PERGAMON

Neuropsychologia 40 (2002) 1601–1607

NEUROPSYCHOLOGIA

www.elsevier.com/locate/neuropsychologia

Cerebral hemispheric differences in memory of emotional and non-emotional words in normal individuals

Seiji Nagae [a,*], Morris Moscovitch [b]

[a] *Department of Psychology, Fukuoka University of Education, Munakata, Fukuoka 811-4192, Japan*
[b] *Department of Psychology, University of Toronto, St. George Campus, Toronto, Ont., Canada M5S 3G3*

Received 3 January 2001; received in revised form 17 December 2001; accepted 4 January 2002

Abstract

The present study was designed to examine the cerebral hemispheric differences in memory of positive, negative and non-emotional words using a new method of successive presentation to each visual half-field in which perception of each item was nearly perfect thereby allowing laterality differences for effects of emotion on memory to emerge unconfounded by perception (Experiment1). This procedure was compared with traditional perceptual identification (Experiment 2). In Experiment 1, 12 words were presented successively in each half field in each trial followed by free recall at the end of the trial. The results showed that recall of positive and negative emotional words was better than that of non-emotional words in both visual fields. Recall of positive and negative emotional words was not different in left and right visual fields (RVFs) although the recall of non-emotional words was better in the RVF than in the left visual field (LVF). The differences in recall between emotional and non-emotional words was greater in the LVF than in the RVF. Experiment 2 used the more traditional method of perceptual identification following each visual half-field presentation of a single item. Perceptual identification was better in the RVF than the LVF in each word condition. There were no visual field differences in perceptual identification between emotional and non-emotional words, as there was for memory in Experiment 1. The results supported the hypothesis that explicit memory for emotional words was dependent more on the right hemisphere, whereas perception of both emotional and non-emotional words was more dependent on the left hemisphere.

Keywords: Cerebral hemispheric difference; Memory; Emotional word; Visual half-field

1. Introduction

A number of studies have found that the right hemisphere plays a special role in processing the emotional properties of non-verbal stimuli [5,16,17,27]. These studies support a model of right hemisphere specialization for emotional processing (right hemisphere model), possibly because of the greater involvement of the right hemisphere in mechanisms of automatic and behavioral arousal [13]. Some studies, however, suggest that there is differential hemispheric specialization for emotion (valence model). This model posits that the left hemisphere is more involved in processing positive emotions whereas the right hemisphere is more involved in processing negative emotions [3,7,25].

Neither the right hemisphere model nor the valence model has been supported consistently by results of laterality (visual half-field) studies on perception and memory for emotional words. Graves et al. [11] found that normal adult males perceived emotional words more accurately than non-emotional words in the left but not the right visual field (RVF). They interpreted their findings as supporting the right hemisphere model. However, in their study ten-twelfths of the emotional words were negatively valenced. Strauss [26] reported that both emotional and non-emotional words were perceived better in the RVF. This study did not support either the right hemisphere or valence models. Strauss's finding conflicts with the result of Graves et al. [11]. Eviatar et al. [10] also found no evidence to support these two models, with emotionality of words in their study having the same effect on perception in both visual fields.

Each of the above studies was concerned only with perception of very briefly exposed stimuli, without any appreciable memory component. Studies that examined cerebral hemispheric differences in memory of emotional and non-emotional words in normal individuals are rare. Ali and Cimino [1] investigated the hemispheric lateralization of perception and memory for emotional verbal stimuli in normal individuals. Subjects were presented positive, negative, and neutral words and non-words in the LVF or the RVF. A stimulus was presented for 150 ms either to the LVF or RVF. They were asked to recall freely the presented words after

* Corresponding author.
E-mail address: nagaex@fukuoka-edu.ac.jp (S. Nagae).

0028-3932/02/$ – see front matter
PII: S0028-3932(02)00018-0

a set of items, and after a 20 min delay, to recognize the words. Ali and Cimino [1] indicated that perception and free recall data provided partial support for the valence model and recognition memory data provided strong support for this model. However, their findings related to the perception of emotional words do not agree with the findings of prior studies. The stimulus duration and words used in their study were different from prior studies. Furthermore, their results concerning memory for emotional words also are not consistent with the results of prior research on patient populations that show a right hemisphere advantage for memory of emotional words [6,19], regardless of their valence.

