Hemispheric specialization and the perception of emotion: Evidence from right-handers and from inverted and...

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NOTE

HEMISPHERIC SPECIALIZATION AND THE PERCEPTION OF EMOTION: EVIDENCE FROM RIGHT-HANDERS AND FROM INVERTED AND NON-INVERTED LEFT-HANDERS*

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Abstract—Right-handers and inverted and non-inverted left-handers viewed emotional expressions in one hemifield and, simultaneously, a neutral expression of the same poser in the other hemifield. Subjects were required to identify the side containing the affective face. Happy faces with open (i.e. salient) and closed mouth smiles and sad faces were used as stimuli. For right-handers and inverters reaction time was faster to right hemifield presentations for happy faces and to left hemifield presentations for sad faces. Non-inverters showed the reverse pattern. The saliency of the happy expressions had no effect on the magnitude and direction of asymmetry for any group. The data support the hypothesis of differential hemispheric specialization for positive and negative emotion and demonstrate opposite patterns of asymmetry in affect perception for inverted and non-inverted left-handers.

INTRODUCTION

Evidence of left hemispheric (LH) specialization for positive affect and right hemispheric (RH) specialization for negative affect has come primarily from investigations of clinical populations [8, 25, 27, 30] and electrophysiological studies of normal subjects [3, 4]. These investigations have focused on neurological and electrophysiological correlates of positive and negative emotional states and associated affective behaviors such as laughing and crying.

A different picture of brain organization, however, has emerged from research on the perception of emotional stimuli such as emotional facial expressions [15, 20, 28, 29], cartoons [9] and affectively toned speech [2, 31]. Findings from both normal subjects and patients with unilateral brain damage have usually implicated the RH as superior in this domain (but see [14]).

There has been some discrepancy, however, in the results from tachistoscopic studies of perceptual asymmetries. Ladavas *et al.* [15], Ley and Bryden [20], Strauss and Moscovitch [28] and Suberi and McKeever [29] reported an RH advantage in emotional face perception, regardless of the type of expression. Ley and Bryden [20] and Suberi and McKeever [29], however, found that the advantage was greatest for certain negative emotions, although the difference was not significant. Reuter-Lorenz and Davidson [26], on the other hand, found an RH advantage only for sad faces and an LH advantage for happy faces. Differences in procedure and stimuli may have contributed to the differences in these results.

Ley and Bryden [20], Suberi and McKeever [29] and Strauss and Moscovitch [28] all used a same–different recognition paradigm. When faces are used as stimuli in this type of paradigm, even if the task is to discriminate emotion, an RH advantage may emerge because of the role of the RH in face recognition [1]. Additionally, this task may introduce cognitive operations which confound or obscure the emotion perception capabilities of the right and

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left hemispheres. By asking subjects simply to detect emotion, not to categorize or match the expression with some other exemplar, REUTER-LORENZ and DAVIDSON [26] may have obtained a measure of emotion perception that was less confounded by cognitive factors.

In the Reuter-Lorenz and Davidson paradigm an emotional face was presented to one visual field and a neutral face to the other. The subjects' task was to indicate the side on which the emotional face was presented. As dichotic listening experiments have indicated [13], conditions of inter-hemispheric competition may be particularly sensitive indicators of hemispheric differences. Thus the paradigm used by Reuter-Lorenz and Davidson may have also allowed for the differential sensitivities of the hemispheres to happy and sad faces to emerge more fully.

The stimuli from the different affective categories were well matched in the Reuter-Lorenz and Davidson study. Separate analyses were performed on faces which were matched for both perceived intensity and spontaneity of emotional expression. Differences between stimuli along these dimensions may have contributed to the pattern of laterality found in the other investigations.

One stimulus characteristic which Reuter-Lorenz and Davidson did not control was cue saliency in the faces. Pictures of faces with broad open mouth smiles in which teeth were visible were used for the happy expressions. The saliency of the mouth as a cue for identifying happy faces may have promoted the use of an analytic strategy which contributed to the LH advantage for happy faces [24]. This implies that stimulus features which could be independent of the emotional content of the face produced the pattern of asymmetry.

