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An examination of the right-hemisphere hypothesis of the lateralization of emotion

Stephen D. Smith*,[1], M. Barbara Bulman-Fleming

Department of Psychology, University of Waterloo, Canada

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Abstract

The Right-Hemisphere Hypothesis posits that emotional stimuli are perceived more efficiently by the right hemisphere than by the left hemisphere. The current research examines this hypothesis by examining hemispheric asymmetries for the conscious and unconscious perception of emotional stimuli. Negative, positive, and neutral words were presented for 17 ms to one visual field or the other. Conscious perception was measured by using a subjective report-of-awareness measure reported by participants on each trial. Unconscious perception was measured using an ''exclusion task,'' a form of word-stem-completion task. Consistent with previous research, there was a right-hemisphere advantage for the conscious perception of negative information. As in previous studies, this advantage for conscious perception occurred at the expense of unconscious perception. Specifically, there was a right-hemisphere inferiority for the unconscious perception of negative information. Contrary to the predictions of the Right-Hemisphere Hypothesis, there were no hemispheric asymmetries for the perception of positive emotional information, thus suggesting that the Right-Hemisphere Hypothesis may not be applicable to all behavioral studies.

1. Introduction

The Right-Hemisphere Hypothesis of the lateralization of emotion states that the right hemisphere (RH) is superior to the left hemisphere (LH) at perceiving *all* emotions, regardless of valence (i.e., positive or negative). Evidence in favour of this theory has been found using several different methodologies. Many lesion-based studies have shown that damage to the RH leads to profound deficits in emotional perception, whereas emotional impairments resulting from LH damage are relatively minor (see Borod, 1992; for a review). However, behavioral studies utilizing neurologically intact individuals have provided inconsistent results. In some studies, both positive and negative stimuli are preferentially processed by the RH; in other studies, only negative stimuli result in an RH advantage. The purpose of the current research is to test the utility of the Right-Hemisphere Hypothesis by examining hemispheric asymmetries for positive and negative stimuli. These hemispheric asymmetries will be analyzed both for items that were *consciously* perceived and for items that were *unconsciously* perceived.

The current research is an extension of previous work performed in our laboratory (Smith & Bulman-Fleming, 2004). In this previous research, negative or neutral words were presented for 17 ms to one visual field or the other. Participants were required to give two responses on each trial. First, participants stated if they were able to perceive the entire word, part of the word, or nothing at all (i.e., they provided a subjective report of awareness). This response indicated the degree to which the emotional or neutral stimuli were consciously perceived. Second, participants were asked to complete

* Corresponding author.
E-mail address: stephen.d.smith@vanderbilt.edu (S.D. Smith).
[1] Present address: Department of Psychology, Vanderbilt University, 301 Wilson Hall, 111 21st Avenue, Nashville, Tennessee 37203, United States.

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the word stem (i.e., the first 3 letters of the 5-letter word) with the first word that came to mind *other than* the presented word (i.e., they performed an "exclusion task"; Debner & Jacoby, 1994). The logic of this task is as follows: If participants *consciously* perceived the word, then they would use a different word to complete the word stem. In contrast, if participants *unconsciously* perceived the word, then this word would be the most available word to the participants when they were shown the word stem. This priming would result in participants using the presented word even though they were instructed not to do so ("exclusion failures").

In our previous research (Smith & Bulman-Fleming, 2004), we found an RH advantage for the conscious perception of negative words. In fact, for RH trials, there was a greater degree of conscious perception for negative words than for neutral words. Critically, this RH-advantage for conscious perception appeared to occur at the expense of unconscious perception. Negative words presented to the RH did not show evidence of unconscious perception, whereas unconscious perception was elicited in all other conditions. The current research extends this earlier work by presenting negative, neutral, *and* positive words to one visual field or the other. If the Right-Hemisphere Hypothesis is correct, then we would expect similar patterns of hemispheric asymmetries for negative and positive stimuli.

2. Method

2.1. Participants

Sixty-four undergraduate students (40 females and 24 males) from the University of Waterloo participated in exchange for bonus credit in an introductory psychology course. All participants had normal or corrected-to-normal vision and were right-handed.

2.2. Stimuli and apparatus

The stimuli consisted of two word sets, each consisting of 120 words ranging in length from five to seven letters. One set of words consisted of target words; on target trials, the presented word matched the subsequent word stem. The other set of words consisted of baseline words; on baseline trials, the presented word did not match the subsequent word stem. The word stem used on baseline trials corresponded to a target word that was not presented to that participant. These baseline trials therefore provided the proportion of times the target words would be used to complete the word stem even if they were not presented. A critical analysis in this study involved comparing the proportion of exclusion failures on target trials to the baseline level of exclusion failures established on baseline trials.