The purpose of the present study is to use a new technique, the successive presentation method in visual half-fields, to investigate the cerebral hemispheric differences of memory for emotional words in normal individuals. In addition, the present study uses both perceptual and recall tasks because the early studies on laterality may have been confounded by early perceptual stages involved in word recognition that may have masked the laterality effects associated with emotional aspects of the words that emerged in later stages. By using this new technique and separating the effects of perception from those of memory, we hoped to overcome some of the problems facing previous studies and help resolve some of the discrepancies in the literature.

The results from previous studies suggest that laterality studies that use perception to get at underlying asymmetries in other processes (such as emotion) are confounded by (or have to overcome) the effects of the hemisphere involved in initially decoding the material. This is especially a problem when verbal material is used since the RVF (left hemisphere) dominance for processing words is very robust [21]. To overcome the initial (early processing stages) effects of perception, we devised a memory technique in which perceptual influences of reading are minimized to allow the emergence of hemispheric specialization at later stages of information processing. Typically, visual half-field studies place the burden of processing at early perceptual stages involved in stimulus analysis and identification. The RVF-left hemisphere advantage in these early stages of processing is carried over to subsequent stages making it difficult, if not impossible, to detect the influence of later, right-hemisphere contributions (see [21] for a detailed exposition of this argument).

We hoped to overcome some of the limitations of the previous studies by separating the effects of perception from those of memory, and thus help resolve some of the discrepancies in the literature. To do so, we adopted a presentation technique in which words were presented successively to each visual field but at a relatively long exposure duration. By presenting stimuli clearly and for a sufficiently long duration so that perception is nearly perfect in either visual field, the processing burden is shifted from early perceptual stages involved in word identification, to later ones in which higher-order attributes of words, such as those related to emotional content, can be detected more easily.

Instead of measuring perceptual identification of the words, which is nearly perfect and equivalent in the two fields, memory for the words is tested at the end of a series of presentations. By emphasizing memory rather than perception, we hoped to keep contamination from processes involved in perceptual identification to a minimum, thereby allowing us to get a clearer picture of hemispheric contribution to emotional connotation of positive and negative words.

Because all stimuli in this experiment are verbal, it is predicted that once the data are collapsed across emotionality [21], subjects will demonstrate an overall RVF advantage in the recall task (Experiment 1) and in the more traditional perceptual identification task (Experiment 2). If processing of emotional stimuli is mediated by the right hemisphere, as the right hemisphere hypothesis predicts, two possible findings are expected when memory for emotional words is assessed (Experiment 1): (1) a memory advantage for emotional words presented initially to the left visual field (LVF), or (2) if there is a substantial contribution from the left hemisphere in mediating verbal memory that offsets the emotional contribution of the right hemisphere, then performance will be equivalent in the two fields. (3) Memory for non-emotional words is expected to better for words presented to the RVF.

If the valence hypothesis is correct and processing of positive and negative emotional stimuli is mediated by the left and right hemisphere, respectively, then it is predicted that memory for positive words would favor the RVF and memory for negative words, if the left. If left hemisphere advantage for verbal material is a factor, then one would predict that it would add to the RVF advantage for positive words and diminish the LVF advantage for negative words. Processing of non-emotional words would be better in the RVF than in the LVF.

Experiment 1 also includes a control, perceptual identification test to show that under the long exposure duration conditions of the study, perception is nearly perfect and equivalent in the two fields. This control serves to substantiate the claim that the results in the memory condition rely on post-perceptual stages of processing where the influence of emotionality can be detected.

In Experiment 2, the same stimuli are used as in Experiment 1, but they are presented at short exposures, placing the burden of processing at early stages of processing. If perceptual identification of verbal stimuli depends more on left than on the right hemisphere processes, then a RVF advantage should be found regardless of the word's emotional connotation.

2. Experiment 1

2.1. Method

2.1.1. Subjects and design

Subjects were 18 right-handed students (10 males, 8 females) at the University of Toronto, Erindale College, who

Table 1
Examples of positive, negative, and non-emotional words used in the experiment

Positive		Negative		Non-emotional	
Baby	Joy	Agony	Grief	Amount	Hour
Belief	Kiss	Anger	Hatred	Array	Idiom
Bloom	Love	Beast	Malice	Code	Item
Charm	Mercy	Blood	Misery	Cost	Length
Dove	Moral	Chaos	Menace	Custom	Method

participated for course credit or money. All had normal, or corrected to normal, visual acuity. Subjects indicated they did not abuse alcohol or drugs. Two within-subjects factors—emotional connotation of words (positive, negative, and neutral) and visual field (left and right)—were used in a 3×2 factorial design.

