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Is Happy Facial Expression Identified by the Left or Right Hemisphere?*

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Abstract A critical difference between the right hemisphere hypothesis and valence hypothesis of emotion processing is whether the processing of happy facial expressions is lateralized to the right or left hemisphere. In this study participants from a Chinese sample were asked to classify happy or neutral facial expressions presented either bilaterally in both visual fields or unilaterally in the left visual field (LVF) or right visual field (RVF). They were required to make the speeded responses using either the left or right hand. It was found that for both left and right hand responses, happy (and neutral) expressions presented in the LVF were identified faster than happy (and neutral) expressions presented in the RVF. Bilateral presentation showed no further advantage over LVF presentation. Moreover, left hand responses were generally faster than right hand responses, although this effect was more pronounced for neutral expression. These findings were interpreted as supporting the right hemisphere hypothesis, with happy expression being identified initially by the right hemisphere.
Key words facial expression, positive emotion, happy, hemisphere, divided visual field.

1 Introduction

Correctly identifying other people's facial expressions of emotions is important to human social interaction in all societies. Many studies suggest that the identification of facial expressions in particular and perceptual processing of emotional information is carried out mainly by the right hemisphere of the brain [1~7]. Damage to the right hemisphere generally produces more significant impairment in recognition of all facial expressions of emotion than damage to the left hemisphere [8~10]. However, this right hemisphere hypothesis is challenged by the valence hypothesis which states that processing of positive emotions is lateralized to the left hemisphere whereas processing of negative emotions is lateralized to the right hemisphere [11~20]. Apparently a critical difference between the two hypotheses is whether processing of happy facial expression is lateralized to the left or right hemisphere, although some studies suggested that both hemispheres may be involved in processing positive emotions [10,21,22].

Both the right hemisphere and valence hypotheses are supported by studies using different experimental manipulations and tasks. Evidence concerning affective facial expressions comes mainly from two lines of research [1]. One line used composite (chimeric) faces in which half-faces of different expressions were re-combined and participants were asked to evaluate the emotional intensity of the combined faces [2,5,21,23~25]. This line of research, however, produced contradictory evidence for either the right hemisphere or the valence hypothesis. Another line of research, which is more pertinent to this study, presented full, normal faces

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to the left

dominantly by one hemisphere, then reaction times (RTs) to faces presented to this hemisphere should be similar to RTs to faces presented to both hemispheres (in bilateral presentation), and TD (e)Tj 0.444 0 TD (s)Tj 0.38 0 TD (e)Tj 0.444 0 TD (n).j 0.444

the faces presented TD (e)Tj 13 0 TD (s)Tj 0.38 0 TD (h)Tj 0.5 0 TD (o)Tj 0.444 0 TD (u)Tj 0.5 0 TD (l)Tj 0.278 0 TD (d)Tj 1 0 bias because new objects may capture attention, making the comparison between RTs to facial expressions in different visual fields more pertinent to emotion processing.

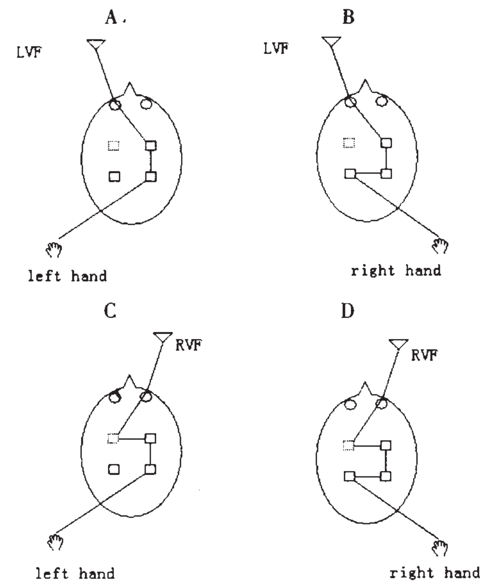

Figure 1 Interaction between stimulus projection and hand response in the brain. Assuming that affective facial expressions are identified by the right hemisphere, A) the left visual field input projects directly to the right hemisphere, where the brain regions connect directly with motor cortexes responsible for the left hand activity; B) the right visual field input projects to the left hemisphere, from whether the information is redirected to the right hemisphere; C) the left side motor cortexes, responsible for the right hand activity, connect across the hemispheres to the brain regions on the right hemisphere either directly or through the motor cortexes on right side; D) in this situation, the processes from stimulus input to hand response are the most complex, with two interhemispheric transmissions of information, one for stimulus input and one for motor control.

2 Method

2.1 Participants

A total of 32 right-handed participants were tested, 16 each for right or left hand responses. In each run, half of the 16 participants were male, half female. They were undergraduate students from Peking University and were paid for their participation. All had normal or corrected-to-normal vision and all gave their informed consent to participate in the study.

2.2 Stimuli

A total of 84 faces were used, 42 with happy expressions and 42 with neutral expressions. Half of the faces in each set were males and half females. All the faces were from different individuals, and they were taken from a standard Chinese facial expression set [32] and from our own unpublished set. To prevent participants from using simple perceptual strategies based on the visibility of teeth when judging facial expressions, care was taken to ensure that happy faces could display either open- or closed-mouth. All faces were edited using Adobe PhotoshopTM, converted to greyscale, and framed within a rectangular of 6.0cm×7.6cm or 3.5°×4.4° in visual angle, with all background removed. Stimulus eccentricity (center to fixation) on the computer screen was 5.0cm, corresponding to a angle of about 2.9°. For unilateral presentations, each face was paired with a unique pattern mask which was created by scrambling randomly the paired face divided into 9×11 pieces. The pattern mask was of the same size as the paired face.

