanities). A graphical summary of trials conducted in relation to demographic measures can be found in Figure 1. All participants provided written consent for this experiment, but IRB approval was not obtained.

Design and Materials

The DVF paradigm was conducted using Lateralizer software operating on a laptop PC with a screen size of 13.3" and resolution of 1366x748 pixels (Motz et al. 2012). Experiments were conducted in quiet artificially-lit rooms, with time and location dependent upon the participants' convenience. The stimuli used were moderately-arousing matched-pair affective photos from the University of California's Emotion and Cognition lab (Mather & Nesmith 2008). These photos consisted of one person in an affective or neutral situation. For the positive affect condition, there were four positive affect photos with neutral affect matches. For the threat detection condition, there were four threatening photos with neutral (non-threatening) matches. A practice condition was also conducted, using separate sets of positive and threatening matched-pair photos. The experimental stimuli can be found in Figure 2. Lateralization is operationalized by the accuracy and response time (RT) of each trial.

Procedure

For each condition, twelve photos were presented in random order and visual field. There were six photos per stimulus type, three of which were presented in each visual field. Photos were presented for 200ms, with a fixation crosshair presented for 5 seconds prior to each photo. Participants were instructed to maintain visual focus on the region of the screen where the fixation crosshair was placed, in order to maintain a divided visual field. Photo presentation of 200ms was chosen, as saccades normally take around 200ms to initiate, thus keeping visual focus on the fixation crosshair (Motz et al. 2012). Immediately before starting the experiment, participants were instructed to decide whether a photo was “emotional” or “neutral”. They were also told to indicate their appraisal as quickly as possible by pressing the keyboard key “G” for neutral and “H” for emotional, using their left and right index fingers respectively. The Lateralizer software presents a preview of the stimuli prior to each condition; these previews were manually covered in an effort to reduce confounding. Specifically, it was done to prevent the use of memorization strategies, rather than affective appraisals, in the task. The practice round was presented first, and participants were free to repeat the round until they felt comfortable at performing the task. Immediately after the practice round, participants underwent both experimental conditions in counterbalanced order. A graphical representation of the experimental design and procedure can be found in Figure 3.

Statistical Analysis

Data collection and statistical analysis was done using the IBM SPSS (version 21) software package. Data was preprocessed through the elimination of within-subject RT outliers using Grubbs’ test for outliers. Out of a total of 408 trials, 21 were discarded as outliers (~5%). The analytic method used was the multivariate analysis of covariance (MANCOVA). RT and accuracy were set as dependent variables. Handedness, VF, stimulus type, and condition were set as fixed factors. Sex, major, and age were set as covariates. The effects of the covariates on the dependent variables were "factored out" of the final results.

Results

Sex was found to have a strong effect on the dependent variables (F = 7.981, P < 0.001), with women having faster RTs than men, though accuracy was unaffected. Stimuli type was also found to have a robust effect on the dependent variables (F = 8.536, P < 0.001), with neutral stimuli resulting in faster RTs. Again, accuracy was unaffected. Handedness was found to have a marginal effect on the dependent variables (F = 2.900, P = 0.056); left-handers had faster RTs than right-handers, though accuracy was again unaffected. None of the other covariates or fixed factors produced statistically-significant effects independently.

*Handedness * Stimuli Type* had a marginal effect on dependent variables, with left-handers performing much better in neutral trials versus emotional trials—this effect was much less pronounced in the right-handed group (F = 2.887; P = 0.059). *Handedness * Visual Field * Stimuli Type* also had marginal effects on the dependent variables (F = 2.735; P = 0.068). More revealingly, *Handedness * Visual Field * Stimuli Type * Condition* was found to have relatively robust effects on the dependent variables (F = 2.979; P = 0.051). For emotional stimuli, right-handers had a RH/LVF performance advantage in the threat-detection condition, and a LH/RVF advantage in the positive affect condition. This pattern was reversed for left-handers. For neutral stimuli, both handedness groups had a LH/RVF performance advantage in both conditions. Bar graphs of this can be seen in Figure 4. Interestingly, *Handedness * Visual Field* was found to have the least effect on the dependent variables of any input variable(s) (F = 0.183, P = .833). Full MANCOVA results can be found in Table 1.