2.1.2. Stimulus materials

Thirty positive, 30 negative emotional nouns and 30 non-emotional nouns (Table 1) were selected from the list reported by Rubin and Friendly [24]. Positive emotional nouns consisted of words rated over 4 points in emotionality (mean = 5.28) and goodness value (mean = 5.72) on a 7-point scale. Negative emotional nouns consisted of words rated over 4 points in emotionality (mean = 5.55) and under 3 points in goodness (mean = 2.16). Non-emotional nouns consisted of words rated under 4 points in emotionality (mean = 2.58). Mean goodness value of non-emotional nouns was 4.07.

Concreteness values [23] of these three word groups were as follows: positive (mean = 3.29), negative (mean = 3.49), and non-emotional (mean = 3.42). Thorndike–Lorge frequency values of them were the same in all conditions (high = 15 words, medium = 10 words, low = 5 words each). Word length was from 3 to 6 letters.

Sixty lists of 12 nouns containing 4 positive, 4 negative emotional words and 4 non-emotional words were constructed. Half of the 12 nouns were presented in the left side of the visual field, and the other half in the right side of the visual field, in random order. Over the 60 lists, presentations were balanced so that each word was repeated an equal number of times and the number of repetitions was equal between the two visual fields.

2.1.3. Apparatus

All subjects were individually tested using an IBM Pentium microcomputer and View Sonic 15 GS monitor. All stimuli were presented in black on a white background. Each word appeared at 1° of the visual angle to the left and right from the point of fixation. All words were horizontally oriented and subtended a range between 1 and 4° of the visual angle from the point of fixation. A digit between 1 and 5 and/or a figure (circle, triangle, square, diamond, star) was displayed at the fixation point together with a word four times in each set of 12 trials. The digits and the figures were $0.5^\circ \times 0.5^\circ$.

2.1.4. Procedure

The experiment was conducted in two stages.

2.1.4.1. Visual half-field recall task. The subjects were presented with two 12-word practice lists. These words were different from those in the experimental conditions. After practice, subjects were given the 30 12-word experimental lists according to the successive presentation method. Subjects were asked to fixate a small cross presented as a warning signal for 1 s in the center of the screen. Twelve word stimuli were exposed randomly and successively in either the left or right visual half-field, with an equal number, six, in each field. The word stimuli were presented for a duration of 180 ms each. This value was chosen because pilot testing indicated that identification of any single item at this exposure duration was almost perfect, yet the duration fell short of the 200 or more ms needed for initiation of eye movements. Each presentation followed the previous stimulus immediately. After the 12-word presentation, a small question mark was presented in the center of the screen as a recall signal. The subject's task was to recall as many words as possible. After recall, 5 digits and 5 figures arranged randomly on the screen were presented. To check that fixation was maintained throughout the presentation, subjects were asked to recognize the four central stimuli that were presented with the words. Each subject received 30 12-word trials (see above).

2.1.4.2. Perceptual test. Immediately after the visual half-field recall task, subjects were given a perceptual test. The procedure of the perceptual test was the same as that of the visual half-field recall task, except that subjects were asked to read words and central stimuli aloud immediately after each one was presented. The subjects were presented with two 12-word lists. The perceptual test was introduced to confirm that subjects could perceive the stimuli presented in the visual half-field, because the present study is an experiment on memory not perception.

2.2. Results

There were no significant sex differences on the data of word recall and perceptual tests, and they were omitted from further analysis.

2.2.1. Recall of words

The results of the visual half-field recall task are shown in Fig. 1. Analysis of variance of correct recall indicated that two main effects were significant: the emotional connotation of the word, $F(2, 17) = 20.38$, $P < 0.01$; and visual field, $F(1, 17) = 7.69$, $P < 0.01$. Positive and negative emotional words were recalled better than non-emotional words ($P < 0.01$, respectively) while there was no difference of word recall between positive and negative emotional words. As predicted there was a main effect favoring the RVF.