Each of the 120 target words was matched with a baseline item that had an equivalent word length, emotional valence, word frequency, arousal level, and number of possible word-stem completions. Either the baseline word or the target word was presented on a given trial and each word pair was chosen only once. Trials were counterbalanced such that each participant received 10 Positive-Target, 10 Negative-Target, 10 Neutral-Target, 10 Positive-Baseline, 10 Negative-Baseline, and 10 Neutral-Baseline trials presented to the left and right visual fields ($60 \times 2 = 120$ trials).

As in Smith and Bulman-Fleming (2004), words were vertically presented 30 mm from the centre of the screen. On average, words measured 4 mm in width and 32 mm in height. Participants viewed the stimuli from a chin rest positioned 65 cm from the monitor.

2.3. Procedure

Each trial began with a fixation cross (+) presented for 500 ms at the centre of the screen. Following this, a word was vertically presented for 17 ms to one visual field or the other. After a 250-ms blank screen (to avoid masking of the stimuli), participants were asked to indicate whether they had seen the entire word, part of the word, or nothing at all. After participants had responded to this question, the word stem appeared. As mentioned earlier, participants were asked to complete the word stem with the first word that came to mind *other than* the presented word. The responses had to consist of a legitimate, English word that corresponded to the number of blank spaces shown on the screen (e.g., "pho - -" would require two letters to complete the word stem, whereas as "tan - - - -" would require four letters). After completing the word stem, participants initiated the next trial by pressing the spacebar.

3. Results and discussion

Separate analyses were performed on the subjective-report and exclusion-task data. For the subjective-report data, the average number of trials labeled 'conscious' (i.e., perception of the entire word) by participants was calculated for positive, negative, and neutral words presented to each hemisphere. Unconscious trials consisted of trials on which the participants saw either part of the word or nothing at all. These two responses were combined as it has previously been demonstrated that they lead to the same pattern of results (Smith & Bulman-Fleming, 2004). For the exclusion-task data, the average proportion of exclusion failures was calculated for positive, negative, and neutral words presented to each hemisphere. These two calculations provided information about hemispheric asymmetries for conscious and unconscious perception, respectively.

The subjective-report data were analyzed in a 3 (Emotion) × 2 (Hemisphere) repeated-measures ANOVA. As can be seen in Fig. 1A, the RH was superior to the LH at 'consciously' perceiving the items; however, this superiority was particularly apparent for negative words. The Emotion × Hemisphere interaction was significant: $F(2, 62) = 6.49$, $p < .02$. As well, there was a main effect of Emotion; the number of 'conscious' trials was greater for negative words than for positive or neutral words: $F(2, 62) = 6.91$, $p < .01$. This effect was due primarily to the RH advantage for the 'conscious' perception of negative words. Planned comparisons were performed on the subjective-report data from this study in order to gain further insight in the pattern of results. Negative words presented to RH led to more 'conscious' trials than negative words presented to the LH: $t(63) = 6.27$, $p < .001$. This RH advantage also occurred for positive ($t(63) = 3.28$, $p < .01$) and for neutral words ($t(63) = 4.71$, $p < .001$). Additional matched-samples t-tests were performed in order to determine if the RH superiority for the 'conscious' perception of negative words was significantly different from the above-mentioned RH advantages for the 'conscious' perception of positive and neutral words. In fact, both differences were significant: $t(63) = 4.03$, $p < .01$ and $t(63) = 4.51$, $p < .01$ for the negative vs. positive and negative vs. neutral comparisons, respectively. Critically, there was no difference in the level of 'conscious' perception for positive and neutral words presented to the RH ($t < 1$). Thus, the results suggest that there is a specific RH advantage for the 'conscious' perception of negative words.