Discussion

The robust effects of sex and handedness on the dependent variables may be attributable to the small size and unevenness of the demographic groups. There were much more males and right-handers than females and left-handers. Furthermore, two left-handed female participants achieved anomalously good performance in comparison to the rest of the participants. This had significant impact on mean performance for females and left-handers, even when correcting for the uneven demographic groups. Thus, this precludes direct comparison of performance between sex and handedness groups. Also, in contrast to the results of previous studies, neutral stimuli produced better task performance than emotional stimuli (Natale et al. 1983; Everhart et al. 1996; Elias et al. 1997). This may be due to the increased complexity of the stimuli used in this experiment, which used photos of scenes rather than faces. Neutral stimuli used tended to have less features than the emotional stimuli used. Considering the very rapid presentation time of the stimuli (200ms), simpler stimuli such as faces may have been a better choice. Furthermore, the position of the participants was not physically fixed and may have shifted throughout the course of the experiment. This may have compromised the separation of the visual fields, and may account for the fairly large spread of the data.

With these limitations in mind, fairly significant interaction effects were still found. Specifically for emotional stimuli, condition (positive vs. threat) resulted in opposite hemispheric advantage in both handedness groups. However, the patterns of hemispheric advantage elicited were reversed according to handedness. Right-handers had a RH/LVF performance advantage in the threat-detection condition, and a LH/RVF advantage in the positive affect condition; the opposite pattern was seen in left-handers. In contrast, neutral stimuli reliably produced a RH/LVF advantage in both handedness groups and conditions. This suggests that handedness may be a predictor for affective lateralization, with opposite patterns in right- vs. left-handers. However, the RH/LVF advantage found for neutral stimuli is peculiar, and is unlikely to be a statistical artifact it was a reliable feature across all groups and participants. This may be attributable to hemispheric advantages in attention, though handedness may affect this as well (Kinsbourne 1970).

In conclusion, this study may have found evidence for opposite affective lateralization between right- and left-handers. Past studies using similar DVF paradigms have been inconclusive, and the wider implications of this study's findings remain unclear. The results of this study must be considered alongside its methodological limitations and overall lack of statistical robustness. In the future, larger and more even participant groups would be prudent for achieving statistical robustness. The use of simpler stimuli (i.e. faces instead of scenes) would also be a better choice in regards to consistency and validity. Additionally, the physical position of the participants during the experiment should be better controlled for, as alterations could significantly compromise the separation of the visual fields. Furthermore, the experiment was conducted in multiple different locations at different times-of-day. While lighting and noise levels were controlled for, many others were not, such as table height, seat height, and room temperature. These uncontrolled factors may have influenced results. Lastly, handedness should be better qualified; handedness groups were assigned through self-identification, not through verifiable handedness rating-scales.

Figure 1

Number of trials conducted in accordance to demographic groups. This is directly proportional to the unevenness of the demographic groups.

