A DEVELOPMENTAL STUDY OF BILATERAL DEFICIT OF HAND GRIP REACTION TIME IN CHILDREN

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INTRODUCTION

Bilateral deficit, also known as bilateral deficit in movement speed, has been defined as a reduction in force that accompanies maximal two-limb efforts of the homologous limbs relative to single performance; that is, the reaction time is longer for simultaneous bilateral responses than for unilateral ones (Di Stefaro, et al., 1980, Taniguchi, 1999). Although we know that this phenomenon is mediated by neural mechanisms such as interactions between the cerebral hemispheres or spinal reflexes (Ohtsuki, 1994), the underlying mechanism is still far from clear. The purpose of this study was to examine bilateral deficit in children whose nervous system was not yet completely mature, and to clarify the developmental characteristics of bilateral and unilateral movements.

METHODS

Thirteen right-handed children aged 5 to 10 participated as subjects, and were compared to right-handed the 12 right-handed adult subjects aged 18 to 22. The subjects were asked to perform a simple reaction time task in which they grasped a grip bar in response to an auditory stimulus. The subjects were told to respond rapidly, without worrying about grip strength. They were seated facing a loudspeaker, with both arms comfortably resting. The angle of the elbow joint was about 90 degrees, and remained constant throughout each experimental session. During the experiments, the subjects were asked to concentrate on listening to the stimulus sound and performing the tasks. The subjects carried out the tasks under three conditions: with the right hand (dominant); with the left hand (non-dominant); and with both hands simultaneously. Each condition was tested with at least 20 trials. The time difference between the auditory stimulus and the onset of the grip force (reaction time; RT), the auditory stimulus and the appearance of the maximal grip force, and the value of the grip force were measured during the trials (Figure 1), and the resultant data were analyzed statistically.

RESULTS AND DISCUSSION

Under all task conditions, the RT of the children was significantly slower than that of the adult subjects. In the adult subjects, the bilateral RT was consistently slower than either the left or right unilateral RT; 3.7% slower than the unilateral right (dominant hand) RT, and 2.5% slower than the left (Figure 2, left). These differences are not statistically significant. However, the bilateral deficit was not seen in the children to the same extent as in the adults, and, in fact, we found facilitation rather than deficit in some bilateral responses of the children. The mean RT unilateral-bilateral difference was 1 msec for the right dominant hand, corresponding to a 0.5 % increase, and 8.6 msec for the left hand, corresponding to a 3.9 % decrease (Figure 2, right). That is, a lateral difference was observed, but in the form of a bilateral deficit when the right hand was used, and a bilateral facilitation when the left was used.

Figure 2: Mean values of reaction time (RT) in all task conditions

Figure 3 shows individual differences in RT as a ratio of the unilateral-bilateral difference in hand grip responses of the left and right hands. In this figure, bars extending above the 0 line indicate a bilateral deficit phenomenon, and bars extending below the 0 line indicate a bilateral facilitation phenomenon. A bilateral facilitation phenomenon was observed more in children than in the adult subjects. However, the appearance of this phenomenon was not related to their children’s age in month. However, there were few cases indicating significant differences between unilateral and bilateral conditions. If these results imply the lateral difference, then the bilateral deficit was apt to be observed slightly more in right hand than left. It was previously reported that the bilateral deficit was observed in the right hand rather than the left.

Figure 1: Experimental layout

Previous studies have reported that simultaneous bilateral RT is longer than the RT for unilateral movement (Di Stefaro et al., 1980; Ohtsuki, 1981, Taniguchi, 1999). Division of attention, double reciprocal inhibition, and interhemispheric inhibition are postulated as possible causes of bilateral deficit. According to previous research, this phenomenon is mediated by neural mechanisms such as interactions between the
Figure 3: Individual differences in RT as a ratio of the difference between unilateral and bilateral hand grip responses in the left and right hands (Left: adults, Right: children). Bars extending above the 0 line indicate bilateral deficit phenomenon, and bars extending below the 0 line indicate a bilateral facilitation phenomenon.

...cerebral hemispheres or spinal reflexes. However, some cases were not reported be significant bilateral deficit, but instead were reported to be bilateral facilitation (Howard & Enoka, 1991). Anson & Bird (1980) indicated significant bilateral-unilateral differences for finger extension but no significant difference for elbow flexion, because the proximal muscle was activated for elbow flexion. In the present study, the subjects performed a rapid hand grip in response to an auditory stimulus, and the children were assumed to use proximal muscles to perform the hand grip response, which may differ from the adult subjects. In any case, the ability to exhibit a bilateral deficit or bilateral facilitation depends on factors that influence the integration of neural signals from peripheral and central sources (Howard & Enoka, 1991).

The maximal grip force observed during handgrip reaction is shown in Figure 4. The mean value of each condition is indicated: unilateral right, unilateral left, bilateral right, and bilateral left. The maximal grip forces in all conditions were significantly larger in children than adult subjects. The values of the children showed that they used about 50 to 70% of their individual maximal grip strength, while the adults used 2 to 30%. These values reveal that the child subjects carried out the response as quickly as they could, and with maximum strength. In comparing the grip force between unilateral and bilateral conditions, the overall mean grip force which was used to respond unilaterally was slightly larger than that used to respond bilaterally. This seems to indicate a bilateral deficit phenomenon. This tendency was different from that observed in RT. Furthermore, the right-left grip force difference during simultaneous bilateral exertion was quite a bit smaller in the children in each trial, than in the adults.

In motor behavior, nonintended interactions between commands to different muscles and different limbs commonly occur. The contralateral irradiation that is seen at a high level of motor activation may reveal basic inborn patterns of motor organization that are successfully suppressed under normal conditions of motor behavior. Zijdewind & Kernell (2001) indicated that the actual coactivation of the contralateral homologous muscle is likely to be a consequence of such a central “spreading-out” of facilitation. It is possible that this “irradiated” facilitation occurred at cortical and/or subcortical levels.

Figure 4: Mean values of maximal grip force during hand grip responses in all task conditions. (UR; unilateral right, UL; unilateral left, BR; bilateral right, BL; bilateral left)

Generally, it is difficult for children to manipulate things separately while they are carrying out a task. In the present study, it was presumed that facilitation rather than inhibition occurred in the children as they carried out a bilateral simultaneous movement, that is, a kind of maximal effort when they responded as fast as possible. We hypothesized that different mechanisms may be responsible for fast bilateral movement in children.

REFERENCES