Reuter-Lorenz and Davidson's pattern of results are consistent with some of the clinical and electrophysiological evidence of affect asymmetries. However, it is the only tachistoscopic study on emotion perception to find an LH advantage for happy faces. In this light it seemed important to replicate and extend these findings and examine the above alternative explanations.

In the present investigation happy faces with closed mouth smiles were included to reduce the saliency of the mouth as a single cue by which happy faces could be discriminated. In addition, asymmetries in affect perception were examined in inverted and non-inverted left-handers.

Handwriting posture can be inverted, in which case the hand lies above the line of print and the pen points toward the bottom of the page, or non-inverted, in which case the hand lies below the line of print and the pen points to the top of the page. Based on the performance of inverted and non-inverted left-handers on various linguistic and spatial tasks, LEVY and REID [18, 19] hypothesized that hemispheric organization differs in these two groups. Currently the best description of the evidence is that when laterality is measured with visual tasks, inverted left-handers, like right-handers, have certain linguistic processes lateralized to the LH and are RH-dominant for visuospatial processes [17]. Non-inverted left-handers have an opposite pattern of lateralization, with language primarily in the RH and spatial processes in the LH. Accordingly, it is predicted that both right-handers and inverted left-handers should show similar patterns of asymmetry in the perception of emotional faces: an LH advantage for happy faces and an RH advantage for sad faces. Non-inverted left-handers should show the opposite pattern.

METHOD AND PROCEDURE

Subjects

A total of forty undergraduates volunteered to be subjects and received course credit in Introductory Psychology for their participation. There were 10 male and 10 female non-inverted right-handers. Left-handers were selected on the basis of LEVY and REID's criteria [18]. Ten left-handed inverters and 10 left-handed non-inverters, 5 male and 5 female in each group, participated in this study. Handedness was assessed with the Edinburgh Inventory [23].

Stimuli

Slides of open and closed mouth happy, sad and neutral expressions were selected from Ekman's pictures of facial affect [7].

Procedure

Two pictures of the same poser were presented simultaneously, one to each visual hemifield. The inner edge of each image fell 2° off central fixation. One picture was an emotional expression and the other was a neutral expression. Happy open mouth, happy closed mouth and sad expressions were presented in a random sequence to the right or left visual hemifields. The stimuli were presented in a Scientific Prototype tachistoscope for 250 msec at an illumination level of 4 mL.

Approximately 500 msec prior to stimulus onset, a warning tone signalled the subject to fixate a central point and prepare for the stimulus. Subjects were instructed not to move their eyes from the central point until the offset of the stimulus. Their task was to indicate whether the emotional face appeared on the left or right of the screen by pressing the response key on the corresponding side. For half the trials subjects used the right hand to respond and for the other half the left. Reaction time from stimulus onset until button press was recorded manually by the experimenter.

Twenty-four pictures of open mouth happy expressions and 24 sad expressions were presented to each visual hemifield. Due to a limited number of closed mouth happy expressions in the Ekman set, only 16 of these expressions were presented to each hemifield.

RESULTS

The data for right-handers were analyzed separately from the left-handers' data and will be discussed first. The accuracy data, presented in Table 1, indicate that for right-handers happy open mouth smiles are associated with higher accuracy than the other two expressions, which do not differ. A two-way analysis of variance (ANOVA) with emotion and hemifield as within-subject factors yielded only a significant main effect for emotion [$F\ (2, 38)=22.7$; $P<0.001$].

Table 1. Accuracy*

	Open-mouth happy	Closed-mouth happy	Sad
Right-handers $\bar{x}$	84.5	68.9	68.8
($n=20$) s.d.	(12.9)	(15.6)	(14.2)

* As % correct scores.

Reaction time (RT) scores for correct trials only are presented in Fig. 1. A two-way ANOVA computed for these data indicated a significant emotion × hemifield interaction [$F\ (2, 38)=8.9$; $P<0.001$]. Responses to both happy open and closed mouth smiles were faster for right visual field (RVF) presentations [$t\ (38)\ 2.7$; $P<0.05$; $t\ (38)=3.1$; $P<0.05$ respectively], whereas responses to sad faces were faster for left visual field (LVF) presentations [$t\ (38)=3.1$; $P<0.05$]. The only other significant effect was a main effect for emotion [$F\ (2, 38)=32.8$; $P<0.001$], which was due to faster responses to happy open mouth expressions.

