Intern. J. Neuroscience, 1982, Vol. 16, pp. 227–230
0020–7454/82/1604–0227 $06.50/0

© 1982 Gordon and Breach Science Publishers, Inc.
Printed in Great Britain

SEX DIFFERENCES IN HEMISPHERIC FUNCTION: IMPLICATIONS FROM A HEMISPHERIC TIME SHARING TASK

TAKESHI HATTA and NAOHIRO MINAGAWA
Osaka University of Education, Japan

A microcomputer controlled test of hemispheric time sharing was conducted on normal male and female students. Subjects engaged in a unimanual task involving sequential finger movement alone and in two conditions with concurrent cognitive activity. The verbal task interfered more with right than left hand activity in both male and female subjects. The spatial task interfered more with left than right hand activity in male subjects while female subjects did not show any hand differences. Possible sex differences in brain function were discussed.

Int J Neurosci Downloaded from informahealthcare.com by Cornell University on 12/27/14
For personal use only.

The question of sex differences in human brain function has been the subject of many recent studies (Knox & Kimura, 1970; Lake & Bryden, 1976). Several studies which have revealed sex differences, suggest that females are less lateralized in verbal and/or spatial processing (McGlone, 1978). These findings were obtained using noninvasive research methods involving, for example, dichotic listening, tachistoscopic and dichaptic presentation.

Kinsbourne & Cook (1971) described another noninvasive technique for brain function study. They showed that concurrent speech has a differential effect on the right and left hand performance of normal right-handed people. Many studies confirmed the findings and the verbal-manual time-sharing task has become one of the most useful noninvasive techniques for estimating the lateralization of cerebral hemisphere functions.

The purpose of the present study was to examine sex differences in cerebral hemispheric function by the use of the time-sharing method. Until now, few studies have examined sex differences using this method. All of the procedures in the experiment were controlled by a personal computer. As the time sharing paradigm has not been fully developed as a tool for studying hemisphere lateralization, small methodological differences could prove to be important. But these discrepancies can be avoided by using computer controlled experiments, because a common procedure can then be used in all laboratories.

The interference effects of the concurrent verbal and spatial tasks upon the manual activity were examined using normal female and male adults.

The authors are much indebted to Mr. Minoru Nakajima for his assistance in preparing the computer program.

METHOD

Subjects

Sixteen right-handed university students (8 male, 8 female) served as subjects. Handedness was assessed by H.N. Inventory (Hatta and Nakatsuka, 1975). All subjects were unskilled at typing.

Apparatus

A unimanual task involving sequential finger movement was performed on a key-board of the personal computer (NEC PC 8001). Four keys (G, H, J, K) were used throughout the experiment. The residual keys were occluded by cardboard.

Subjects were required to press four keys in H–K–G–J order for the left hand and J–G–K–H for the right hand. All key pressings were stored in the computer memory and were printed out at the end of the session.

Cognitive tasks were presented in the monitor CRT display (Sony PVM 2020) and included:

Reading. Read aloud the 2 letter nonsense word lists which were shown on the display screen.

Space Relations. Deciding whether or not geometric shapes scattered in the left visual field could be combined to make an object presented in the right visual field.

The subjects' oral responses to the *Reading* task were recorded, and scored after the session. For the *Space Relations* task subjects were required to indicate their response manually after 15 sec.

RIGHTSLINK

Procedure

After each subject filled out the handedness questionnaire, he or she was asked to look at the CRT display. The instructions were then presented on the CRT display, and each subject conducted the experiment alone.

Each subject was given practice on the verbal and spatial tasks as well as on the manual task. Each experimental condition commenced when the subject pressed a start button, and this was accompanied by a warning buzzer.

Each subject accomplished the manual task in six different conditions:

1. left-hand control condition (LC) where there was no concurrent task;
2. right-hand control conditions (RC), in which there was no concurrent task;
3. left-hand activity while reading word lists which were displayed in CRT display (LV);
4. right-hand activity while reading word lists (RV);
5. left-hand activity while resolving spatial task (LS);
6. right-hand activity while resolving spatial task (RS).

