Dependence of Reaction Time on Visual Fields in Patients with Unilateral Hemispheric Lesions

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ISAGODA, A., NAKAMURA, R. and SAJIKI, N. Dependence of Reaction Time on Visual Fields in Patients with Unilateral Hemispheric Lesions. Tohoku J. exp. Med., 1981, 134 (3), 295-299 — Reaction times (RTs) to light stimuli which appeared at central and lateral positions were measured in 13 normal subjects and 34 patients with unilateral lesions in the left or the right hemisphere. The normal subjects showed slowing of RTs to both lateral stimuli compared to the central stimulus, the extent of which was equal between the left and right hands. The patients with left hemispheric lesions had slower RTs to the stimulus contralaterally to the lesion than ipsilaterally and centrally. The patients with right hemispheric lesions had slower RTs both to the contralateral and central stimuli than to the ipsilateral. The results are discussed in relation to functional differentiation of the left and right hemispheres for visual processing. reaction time; visual perception; left-right differentiation

It is well known that each hemisphere represents or controls principally the contralateral side of the body. However, recent neuropsychological studies have revealed that the right hemisphere is of primary importance for complex visuospatial functions and for more fundamental perceptual processes (Kimura and Durnford 1974).

Carmon and Benton (1969) observed that patients with right hemispheric lesions showed an impairment in the discrimination of tactile stimuli on both hands, while patients with left hemispheric lesions showed an impairment only on the right hand. According to Hosokawa et al. (1981) who examined the tone-gap detectability in normal subjects and patients with unilateral subcortical lesions, the right subcortical lesions resulted in loss of the efficiency of binaural system. Studying the postural dependence of reaction time (RT) in patients with ventrolateral thalamotomy, Nakamura et al. (1979) reported that the right hemisphere including subcortical structures had bilateral control on the proprioceptive input. These studies suggest that the right hemisphere receives information from sensory receptors in both sides of the body, whereas the left only from the contralateral side. Then, for visual perceptions, it is likely that the right hemisphere covers wider visual fields than the left hemisphere. Therefore, it would be expected that RT performance to

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signals in different visual fields is more impaired in patients with right hemispheric lesions than those with left hemispheric lesions.

In this study, we examined the dependence of RT on visual fields in normal subjects and patients with unilateral hemispheric lesions, and tried to postulate the notion above mentioned.

SUBJECTS AND METHODS

The experiments were performed for 17 patients with left hemispheric lesions (LHL; 14 males, 3 females) and 17 with right hemispheric lesions (RHL; 13 males, 4 females) due to cerebrovascular diseases, and 13 normal subjects (9 males, 4 females). There were no significant differences among the groups with respect to the age in years (LHL 50.7±9.9, RHL 52.5±10.0, control 48.7±10.4) and post-onset months (LHL 7.9±4.5, RHL 7.7±5.5). They were all right handed and had no clinical evidence of visual field defects.

The subject was seated in front of a hemispheric screen, 70 cm in radius. The head was positioned in a head-and-chin rest so as to maintain the midpoint between the eyes fixed at the center of the hemispheric screen. The subject was instructed to keep his gaze at the center and to respond to a light stimulus by means of key-press with his index finger as fast as possible. Onset of the light stimulus was controlled by the experimenter and offset of it was synchronized with the subject's response. The stimuli consisted of five red light emitting diodes (3 mm in diameter) mounted on a horizontal line of the screen at the center, 10 degrees and 30 degrees apart from the center to both sides respectively. One of the five lights appeared in random sequence with 2–3 sec intervals.

RT, the time interval between stimulus onset and key-press, was measured with a msec scale by a digitimer (TW-7011A and DP-9A, TAKEI). The half of the control subjects performed the trials first with the left hand and the other half with the right, and the patients with the hand ipsilateral to the lesion. Fifteen trials were made at each stimulus position. Responses to the stimuli at 10 degrees on each side were excluded in the later analysis. The geometric means of 15 trials for the stimuli at the center and 30 degrees in each (left and right) were taken as the data.

RESULTS

Table 1 shows the means and S.D.s of RTs in each group for three positions of the stimulus.

RTs of the left hand in the LHL group were compared to those obtained with the left hand in the control group and similarly RTs of the right hand in the RHL group. As for overall RTs which were calculated as the mean of the data in three positions, the RTs of each patient group were slower than those of the control group (Mann-Whitney method: LHL, z=3.27, p=0.001; RHL, z=3.08, p=0.002). RTs of the LHL group were slower for all positions of the stimulus than those of

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<th>Table 1. Mean (s.d.) of RT (msec)</th>
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the control group (Mann-Whitney method: Left, $z=2.34$, $p=0.019$; Center, $z=3.24$, $p=0.001$; Right, $z=3.37$, $p=0.001$) and similarly the RHL group (Mann-Whitney method: Left, $z=3.25$, $p=0.001$; Center, $z=3.33$, $p=0.001$; Right, $z=2.35$, $p=0.019$). There was no significant difference in overall RTs between the LHL and the RHL groups (Mann-Whitney method: $z=1.05$, $p=0.293$).