For the left-handers three-way ANOVAs with hand posture as a between-subjects factor and emotion and hemifield as within-subject factors were computed for the accuracy and RT data. The accuracy data for inverted and non-inverted left-handers are presented in Table 2. It can be seen that the performance of the two groups did not differ for any of the emotions. The only significant effect was a main effect for emotion [$F\ (2, 36)=8.3$; $P<0.002$], again due to higher accuracy for the happy open mouth expressions.

Table 2. Accuracy*

	Open-mouth happy	Closed-mouth happy	Sad
Left-handed inverters $\bar{x}$	84.6	73.5	69.9
($n=10$) s.d.	(11.9)	(13.7)	(13.2)
Left-handed non-inverters $\bar{x}$	86.8	74.5	71.1
($n=10$) s.d.	(11.7)	(8.6)	(12.9)

* As % correct scores.

The RT analysis also indicated a main effect for emotion [$F\ (2, 36)=27.4$; $P<0.001$] due to faster responses to the open mouth smiles. In addition, there was a three-way interaction between hand posture, emotion and hemifield [$F\ (2, 36)=5.7$; $P=0.007$]. This effect indicates that the pattern of hemifield advantage for happy and sad faces varied reliably as a function of handedness and handwriting posture.

As can be seen from Fig. 2, inverted left-handers showed faster RTs for open and closed mouth smiles when these faces were presented to the RVF compared to LVF presentations [$t\ (9)=1.9$; $P<0.05$; $t\ (9)=2.04$; $P<0.05$, one tail, respectively]. For sad faces LVF presentations were associated with shorter RT's compared to RVF presentations [$t\ (9)=1.53$; $P<0.075$, one tail].

A striking reversal of this pattern was found for the non-inverted left-handers (see Fig. 3). Open and closed mouth smiles were associated with shorter RTs for LVF presentations [t (9)$=2.5$; $P<0.025$; t (9)$=1.2$; $P<0.10$, one tail, respectively]. When sad faces were presented to the RVF RTs were shorter than when the same faces were presented to the LVF [t (9)$=2.9$; $P<0.01$, one tail].

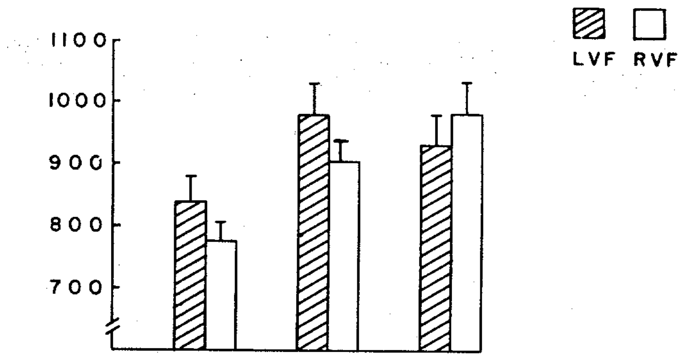

FIG. 1. RT for right-handers ($n=20$).

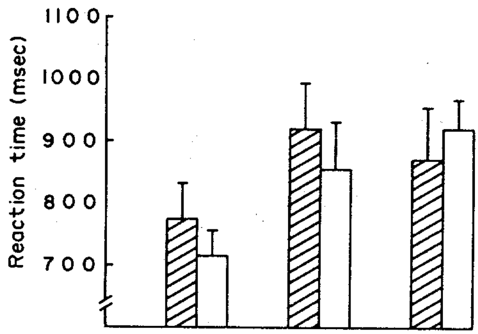

FIG. 2. RT for inverted left-handers ($n=10$).

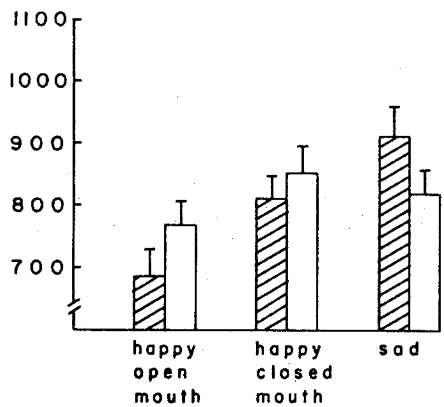

FIG. 3. RT for non-inverted left-handers ($n=10$).