One half of the subjects executed the tasks in the following order LV–LS–RV–RS–LC–RC; the other half used the order of RV–RS–LV–LS–RC–LC. Two trials of 15 sec each were given in all conditions.

Each subject was requested to press the key board as fast and accurately as possible, from the time the start buzzer sounded until the stop buzzer sounded. The personal-computer did not store any other key pressings.

Scoring

A dot printer listed out the subject's key-pressing responses at the end of the session. Unimanual performance was scored for number of correct responses corresponding to the required sequence. Each subject's unimanual performance on the four conditions with concurrent cognitive activity was converted to the percentage change from baseline; baseline comprised performance with that hand without concurrent activity. Scoring of the cognitive performance was as follows: number of words correctly read (Reading), number of correct answers (Space Relations).

RESULTS

Reduction of Unimanual Performance

Table 1 shows the mean percentage reduction in key-pressing rate for each hand of the *Reading* task. An analysis of variance revealed greater hand performance deterioration with the right hand (F 1, 14 = 6.98, $p < .05$). The main effect of sex, and the interaction between the main variables were not significant (F 1, 14 = 0.40, 0.81, respectively).

Table 2 presents the mean percentage reduction in key-pressing in the *Space Relations* task. An analysis of variance showed that both main effects and the interaction were significant (F 1, 14 = 6.46 (sex), $p < 05$; F 1, 14 = 10.24 (hand), $p < .01$; F 1, 14 = 5.42 (interaction), $p < .05$). This indicates that male subjects showed greater left hand performance reduction and no deterioration with the right hand, while females showed a greater performance reduction with both hands.

Performance of the Concurrent Cognitive Task

Number of words read during 15 sec in each condition are shown in Table 3. An analysis of variance revealed that the main effects and the interaction were significant (F 1, 14 = 6.56, $p < .05$, sex; F 1, 14 = 42.07, $p < .01$, hand; F 1, 14 = 7.73, $p < .05$, interaction). This indicates that: 1. performance deteriorated significantly with hand performance, key-pressing; 2. male subjects showed a

TABLE 1

Mean percentage reduction of correct unimanual responses during the *Reading task* SDs are represented in parentheses.

	Left Hand	Right Hand
Male	21.9 (9.9)	36.4 (15.2)
Female	22.6 (8.9)	29.7 (11.7)

TABLE 2

Mean Percentage Reduction of Correct Unimanual Responses during the *Spatial Relation* Task SDs are shown in parentheses.

	Left Hand	Right Hand
Male	17.4 (6.3)	− 0.9 (14.3)
Female	22.3 (10.8)	19.4 (11.6)

Int J Neurosci Downloaded from informahealthcare.com by Cornell University on 12/27/14
For personal use only.

RIGHTSLINK

greater deterioration compared to females in performances with each hand; 3. female subjects showed a greater deterioration with the right hand while they did not show any reduction in left hand performance. Table 4 gives the results of the *Spatial Relations* task. Though the Table gives the impression that male subjects show greater deterioration with their left hand and females show a greater deterioration with their right hand, analysis of variance did not reveal any significant difference.

DISCUSSION

The present study had three aims: first, to study sex differences by using a hemispheric time sharing task, second, to examine the discriminability of our new spatial task, and, third, to examine the validity of our computer-controlled time sharing test.

As noted before, sex differences in human brain function were suggested by other noninvasive research methods. However, few studies have reported sex differences using time sharing methods (Dalby, 1980). The present results reveal sex differences which are generally consistent with previous findings. However, in the verbal loading condition both groups of subjects showed a greater reduction of unimanual performance with the right hand, whereas in the spatial loading condition, there is a clear sex difference in the reduction of unimanual performance.

Male subjects showed a greater reduction with their left hand compared to the right, while female subjects showed an equal reduction in performance. Similar sex differences were observed in the cognitive task.

The results of the verbal loading task were identical with the previous studies and can be interpreted by the functional distance theory; that is, speech and right hand key pressing are controlled within the left hemisphere, and there is therefore no interfering cross-talk between them (Kinsbourne and Hicks, 1978; White and Kinsbourne, 1980). Furthermore, the results of the spatial loading task can be interpreted as follows: as spatial function is strongly lateralized to the right hemisphere, in male subjects, left hand key pressing is contaminated, and there is a greater reduction in unimanual performance. On the other hand, in the case of female subjects lateralization of spatial ability is not so clear (i.e., bilateral specialization), and few significant differences between left and right hand performance will be observed.