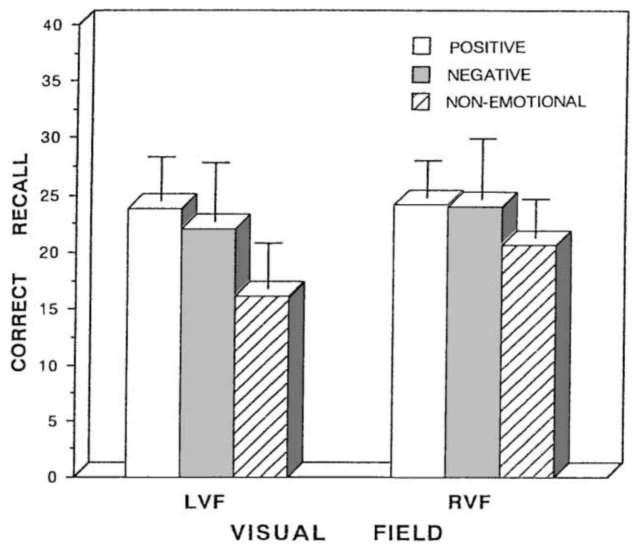

Fig. 1. Mean correct number of positive, negative and non-emotional words recalled in each visual field.

The emotionality of word × visual field interaction was significant, $F(2, 34) = 3.78$, $P < 0.05$). This interaction indicated that recall of non-emotional words was greater for words presented in the RVF than in the LVF ($P < 0.01$), with no significant visual field differences for positive and negative emotional words. Further analyses showed that recall of positive and negative emotional words in both the RVF and LVF was greater than that of non-emotional words ($P < 0.05$, respectively), with the emotional-non-emotional difference being larger in the left field. The difference between positive and negative emotional words in either visual field was not significant. The correct recall rate of the central stimuli was 40.4%. Although it was not high, we think that faulty memory rather than poor fixation accounted for the relatively low rate. Even if fixation were biased, it would not account for the differential effects of emotionality on laterality.

2.2.2. Perceptual test

The results of correct responses on the perceptual test are shown in Table 2. Identification was excellent, and over 90% correct, in both visual fields. Analysis of variance with the correct responses indicated that neither the main effect of emotionality of word and visual field nor their interaction was significant. Therefore, it was confirmed that subjects could perceive the stimuli almost perfectly, and equally well, in each visual field.

Table 2
Mean number of correctly identified positive, negative and non-emotional words in each visual field in the perceptual test (maximum = 4.0)[a]

	LVF (S.D.)	RVF (S.D.)
Positive	3.72 (0.56)	3.61 (0.68)
Negative	3.67 (0.44)	3.94 (0.23)
Non-emotional	3.89 (0.31)	3.72 (0.45)

[a] LVF, left visual field; RVF, right visual field.

2.3. Discussion

There are a number of interesting findings in Experiment 1, all of which are consistent with predictions derived from the hypothesis that there is a left hemisphere advantage for verbal memory and a right hemisphere advantage for emotion. Taken together, the results favor the right hemisphere model over the valence model of emotion. Consistent with the idea of a left-hemisphere superiority for processing and remembering words, there was an overall recall advantage for words presented to the RVF. This finding agrees with that of Ali and Cimino [1]. Additionally, we found that emotional words, whether positive or negative, were recalled better than non-emotional words, corroborating the findings of Hayward and Strongman [12] and Manning and Julian [18].

Against this background of main effects, the interaction between emotionality and visual field provides the evidence most relevant for distinguishing the right hemisphere from the valence model. Although the recall of non-emotional words was better in the RVF, as predicted if there is a left-hemisphere advantage for verbal memory, there was no visual field advantage for either positive or negative emotional words. These results follow from the possibility that right hemisphere advantage in processing emotion was offset by the left-hemisphere's advantage for processing and remembering verbal material.

These results favor the right hemisphere model over the valence model which would have predicted a definite RVF advantage for positive words (see introduction) with a possible LVF advantage for negative words. Consistent with the right hemisphere model of emotion, we found that the difference in recall in favor of positive and negative emotional words over non-emotional words, though found in both visual fields, was greater in the left.

One reason that we were able to find laterality differences between emotional and non-emotional words is that we placed the emphasis on memory and not on perception where a RVF-left hemisphere advantage for word perception would prevent the detection of a right hemisphere contribution for emotion. As the results of the perceptual control condition indicated, we succeeded in making word perception excellent and equivalent in both visual fields thereby allowing right-hemisphere influences on emotion to emerge. In Experiment 2, we show that if the perceptual aspects are stressed, then the laterality differences between emotional and non-emotional words is diminished or eliminated.

