Relationship between Sex-role Identity and Functional Cerebral Lateralization

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Abstract The present study examined the relationship between sex-role identity (SRI) and functional cerebral lateralization (FCL) in right-handed males. Two tasks (figure task and location task) were used to assess FCL. The figure task required the identification of shape stimuli, while the location task involved identification of the position of stimuli. SRI was assessed by the Bem Sex Role Inventory (BSRI). Males with higher masculine scores in the BSRI indicated greater differences in the reaction time between right and left visual-fields in the location task. This finding suggests that males with higher masculinity in SRI might have greater FCL. *J Physiol Anthropol Appl Human Sci* 24(3): 221–225, 2005 <http://www.jstage.jst.go.jp/browse/jpa> [DOI: 10.2114/jpa24.221]

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Introduction

Males may have greater functional cerebral lateralization (FCL) compared with females (Kimura, 1992; Kikuchi, 1998) in humans. Although sexual differences in FCL have been shown in functional magnetic resonance imaging (fMRI) studies (Levin et al., 1998; Baxter et al., 2003), greater FCL in males has not been reported in fMRI responses (Gur et al., 2000). A review of visual half-field experiments has revealed no differences in performance between right and left visual-fields in males (Hiscock et al., 1995). These studies are inconsistent with the finding that greater FCL occurs in males.

Sex-role identity (SRI) may be related to FCL. Sex steroidal hormones have been identified as a major factor in sexual differentiation of brain function (Toran-Allerand, 1984; Kimura, 1992; Kikuchi, 1998). On reviewing the relationships between sex steroidal hormones and FCL, Wisniewski (1998) concluded that testosterone is the most likely candidate to influence FCL. It has been thought that testosterone (androgen) plays a role in masculinizing SRI (Dörner, 1985; Wilson, 1999, 2001). Baucom et al. (1985) have reported that females with high masculinity levels display higher testosterone levels than those with low masculinity levels. Moreover, a positive

relationship between masculine scores and spatial performance has been observed (Hamilton, 1995). In comparison with homosexual males, heterosexual males have shown better spatial performance (Sanders and Wright, 1997), demonstrating that a significant difference exists between the left and right visual-field scores in heterosexual males, although the visual difference was not significant for homosexual males. Those findings imply that males with a higher masculine level have greater FCL.

The present study was designed to investigate the relationship between SRI and FCL in right-handed males. We evaluated FCL by visual tasks, where a stimulus was delivered to the peripheral visual-field, because semi-field visual information is relayed en masse to the contralateral visual cortex via the chiasm (Wolter, 1965). Since it has been suggested that testosterone accelerates information processing of the right cerebral hemisphere (Tan et al., 1993), two visual tasks espousing identification of the shape (figure task) and position (location task) of a target-stimulus were performed. The location task would strongly involve information processing of the right cerebral hemisphere, as this cerebral hemisphere dominates the functional aspects of visuo-spatial attention and visuo-spatial information processing (Heilman and Van Den Abell, 1980; Corbetta et al., 1993; Nobre et al., 1997; Butler et al., 2004).

Methods

Subjects

Thirteen healthy males of ages 22–28 (mean: 25 ± 1.6) years participated in the study. All subjects were assessed as right-handed by the Chapman Handedness Inventory (Chapman and Chapman, 1987).

Apparatus

A personal computer (Pro-650, EPSON DIRECT Co. Ltd., Japan) with an 18-inch LCD display (Flex Scan L676, EIZO NANO Co. Ltd., Japan) and a timer board (PC-6301, Interface Co. Ltd., Japan) was installed with a mouse. Subjects used a chin-rest to maintain a consistent distance of 56 cm from the eye to the display panel at variable visual angles.

a: Figure task

b: Location task

Fig. 1 These panels symbolize the sequence of display for the two visual tasks.

Visual tasks

For the figure task (Fig. 1a), a prediction stimulus (circle, triangle or quadrangle; visual angle: 0.5° from the horizontal plane) was presented in the center of the display. Subjects were required to click the stimulus with the mouse, whereupon it disappeared. After the stimulus had disappeared, a fixation box (visual angle: 0.5° ; see above) appeared in the center of the display panel for 2000–4000ms followed by display of a target-stimulus (circle, triangle or quadrangle; visual angle: 0.5° ; see above) with a digit (0, 1, 2 or 3; visual angle: 0.3°) for 100 ms. The target-stimulus was located at 3° or 6° from the digit in the fixation box. The subject was instructed to press a button on the mouse as quickly as possible, and the reaction time (RT) was clocked when the target-stimulus was identical with the prediction stimulus. Finally, a report form with digits appeared, and subjects keyed in the digit detected by clicking the corresponding digit on the display.

The location task was conducted in a manner similar to the figure detection task. In the location task (Fig. 1b), landmark stimuli (four quadrangles; visual angle 0.5° ; see above) were presented at 3° or 6° from a prediction stimulus ("in" or "out"; 10-point Gothic font). A target-stimulus (circle; visual angle 0.5° ; see above) appeared at a location, either central (in) or peripheral (out) from the landmark stimulus. Subjects were then required to detect the location of the target-stimulus.

In both tasks, it was confirmed that the subjects could detect the target-stimuli of each location before the experiment.

Bem Sex Role Inventory (BSRI)

The BSRI (Bem, 1974) was used to assess masculine personality characteristics. Of the 60 items in the BSRI, 20 items each within the inventory were concerned with masculine and feminine characteristics, respectively. Subjects were required to rate themselves using a 7-point scale on each item. The scale ranged from 1 (never true) to 7 (always true).