The above results in sex differences in the spatial loading also answer the second question. Compared to the fact that many verbal loading tasks reported clear right hand interference effects, only a few studies have revealed left hand interference on the spatial loading task (Dalby, 1980; McFarland and Ashton, 1978; Bower, *et al.*, 1978). The present results clearly show that our new spatial loading task has enough discriminability.

Finally, the present results demonstrate the success of computerization of the time sharing test. One problem may be that our present computer aided time sharing test is incomplete; however, a computer controlled laterality test can provide identical testing conditions everywhere. Thus, by using this method, comparisons between the results obtained by different researchers is possible, and a contribution may be made to research in functional brain asymmetry.

TABLE 3

Mean Number of Words Read During 15 sec Unimanual Key Pressing Performance SDs are shown in parentheses

	No Key-pressing	Left hand Key-pressing	Right hand Key-pressing
Male	28.8 (2.1)	22.6 (5.7)	19.8 (5.0)
Female	29.9 (3.6)	28.4 (4.6)	25.8 (4.5)

TABLE 4

Mean Correct Responses in the Space Relations Task during 15 sec Unimanual Key Pressing performance (Max. 2.0). SDs are shown in parentheses.

	No key-pressing	Left hand key-pressing	Right hand key-pressing
Male	1.17 (0.89)	1.08 (0.86)	1.17 (0.79)
Female	1.25 (0.72)	1.17 (0.79)	2.00 (0.82)

REFERENCES

Bowers, D., Heilman, K. M., Satz, P., & Altman, A. Simultaneous performance on verbal, nonverbal and motor tasks by right-handed adults. *Cortex*, 1978, **14**, 540–556.

Dalby, J. T. Hemispheric timesharing: verbal and spatial loading with concurrent unimanual activity. *Cortex*, 1980, **16**, 566–573.

Int J Neurosci Downloaded from informahealthcare.com by Cornell University on 12/27/14
For personal use only.

RIGHTSLINK

Hatta, T., & Nakatsuka, Z. H.N. Handedness Inventory. In S. Ohno (Ed.) Papers in celebration of 63rd birthday of Professor Chuishi, Osaka City University, 1975.

Hicks, R. E. Intrahemispheric response competition between vocal and unimanual performance in normal adult males. *Journal of Comparative and Physiological Psychology*, 1975, **89**, 50–60.

Kinsbourne, M. & Cook, J. Generalized and lateralized effects of concurrent verbalization on a unimanual skill. *Quarterly Journal of Experimental Psychology*, 1971, **23**, 341–345.

Kinsbourne, M. & Hicks, R. E. Functional cerebral space: A model for overflow transfer and interference effects in human performance. In J. Requin (Ed.), Attention and performance VII, Hillsdale, N.J.: Erlbaum, 1978.

Knox, C. & Kimura, D. Cerebral processing of nonverbal sounds in boys and girls. *Neurospychologia*, 1970, **8**, 227–237.

Lake, D. A. & Bryden, M. P. Handedness and sex differences in hemispheric asymmetry. *Brain and Language*, 1976, **3**, 266–286.

Lomas, J. Competition within the left hemisphere between speaking and unimanual tasks performed without visual guidance. *Neuropsychologia*, 1980, **18**, 141–150.

McFarland, K. A. & Ashton, R. The lateralized effects of concurrent cognitive activity on a unimanual skill. *Cortex*, 1975, **11**, 283–290.

McFarland, K. A. & Ashton, R. The influence of concurrent task difficulty on manual performance. *Neuropsychologia*, 1978, **16**, 735–741.

McGlone, J. Sex differences in functional brain asymmetry. *Cortex*, **14**, 122–128.

White, N. & Kinsbourne, M. Does speech output control lateralize over time? Evidence from verbal-manual time-sharing tasks. *Brain and Language*, 1980, **10**, 215–223.

Int J Neurosci Downloaded from informahealthcare.com by Cornell University on 12/27/14
For personal use only.

RIGHTSLINK