3. Experiment 2

Experiment 1 has shown that by reducing the confounding influence of perceptual components, the successive presentation method in visual half-fields is able to reveal laterality differences in memory for emotional and non-emotional words. As a test of this idea, in Experiment 2 we conducted a typical perceptual identification study with brief exposures to examine laterality differences between emotional and non-emotional words. According to our hypothesis (see [21]), the RVF-left hemisphere advantage in verbal processing will mask much of the emotionality effect. It is predicted that a RVF advantage and a diminished or absent laterality effect for emotion will be obtained in all conditions.

3.1. Method

3.1.1. Subjects and design

Subjects were 18 right-handed students (8 males, 10 females) at the University of Toronto who had not participated in the first experiment. All had normal, or corrected to normal, visual acuity. Subjects indicated they did not abuse alcohol or drugs. Two within-subjects factors—emotionality of word (positive, negative, non-emotional) and visual field (left and right)—were used in a 3×2 factorial design.

3.1.2. Stimulus materials

Thirty positive, 30 negative nouns and 30 non-emotional nouns were used. These words were the same as those used in Experiment 1. There were 180 trials divided equally between positive, negative and non-emotional words, with half of each group presented to each visual field.

3.1.3. Apparatus

The apparatus was the same as that used in Experiment 1 as was the location of the words in the visual field and the occurrence of the accompanying fixation digit or figure.

3.1.4. Procedure

Immediately after eight practice trials, each subject was given a visual half-field presentation task. Subjects were asked to fixate their gaze on a small cross for 1 s in the center of the screen. One hundred and eighty words were presented in either the left or the RVF in random order. The word stimuli were presented for a duration of 40 ms. The task was to report the word and the central stimulus (if it was presented together with a word) aloud immediately after presentation.

3.2. Results

The results are illustrated in Fig. 2. They show that perceptual identification favored the RVF regardless of the emotional connotation of the word, even though emotional words were perceived better than non-emotional words. These impressions were confirmed by analysis of variance. Two main effects were significant: emotionality of word, $F(2, 17) = 10.13$, $P < 0.01$; and visual field, $F(1, 17) = 38.24$, $P < 0.01$. Positive and negative emotional words were identified better than non-emotional words ($P < 0.01$ and $P < 0.05$, respectively). Furthermore, positive words were identified better than negative words ($P < 0.05$).

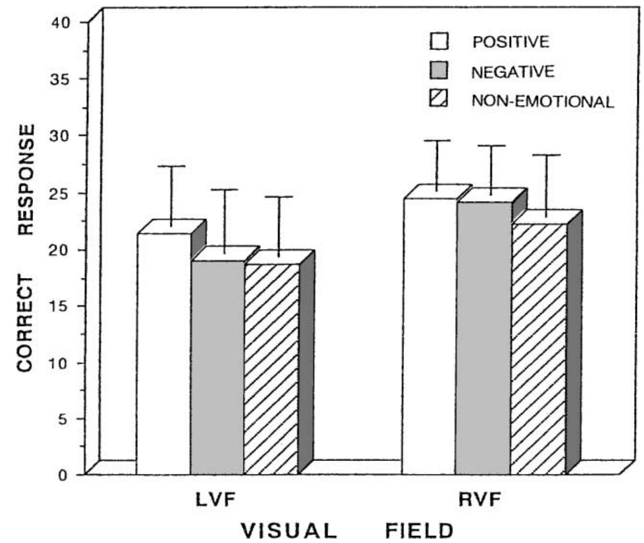

Fig. 2. Mean number of correctly identified positive, negative and non-emotional words in each visual field.

Identification of all words was better in the RVF with no interaction with emotion.

Correct response rate of central stimuli was 93.3%. This result shows that almost all subjects maintained accurate fixation until the word was presented. Jones and Santi [15] too report that almost all normal subjects maintain accurate fixation in visual half-field presentation task.

3.3. Discussion

The results of Experiment 2 show that a RVF advantage was obtained in each word condition, with no significant interaction between emotionality and visual field (see also [9,26]). These results are consistent with our prediction that performance in visual half-field studies on perceptual identification of words will reflect primarily the verbal processing superiority of the left hemisphere, and impede the detection of right hemisphere contribution to emotion.