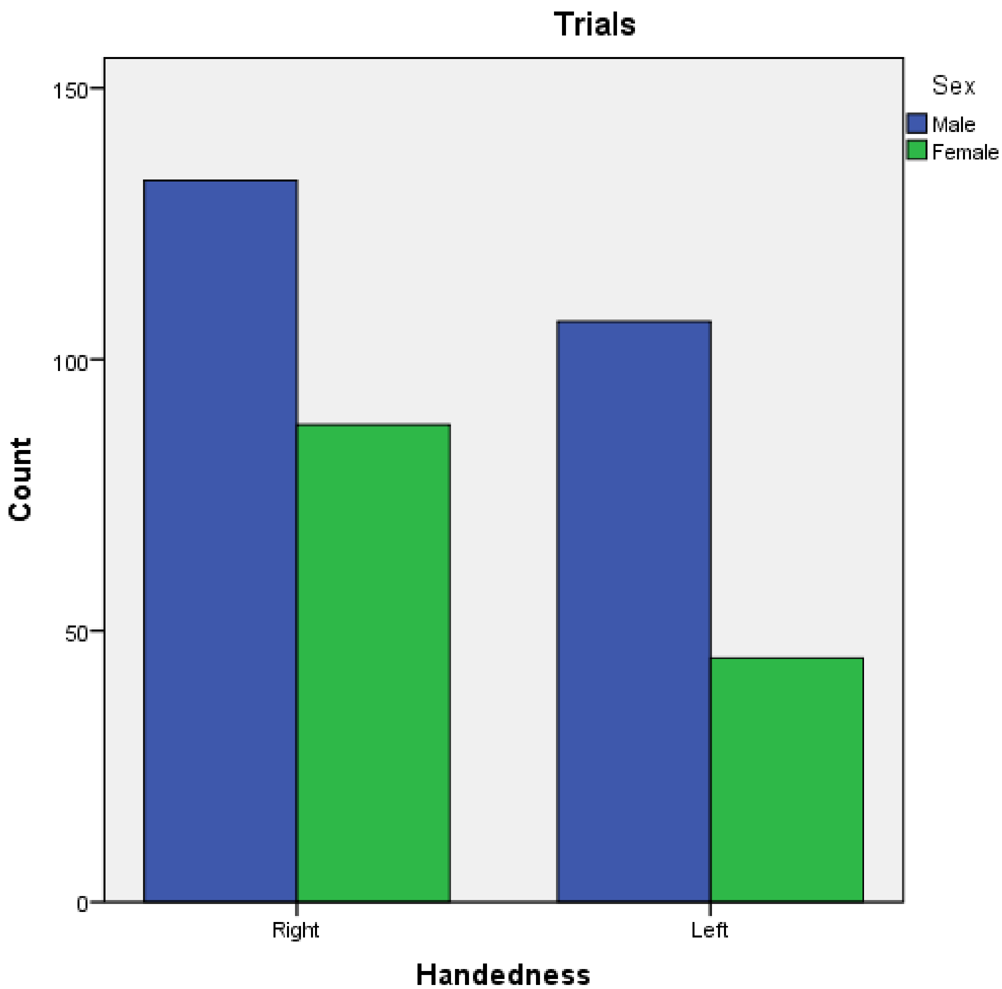

Figure 2

Matched-pair stimuli used for A) Threat-detection condition B) Positive-affect condition. Left-hand images show neutral stimuli, and right-hand images show matched emotional stimuli.

A) **B)**

Figure 3

Diagram of the experimental design and procedure. "N" represents number of trials per subject.

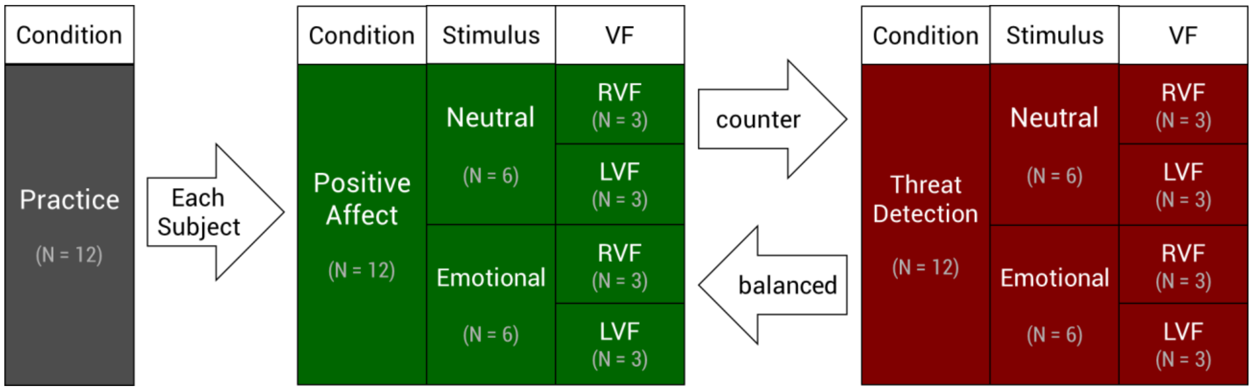

Figure 4

Response time measured in milliseconds. Comparison of performance between handedness, visual field, stimuli type, and experimental condition. For emotional stimuli, right-handers had a RH/LVF performance advantage in the threat-detection condition, and a LH/RVF advantage in the positive affect condition. This pattern was reversed for left-handers. For neutral stimuli, both handedness groups had a LH/RVF performance advantage in both conditions