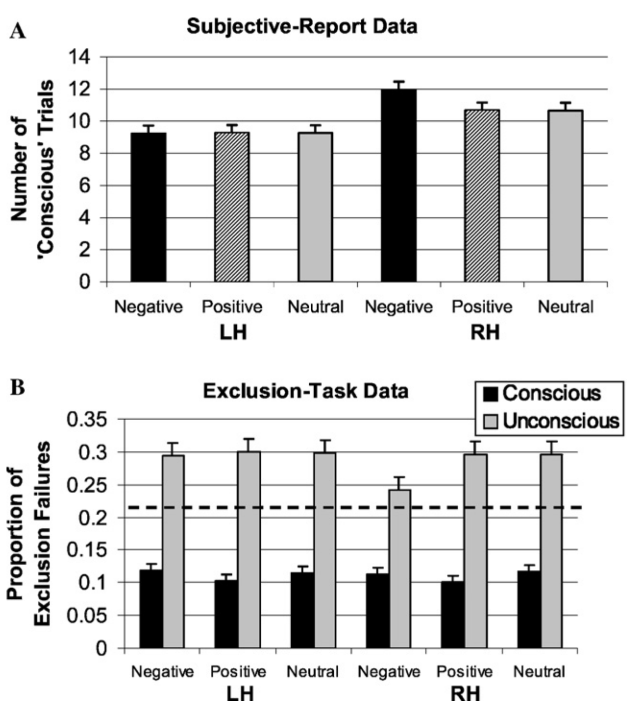

Fig. 1. (A) The number of trials labeled as being 'conscious' for each hemisphere. (B) The mean proportion of exclusion failures for 'conscious' and 'unconscious' trials. The dashed line represents the mean baseline level of exclusion failures. Error bars indicate the standard error of the mean for both (A) and (B). Note that the RH superiority for conscious perception in the subjective-report measure led to an RH inferiority for unconscious perception in the exclusion task.

The data from the exclusion task are depicted in Fig. 1B. There are three elements of this figure that are of importance. First, when participants were able to 'consciously' perceive the presented words, they followed the exclusion-task instructions and completed the word stem with an alternate word. For all six trial types (three emotions for each hemisphere), the proportion of exclusion failures was significantly *below* baseline levels (all t values > 2.30 and all p values < .05) for 'conscious' trials. This finding demonstrates that the participants understood the instructions for the exclusion task. Second, for five out of the six possible trial types, participants showed evidence of unconscious perception. Specifically, the proportion of exclusion failures was significantly *above* baseline levels for 'unconscious' trials (those on which participants did not see the entire word) for positive words presented to either hemisphere, neutral words presented to either hemisphere, and negative words presented to the LH (all t values > 2.10 and all p values < .05). These results demonstrate that the methodology used in this study was sensitive enough to detect unconscious perception. Third, the proportion of exclusion failures for negative words presented to the RH—the trial type that showed the largest degree of 'conscious' perception—did *not* show any evidence of unconscious perception. Specifically, the proportion of exclusion failures for this trial type did not differ from the baseline level of exclusion failures: $t(63) = 1.28$, $p = 0.21$. The proportion of exclusion failures for negative words presented to the RH differed from the proportions of exclusion failures for positive and neutral words presented to the RH: $t(63) = 2.30$, $p < .05$ and $t(63) = 2.24$, $p < .05$ for comparisons with positive and neutral words, respectively. It also differed from those for all three emotions presented to the LH (all t-values > 2.20). This finding demonstrates that the RH advantage for 'conscious' perception occurred at the expense of unconscious perception.

There are two important implications of the current research. First, the RH advantage for 'conscious' perception and accompanying RH deficit for unconscious perception replicates our earlier research (Smith & Bulman-Fleming, 2004). Second, the failure to detect any hemispheric differences for the perception of positive emotions provides evidence against the Right-Hemisphere Hypothesis. If this hypothesis were entirely valid, we would have expected that negative and positive stimuli would have elicited similar patterns of results. Instead, the predicted RH advantage was found only for negative stimuli. These results suggest that the Right-Hemisphere Hypothesis has limitations when applied to behavioral studies using neurologically intact participants. It is possible that the results of such studies are better accounted for by an alternate theory, the Valence Hypothesis (e.g., Davidson, 1995), or by a hybrid of these two theories. Future research will address these possibilities.

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References

Borod, J. C. (1992). Interhemispheric and intrahemispheric control of emotion: A focus on unilateral brain damage. *Journal of Consulting and Clinical Psychology, 60*, 339–348.

Davidson, R. J. (1995). Cerebral asymmetries, emotion, and affective style. In R. J. Davidson & K. Hugdahl (Eds.), *Brain Asymmetry* (pp. 361–387). Cambridge, MA: MIT Press.

Debner, J. A., & Jacoby, L. L. (1994). Unconscious perception: Attention, awareness, and control. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 304–317.

Smith, S. D., & Bulman-Fleming, M. B. (2004). A hemispheric asymmetry for the unconscious perception of emotion. *Brain & Cognition, 55*, 452–457.