The finding that positive and negative emotional words and non-emotional words were recognized more accurately when the words were presented tachistoscopically in the RVF is agreement with the finding of Strauss [26] and Eviator [9]. This visual field effect agrees with the consistent findings of the RVF superiority for verbal stimuli. In general, our results show that emotionality of words did not preferentially enhance perception by the right hemisphere. This result is consistent with a PET study by Beauregard et al. [2] who found that viewing random-letter strings or abstract, concrete, or emotional words with positive or negative connotations produced robust activation of cerebral blood flow in the left posterior temporal lobe, regardless of word type.

4. General discussion

The major finding of the present study is that there is a right-hemisphere advantage in processing memory for words with both positive and negative emotional connotations of words. This advantage is revealed when perceptual factors are reduced or eliminated and memory is a crucial component of the task. These results support a right hemisphere, over a valence, model of emotion. Although neutral words were recalled best when presented to the RVF consistent with a left-hemisphere advantage for verbal memory, positive and negative emotional words did not show such an advantage, indicating that right-hemisphere contribution to emotion counteracted the left hemisphere advantage for verbal memory. Moreover, there was a larger difference in recall between emotional and non-emotional words in the LVF than in the RVF, as the right hemisphere, but not the valence, model would predict. The contribution of the right hemisphere to memory for emotional word is likely related to its involvement in autonomic and behavioral arousal during emotional states [13]. The results of this study are also consistent with the view that the processing of emotionally valenced stimuli may be preferentially mediated by the parietal regions of the right hemisphere [13].

Our study also showed that right hemisphere contributions to processing emotional connotations of words can be detected in visual half-field studies only once the influence of the left-hemisphere on perceptual identification of verbal material is diminished or eliminated. To do so we used a new successive presentation technique in which words are presented at exposure durations long enough to ensure that perceptual identification is nearly perfect and equivalent in both fields, yet short enough to preclude eye movements. Instead of testing for perceptual identification, we tested memory for words presented to either visual field to determine if any laterality effects for emotional connotation would be found. As predicted, we found laterality differences between emotional and non-emotional words when using the successive presentation technique, long exposures, and testing for memory in Experiment 1. In contrast, when testing for perceptual identification at short exposure durations in Experiment 2, we found a RVF advantage for all words, whether emotional or neutral, consistent with the observation that word perception favors the left hemisphere [20,21].

One interpretation of the present study is that laterality effects in processing emotional quality of words emerged at later stages of processing, particularly those associated with memory encoding, rather than with perception. Our finding that emotional words are not just remembered better than neutral words (Experiment 1), but also perceived better (Experiment 2) argues against this simple interpretation. Instead it suggests that emotional connotation can contribute to perception, perhaps in a top-down fashion, in which visual half-field laterality effects are not detected easily. Once perceptual influences are diminished and memory is emphasized, right hemisphere contributions, which had been masked, emerge more clearly.

Our findings raise the question as to whether the successive presentation, memory technique will be effective even if it is combined with presentations at short exposure durations, as in Experiment 2, where perception is poor. We predict it would not be, based on our hypothesis that laterality effects at early stages of processing will have an over-riding influence on later stages. It may be the case, however, that once memory is given full play, it provides an opportunity for non-perceptual factors to contribute more to laterality effects than they would in studies whose focus is on perception.

We hope future studies will decide between the two alternatives. Whatever the outcome of those future experiments, the present study demonstrated that adding a memory component to laterality tests is important for uncovering laterality effects for connotations of words whose influence comes into play at late stages of processing, but may be masked by earlier stages where perceptual influences are strongest. In other words, the present study demonstrated that by eliminating the confounding effects of perception, and placing the emphasis on later stages of processing, such as memory, successive presentation/memory technique could be used to reveal hemispheric asymmetries at these later stages [20,21]. This technique may be applied successfully to study laterality associated with other attributes of words, such as concreteness [10,22], imageability [8], frequency [14], and word length [4,9], that so far have yielded inconsistent right-hemisphere effects.

Acknowledgements

The authors are greatly indebted to Marcel Kinsbourne, Martin L. Albert, Harold Goodglass, and Marlene Oscar-Berman for constructive criticism and discussions, Marilyne Ziegler for technical assistance and Elizabeth Olszewska for research assistance. This research was supported in part by a NSERC of Canada grant (A8347) to MM.