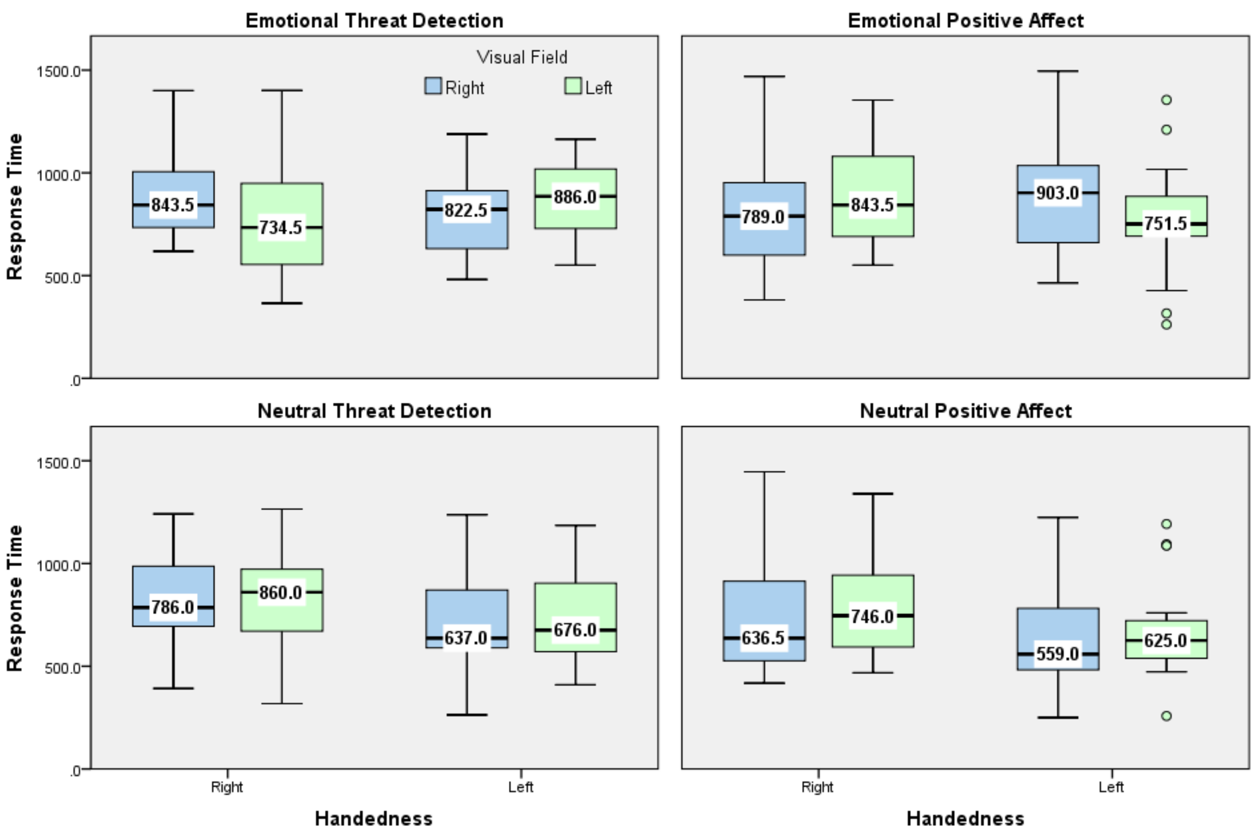

Table 1

Full results of multivariate analysis of covariance (MANCOVA). Dependent variables: response time and accuracy. Fixed factors: handedness, visual field, stimuli type, and experimental condition. Covariates: Sex, Age, and Major.

Multivariate Tests[a]					
Effect		F	Hypothesis df	Error df	Sig.
Intercept	Wilks' Lambda	440.235	2.000	353.000	.000
Sex	Wilks' Lambda	7.981	2.000	353.000	.000
Major	Wilks' Lambda	2.051	2.000	353.000	.130
Handedness	Wilks' Lambda	2.900	2.000	353.000	.056
VF	Wilks' Lambda	1.030	2.000	353.000	.358
Stimuli	Wilks' Lambda	8.536	2.000	353.000	.000
Condition	Wilks' Lambda	2.246	2.000	353.000	.090
Handedness * VF	Wilks' Lambda	.183	2.000	353.000	.833
Handedness * Stimuli	Wilks' Lambda	2.887	2.000	353.000	.059
Handedness * Condition	Wilks' Lambda	.740	2.000	353.000	.478
VF * Stimuli	Wilks' Lambda	.557	2.000	353.000	.573
VF * Condition	Wilks' Lambda	.764	2.000	353.000	.467
Stimuli * Condition	Wilks' Lambda	.929	2.000	353.000	.396
Handedness * VF * Stimuli	Wilks' Lambda	2.735	2.000	353.000	.068
Handedness * VF * Condition	Wilks' Lambda	.934	2.000	353.000	.394
Handedness * Stimuli * Condition	Wilks' Lambda	.258	2.000	353.000	.772
VF * Stimuli * Condition	Wilks' Lambda	.341	2.000	353.000	.711
Handedness * VF * Stimuli * Condition	Wilks' Lambda	2.979	2.000	353.000	.051

a. Design: Intercept + Sex + Major + Handedness + VF + Stimuli + Condition + Handedness * VF + Handedness * Stimuli + Handedness * Condition + VF * Stimuli + VF * Condition + Stimuli * Condition + Handedness * VF * Stimuli + Handedness * VF * Condition + Handedness * Stimuli * Condition + VF * Stimuli * Condition + Handedness * VF * Stimuli * Condition

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