DISCUSSION

The data from each handedness group support the hypothesis that the hemispheres are differentially specialized for positive and negative affect. Both the open and closed mouth happy faces were associated with a hemisphere advantage that is opposite to that found for sad faces. It is apparent from the data that the open mouth happy faces were more rapidly and more accurately discriminated in either visual field than the other two expressions. Nonetheless, there was no difference in the magnitude of hemifield advantage for the open and closed mouth smiles, suggesting that cue saliency was not a critical factor in determining the size and direction of perceptual asymmetries.

The possibility still exists that in the present paradigm the discrimination of happy and sad faces is accomplished by analyzing different stimulus features rather than relying on the affective content *per se*. Happy faces may be identified exclusively on the basis of the bottom half of the face (i.e. the mouth) whereas sad faces call for processing the whole face. These differences alone could account for the laterality effect observed in this study. Although the recent work of ZAJONC [33] argues for the precedence of affect in sensory processing, this alternative should still be examined.

We are currently testing this hypothesis and preliminary findings from 10 subjects suggest that sad faces, like happy faces, can be identified as emotional on the basis of a limited number of facial features. If this effect proves to be reliable, it must be established that differential hemisphere advantages for happy and sad faces persist when the number of identifying features in these faces is equivalent.

The pattern of findings for inverted and non-inverted left-handers is consistent with the Levy–Reid hypothesis [18, 19]. These findings suggest that neural processes associated with the perception of facial affect are differentially organized as a function of handedness and handwriting posture.

At present there is some controversy concerning how to characterize the differences between inverters and non-inverters if, indeed, such differences exist [17, 2]. On the basis of sodium amytal investigations, Ajersch and Milner (cited by MILNER [21]) reported that posture does not reliably predict the hemisphere dominant for speech. However, using alpha activity as an index of hemispheric involvement, HERRON *et al* [12] found that dominance associated with other linguistic processes such as reading is related to handwriting posture. Furthermore, MOSCOVITCH and SMITH [22] reported that inverters and non-inverters have different patterns of neural organization subserving visual–motor processes. One way of characterizing the laterality differences of inverters and non-inverters may be in terms of visual–motor processes.

A link between emotion perception and certain visual–motor processes has been made by GOMBRICH *et al.* [11]. According to this view, motor processes involved in emotion expression and experience contribute to the perception of emotion. Through the process of unconscious or subthreshold imitation meaning can be derived from the perception of facial expressions. There is recent evidence suggesting that the motor mechanisms for the expression of positive and negative emotions may be independent and lateralized in opposite hemispheres [27]. It may be that these mechanisms are lateralized differentially as a function of handedness and handwriting posture and underlie the patterns of asymmetry in affect perception found in each of the handedness groups.

To summarize, the results from the present study replicate and extend the findings reported by REUTER-LORENZ and DAVIDSON [26] and demonstrate a further difference in the functional brain organization of inverted and non-inverted left-handers. Thus the discrepancy between these findings and those from other tachistoscopic studies of affect asymmetries needs to be explained. It may be helpful to consider the other investigations of emotion perception which have found differential lateralization of positive and negative emotions using measures other than RT and accuracy. When the perception of emotion arousing stimuli has been assessed by monitoring heart rate [5] or asking the subject to evaluate material, greater LH involvement in positive affect and RH involvement in negative affect has been found ([6, 10, 16]; but see [2]). Differential lateralization of positive and negative emotions may be evident when the subjects' emotional reaction to the stimulus contributes to the type of response being measured in the experiment. In this study it may be that subjects needed to rely on reactions to the briefly exposed stimuli which were barely conscious and perhaps more affective in nature than cognitive. Since subjects did not categorize or match the stimuli with targets, the strategy employed may have been more similar to the kinds of processes used in face-to-face interactions in which fleeting emotional expressions are perceived and elicit spontaneous responses.

The present findings point to the need to draw distinctions between different aspects of emotional processes that may be tapped in various experimental procedures. Furthermore, they demonstrate that characterizing the right hemisphere as the "emotional hemisphere" may be an oversimplification.

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