Table 2 gives the differences of RTs between the central and the lateral position of the stimulus, subtracting RT at the center from RT at the left or the right ($\Delta L$ and $\Delta R$). They are positive when RT to the lateral stimulus is longer than to the central stimulus. $\Delta L$ and $\Delta R$ of all subjects are shown in Fig. 1.

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<th>Table 2. Mean of difference (s.d.) of RT between the central and the lateral positions (left or right), $\Delta L$ and $\Delta R$ (msec)</th>
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Fig. 1. Difference of RTs between the central and the lateral positions of the stimulus ($\Delta L$ and $\Delta R$) in each subject. $\Delta L$ and $\Delta R$ are arranged in order of magnitude.
A: The $\Delta$s for the subjects who performed with the left hand.
B: The $\Delta$s for the subjects who performed with the right hand.

In the control group, $\Delta L$ and $\Delta R$ for the left hand were positive except one. $\Delta L$ and $\Delta R$ were significantly positive ($\Delta L$, $t=4.41$, $df=12$, $p<0.001$; $\Delta R$, $t=5.12$, $df=12$, $p<0.001$). For the right hand, $\Delta L$ was positive in 12 of 13 subjects and $\Delta R$ was positive in 9 of 13 subjects. $\Delta L$ and $\Delta R$ were significantly positive ($\Delta L$, $t=4.36$, $df=12$, $p<0.001$; $\Delta R$, $t=2.69$, $df=12$, $p<0.05$). But there was no significant difference among the $\Delta$s ($F=0.49$, $df=3/48$).
In the LHL group, 7 had positive $AL$, 8 negative and 2 zero, and 16 of 17 subjects had positive $AR$. $AL$ did not differ from zero as a whole ($t=0.54$, $df=16$) but $AR$ was significantly positive ($t=4.69$, $df=16$, $p<0.001$). $AR$ was larger than $AL$ ($t=4.03$, $df=12$, $p<0.001$). Compared to the same hand of the control group, $AL$ was significantly small (Mann-Whitney method: $z=2.56$, $p=0.011$), whereas $AR$ was large but not significant (Mann-Whitney method: $z=1.86$, $p=0.062$).

In the RHL group, 15 of 17 subjects had positive $AL$, and 14 had negative $AR$. $AL$ was significantly positive ($t=4.87$, $df=16$, $p<0.001$) and $AR$ negative ($t=2.58$, $df=16$, $p<0.05$). $AL$ was larger than $AR$ ($t=4.86$, $df=16$, $p<0.001$). Compared to the same hand of the control group, $AL$ was significantly large (Mann-Whitney method: $z=2.62$, $p=0.009$) and $AR$ was significantly small (Mann-Whitney method: $z=3.14$, $p=0.002$).

**DISCUSSION**

The results showed that the control group had longer RTs to the lateral stimuli than to the central stimulus. There was no significant difference among the $A$s in the control group. Using simple RT measure on normal subjects, Berlucchi et al. (1971) found that RTs to lateralized visual stimuli were faster when subjects performed with the hand on the same side of the stimulus than with the other hand, but Filbey and Gazzaniga (1969) did not observe such a difference. This discrepancy may be due to the difference between the methods; in the former the position of stimuli is known to the subject before its presentation, whereas in the latter the position of stimuli is not known. In this respect the method used in the present study was similar to the latter. Therefore, it seems likely that the subject, not knowing the stimulus position before presentation, shows no asymmetry of the $A$s between the left and the right hand.

Both the patient groups had slower RTs for all positions of the stimulus than the control group and showed specific changes on the $A$s. $A$ of the LHL group was nearly zero on the left, ipsilateral side to the lesion, and was positive on the right, contralateral side, while $A$ of the RHL group was positive on the left, contralateral side, and was negative on the right, ipsilateral side. In short, the RT performance of the patients with unilateral hemispheric lesions is more impaired on the side contralateral to the lesion than on the ipsilateral. Moreover, in the patients with right hemispheric lesions RT at the center is more impaired than that at the ipsilateral side while in the patients with left hemispheric lesions RT at the center is similar to that at the ipsilateral side. The results suggest that the RT of the patients with right hemispheric lesions is impaired more widely in the visual fields than that of the patients with left hemispheric lesions. It is plausible that the right hemisphere receives information from wider visual fields than the left hemisphere.

The present findings as well as previous reports (Carmon and Benton 1969; Nakamura et al. 1979; Hosokawa et al. 1981) support the notion that the right
hemisphere is dominant or has bilateral control on receptive functions or the input system.

References