References

[1] Ali N, Cimino CR. Hemispheric lateralization of perception and memory for emotional verbal stimuli in normal individuals. Neuropsychology 1997;11:114–25.
[2] Beauregard M, Chertkow H, Bub D, Murtha S, Dixon R, Evans A, et al. The neural substrate for concrete, abstract, and emotional word lexica: a positoron emission tomography study. Journal of Cognitive Neuroscience 1997;9:441–61.
[3] Borod JC, Andelman F, Obler LK, Tweedy JR, Welkowitz J. Right hemisphere specialization for the identification of emotional words and sentences: evidence from stroke patients. Neuropsychologia 1992;30:827–44.
[4] Bruyer R, Janlin D. Lateral differences in lexical access: word length versus stimulus length. Brain and Language 1989;37:258–65.
[5] Carmon A, Nachson I. Ear asymmetry in perception of emotional nonverbal stimuli. Acta Psychologica 1973;37:351–7.

[6] Cimino C, Verfaellie M, Bowers D, Heilman KM. Autobiographical memory: influence of right hemisphere damage on emotionality and specificity. Brain and Cognition 1991;15:106–18.
[7] Davidson RJ. Emotion and affective style: hemispheric substrates. Psychological Science 1992;3:29–43.
[8] Day J. Right hemisphere language processing in normal right handers. Journal of Experimental Psychology: Human Perception and Performance 1977;3:518–28.
[9] Eviatar Z, Zaidel E. The effects of word length and emotionality on hemispheric contribution to lexical decision. Neuropsychologia 1991;29:415–28.
[10] Eviatar Z, Menn L, Zaidel E. Concreteness: nouns, verbs, and hemispheres. Cortex 1990;26:611–24.
[11] Graves R, Landis T, Goodglass H. Laterality and sex differences for visual recognition of emotional and non-emotional words. Neuropsychologia 1981;19:95–102.
[12] Hayward JA, Strongman KT. Emotional words, free recall, and laterality. Bulletin of the Psychonomic Society 1987;25:161–2.
[13] Heller W. Neuropsychological mechanisms of individual differences in emotion, personality, and arousal. Neuropsychology 1993;7:476–89.
[14] Hines D. Differences in tachistoscopic recognition between abstract and concrete words as a function of visual half-field and frequency. Cortex 1977;13:66–73.
[15] Jones B, Santi A. Lateral asymmetries in visual perception with and without eye movements. Cortex 1978;14:164–8.
[16] Ladavas E, Umilta C, Ricci-Bitti P. Evidence for sex differences in right hemisphere dominance for emotions. Neuropsychologia 1980;18:361–6.
[17] Mahoney AM, Sainsbury RS. Hemispheric asymmetry in the perception of emotional sounds. Brain and Cognition 1987;6:216–33.
[18] Manning SK, Julian L. Recall of emotional words. Journal of General Psychology 1975;92:237–44.
[19] Master DR, Thompson C, Dunn G, Lishman WA. Memory selectivity and unilateral cerebral dysfunction. Psychological Medicine 1986;16:781–8.
[20] Moscovitch M. Information processing and the cerebral hemispheres. In: Gazzaniga MS, editor. Handbook of behavioral neurobiology: neuropsychology, vol. 2. New York: Plenum Press, 1979. p. 379–446.
[21] Moscovitch M. Afferent and efferent models of visual perceptual asymmetries: theoretical and empirical implications. Neuropsychologia 1986;24:91–114.
[22] Nagae S. Semantic processing functions of Kanji and Kana words in the right hemisphere. Japanese Journal of Psychology 1994;65: 144–9.
[23] Paivio A, Yuille JC, Madigan SA. Concreteness, imagery, and meaningfulness values for 925 nouns. Journal of Experimental Psychology: Monograph Supplement 1968;76:1–25.
[24] Rubin DC, Friendly M. Predicting which words get recalled: measures of free recall, availability, goodness, emotionality, and pronounciability for 925 nouns. Memory & Cognition 1986;14:79–94.
[25] Silberman EK, Weingartner H. Hemispheric lateralization of functions related to emotion. Brain and Cognition 1986;5:322–53.
[26] Strauss E. Perception of emotional words. Neuropsychologia 1983;21:99–103.
[27] Suberi M, McKeever WF. Differential right hemispheric memory storage of emotional and non-emotional faces. Neuropsychologia 1977;15:757–68.