Design and procedure

The figure and location tasks consisted of 384 and 128 trials, respectively. The former was separated into 6-block trials and while the latter into 2-block trials, with each block consisting of 64 trials. In each task, 75% of trials with the target-stimulus presented the same shape as the predicted stimuli (valid trials), and the remaining 25% of trials were presented in different shapes (invalid trials). Trials of validity and stimulus were randomized within each block. When subjects reported a digit different from the presented digit, the trials were then repeated after the last trial of the block, because the subjects were considered not to have focused on the fixation box. If the error rate of the response in target discrimination exceeded 10%, the block was repeated.

Three blocks for the figure task and one block for the location task were performed daily. Subjects performed the four blocks of visual tasks in an order that virtually counterbalanced cross-effects on the subjects, and all blocks were completed in 2–3 days. The BSRI was measured after the completion of all visual tasks.

Data analysis

RTs for the upper and lower visual-fields were not analyzed, and those in error trials and invalid trials were omitted from the data analysis. Furthermore, RTs which were below the average by $-2 \times \text{S.D.}$ or above the average by $+2 \times \text{S.D.}$ of total RTs were excluded. RTs for the right and left visual-fields were averaged separately.

The masculinity score was calculated by summing the scores within the masculine subscale on the BSRI.

Results

Mean masculinity scores in this study (86.54 ± 11.88 ; $\text{mean} \pm \text{S.D.}$) were slightly lower than the previous values (91.21 ± 15.99 ; Azuma, 1991) established with the BSRI in 307 young Japanese males. The relationship between masculinity scores on the BSRI and ΔRT ($\text{RT difference} = \text{left visual-field RT} - \text{right visual-field RT}$) could be best described by a quadratic equation in the location task (Fig. 2). In the figure task, there was no significant relationship between

Fig. 2 Relationship between masculine scores and the RT differences in the location task

Fig. 3 Relationship between masculine scores and the RT differences in the figure task.

masculinity scores on the BSRI and Δ RT (Fig. 3).

Discussion

While our results demonstrated a significant relationship between masculinity scores and Δ RT in location tasks, significant relationships between the two parameters were not established in figure tasks. The location task is considered to involve visuo-spatial attention and visuo-spatial information-processing, functions which are predominant in the right cerebral hemisphere (Heilman and Van Den Abell, 1980; Corbetta et al., 1993; Nobre et al., 1997; Butler et al., 2004). As such, the present findings suggest that males with a high masculinity level have greater FCL for visuo-spatial attention and/or visuo-spatial information-processing.

However, Δ RT in location tasks would not have been induced by FCL in visuo-spatial information-processing. Testosterone (androgens) has been thought of as the main factor contributing to masculinization of SRI (Baucom et al., 1985; Berenbaum et al., 2000) and accelerating information-processing in the right hemisphere (Tan et al., 1993). If testosterone were to accelerate information-processing in the right hemisphere, the RT to stimuli in the left would be faster than the right visual-field. Conversely, our results indicated shorter RTs to stimuli in the right than the left visual-field in location tasks, suggesting that testosterone could not have accelerated visuo-spatial information-processing in the right hemisphere.

The predominant contribution from the right hemisphere to visuo-spatial attention might induce a shorter RT to the right visual-field in males with higher masculinity levels. It has been demonstrated that visuo-spatial attention directed to the right visual-field activates both cerebral hemispheres (Corbetta et al., 1993; Nobre et al., 1997), albeit that the same attention directed to the left visualfield only activates the right cerebral hemisphere (Corbetta et al., 1993; Heinze et al., 1994; Mangun et al., 1997). Hikosaka et al. (1993a, b) have reported a facilitatory effect of visuo-spatial attention on visual information-processing. Furthermore, Rhodes and Robertson (2002) have found a significantly shorter RT to the right visual-field in valid precue trials, whereas there was no significant Δ RT for invalidly precued targets. They concluded that the allocation of visuo-spatial attention affects processing asymmetries for a visual target. Those studies suggest that visual information-processing of the right visual-field may be facilitated by visuo-spatial attention in both hemispheres, yielding a shorter RT to the right visual-field. Males with higher masculinity levels have been reported to display superior spatial ability compared with those with lower masculinity levels (Hamilton, 1995). Moreover, Voyer and Bryden (1990) have observed a significantly shorter RT to the right visual-field in subjects with higher spatial ability. Those findings might support the idea that males with higher masculinity levels have predominance of the right hemisphere

for visuo-spatial attention.

This study provides an interesting finding in the relationship between SRI and FCL. However, the present findings might not be replicated in left-handed subjects or in other cultures. A review of cross-cultural perspectives inferred that handedness is probably associated with laterality of brain function (Dawson, 1977); viz., current traditional agropopulations such as the Hong Kong Chinese have a significantly lower incidence of left-handers compared with Inuit hunters. The study further advocates that the agropopulation places greater emphasis on conformity in the socialization of females than do Inuit hunters. Therefore, sociocultural factors might have molded the relationship between SRI and FCL. Additionally, according to Moffat and Hampson (1996), right-handed subjects of both sexes indicate a significantly larger right ear advantage than left-handed subjects in the dichotic listening task. Further quantitative studies of sex steroidal hormones and comparative elucidations of handedness and cultural factors correlated with the SRI-FCL relationships are warranted.

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