2.3 Procedure

Participants were tested individually in a dimly-lit room and with a viewing distance of 100cm. During each trial, a fixation sign "+" was presented for 1000ms, followed by a pair of identical faces (for bilateral presentation) or a face and a pattern mask (for unilateral presentation) for 150 ms on either side of the fixation, which remained on screen until the end of face presentation. The screen was then blanked for 2000ms, give a total of 3150ms for each trial. Participants were required to classify, by pressing response keys as quickly and as accurately as possible, whether the presented facial expression was happy or neutral. Response keys were on a joystick, two on the left, two on the right, and one above another on either side. Participants were asked to place the index finger of the response hand on the top key and the middle finger on the lower key. The expression-to-key assignment was counter-balanced over participants. Presentation of stimuli and recording of participants' responses were controlled by the software DMDX [33] .

Each run had 252 trials, with each of the 84 facial expressions presented three times, once in the BVF condition, once in LVF and once in RVF. These trials were completely randomized for each participant, with two breaks allowed every 84 trials. Before the formal test, a practice block of 24 trials, covering all the relevant conditions, was administered to each participant.

3 Results

Trials with incorrect responses were excluded from analyses. Median RTs and error percentages were then calculated for each participant as a function of experimental conditions. Exactly the same pattern of results were found when mean RTs were used in statistical analyses. Table 1 summarizes the inter-participant means of RTs and error percentages for different types of facial expressions in the three presentation conditions.

Table 1 Mean Reaction Times (ms) and Error Percentages (in parenthesis) to Happy and Neutral Expressions Presented Bilaterally or Unilaterally

	Happy			Neutral		
	BVF	LVF	RVF	BVF	LVF	RVF
Left Hand	623	627	650	843	857	868
	(4.1)	(4.0)	(7.0)	(6.1)	(5.5)	(6.3)
Right Hand	661	665	705	964	967	990
	(3.3)	(4.0)	(5.4)	(8.2)	(8.6)	(9.7)
Average	642	646	677	903	912	929
	(3.7)	(4.0)	(6.2)	(7.1)	(7.0)	(8.0)

For RTs, the main effect of facial expression was highly significant, $F(1,30)=226.42$, $p<0.001$, indicating that responses to happy expressions (655ms) were much faster than responses to neutral expressions (915ms). The main effect of visual field was also significant, $F(2,60)=17.07$, $p<0.001$, and this effect did not interact with response hand, $F(2,60)<1$, nor with facial expression, $F(2,60)<1$, suggesting that for both types of responses and for both happy and neutral expressions, participants' response speed was affected by whether the affective faces were presented at the left, right, or both visual fields. Bonferroni-corrected comparisons showed that responses to bilateral presentation (773ms) were equally fast as responses to LVF presentation (779ms), both of which were faster than responses to RVF presentation (803ms), with $p<0.001$.

The main effect of response hand was marginally significant, $F(1,30)=3.05$, $0.05<p<0.1$, indicating that left hand responses (745ms) were generally faster than right hand responses (825ms). However, this effect interacted with facial expression, $F(1,30)=4.66$, $p<0.05$, indicating that the difference in response speed between response hand was mainly contributed by neutral expressions (left hand, 856ms vs. right hand, 973ms), and only little by happy expressions (633ms vs. 677ms).

Analyses of response error rates found a significant main effect of facial expression, $F(1,30)=5.20$, $p<0.05$, with more errors committed on neutral expressions (7.39%) than on happy expressions (4.62%). The main effect of visual field was marginally significant, $F(2,60)=3.01$, $0.05<p<0.1$, with slightly higher rate in RVF (7.1%) than in BVF (5.4%) and LVF (5.5%). No other effects reached significance.

4 Discussion

For both left and right hand responses, happy (and neutral) expressions presented in the LVF were identified faster than happy expressions presented in the RVF. Bilateral presentation showed no further advantage over LVF presentation. Moreover, left hand responses were generally faster than right hand responses, although this effect was more pronounced for neutral expression. These findings strongly suggest that happy expression is identified predominantly by the right hemisphere, consistent with the right hemisphere hypothesis.

This pattern of effects can be easily understood under the framework depicted in Figure 1. If identification of happy expressions is lateralized to one hemisphere, stimulus input from the ipsilateral visual field would projected to contralateral hemisphere and this input has to be redirected to the "correct" hemisphere before it could be processed. This interhemispheric transmission takes time to accomplish and would result in delayed emotional categorization. This visual field effect is not affected by the hand used to make responses. But hand response does interact with visual field of stimulus presentation in deciding the overall speed of categorization. Although all our participants were right handed, their responses to both neutral and happy expressions were slowed when the right hand, rather than the left hand was used to make categorization. This finding is consistent with the assumption in Figure 1 that when affective emotions are identified by the right hemisphere, using the right hand to response would need additional interhemispheric connections between motor cortex and brain regions responsible for affective processing.

The question is then why the present study obtained evidence supporting the right hemisphere hypothesis while some other studies obtained evidence supporting the valence hypothesis, even though essentially the same visual field paradigm was used. As pointed out by some researchers such as Davidson [29], Ley and Strauss [30], Rodway et al [27]. and van Strien and van Beek [26], a crucial difference between these visual field studies may lie in wh

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