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The Practice Effect and Its Difference of the Pursuit Rotor Test with the Dominant and Non-dominant Hands

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Abstract The purpose of this study was to examine the practice effect and what difference it makes in the pursuit rotor test for the dominant and non-dominant hands in 30 right-handed Japanese male adults aged 18 to 23 years (Age 20.8±1.4 yrs). The subjects performed the pursuit rotor test for 1 min in 20 trials with a 1-min interval alternately using the dominant and non-dominant hands. After continuing for 10 trials, a 5-min rest was taken. The measurement order was randomly assigned. Contact time of a steel pen and a target was measured in units of 1/10 sec. The measurements showed a constant increasing tendency at every trial until the 6th trial in both hands. Significant linear regressions were identified, but the increase-rate of the dominant hand was significantly larger. Individual differences showed a decreasing tendency at every trial in the dominant hand, but in the non-dominant hand it increased until the 4th trial then decreased. The relationships between measurements of the 1st and 10th trials in both hands and both hands in the 1st or 10th trial were not high. The performance of the pursuit rotor test improves at every trial in both hands, but the improvement rate decreases after the 7th trial. The improvement rate of the dominant hand is high. The change in individual differences differs in both hands and the relationship between the measurements is not high. It can be judged that the practice effect of the pursuit rotor test differs in the dominant and non-dominant hands. *J Physiol Anthropol Appl Human Sci 24(6): 589–593, 2005* http://www.jstage.jst.go.jp/browse/jpa
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Introduction

A task demanding operability of upper limbs and fingers has been mainly examined in study domains regarding motor learning, including eye-hand coordination, using tests such as pegboard and pursuit rotor movements. Strenge et al. (2002) examined the relationship between concentration and pegboard tests using healthy subjects, and reported that there were significant correlations. The pursuit rotor test has been mainly used to identify learning retention. Fine motor skills are largely concerned with succeeding in this test because it requires the ability to visually see a target and match a steel pen to a moving target (Ferslew et al., 1982; Nakafuji and Tsuji, 2001). The pursuit rotor test is one of the most useful tests to evaluate motor control function, which coordinates movements according to each task. To smoothly exert motor control function, information from the central and peripheral nervous systems is integrated in the cerebrum and it is necessary to properly control movements in each motor organ. Motor control function is interpreted to be superior when contraction and relaxation of muscles are smoothly performed according to the movement of a target, and with this, variability decreases and accuracy increases (Brown and Bennett, 2002). The ability to control this motor function is postnatally acquired through learning based on motor experiences.

Functional right and left differences exist in each body part with bilateral symmetry in humans. (Dolcos et al., 2002; Geshwind and Behan, 1982; Gur et al., 1999; Roy et al., 2003). Also, the cerebral hemisphere that controls the movements of the limbs has an anatomical laterality (Touwen, 1972; Oda, 1998). Oda (1998) stated that this morphological laterality means functional asymmetry in sense organs, central nerves, and effectors to efficiently and rationally perform movements, and he defined the functional asymmetry as lateral dominance. This means intensively using only the dominant hand even though one can use either hand. Lateral dominance emerges in infancy under the influence of a genetic factor (Chi et al., 1977). Because the dominant hand is excessively used with aging, such as in writing a letter, using scissors in daily life, a development difference in the dominant and non-dominant hands becomes more prominent. Thus, the practice effect of the pursuit rotor test may differ in the dominant and non-dominant hands by the differences in the amount of information from the central and peripheral nervous systems and the related control functions. However, the differences between the dominant and non-dominant hands and their relationships, and individual differences of practice and adaptation to the pursuit rotor test have not been carefully examined for the acquirement process of motor skills by pursuit movements. In addition, the turn number, representative value, and trial number to evaluate pursuit rotor results are not always unified among researchers (Chi et al., 1977; Butki, 1994). From the above, we hypothesized that the dominant hand is superior to the non-dominant hand in the improvement of pursuit rotor performance with repeated trials, and aspects of the changes and individual differences also differ in both hands.

The purpose of this study was to examine the practice effect and what difference it makes in the pursuit rotor test with the dominant and non-dominant hands.

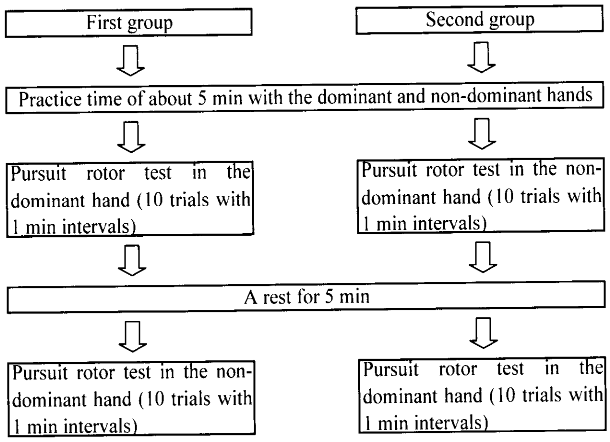

Fig. 1 Experimental procedure in this study.

Method

Subjects

The subjects were 30 Japanese male adults aged 18 to 23 years (Age 20.8±1.4 yrs, Height 172.8±5.1 cm, Weight 67.2±10.3 kg). All were regarded as right-handed based on Oldfield's inventory (Oldfield, 1971). Height and weight were similar to Japanese normative values (Laboratory of Physical Education in Tokyo Metropolitan University, 1989) for this age. No subject reported previous wrist injuries or upper limb nerve damage, and all were in good health. Prior to measurement, the purpose and procedure of this study were explained in detail, and informed written consent was obtained from all subjects. No subject had previously experienced a pursuit rotor test.

Test and Test Procedure

Each subject was randomly assigned to one of two before the experiment considering an order effect. One group was measured in a dominant hand/non-dominant hand order, and the other group in the reverse order. Both groups performed 20 trials with 1-min intervals (one trial was 1 min) (Nakafuji and Tsuji, 2001). After continuing for 10 trials, a 5-min rest was taken. Each of 10 trials was performed by the dominant and non-dominant hands, respectively. The experimental procedure in this study is shown in Fig. 1.

The pursuit rotor test measures the eye-hand motor-control function (Ferslew et al., 1982). Measurement tools and concrete procedures are as follows. The apparatus of the pursuit rotor test (Takei, TKK2110, Tokyo, Japan) has a disc that revolves by means of an electronic speed control motor, and has a target on it. The revolution speed can be changed within a range of 25 to 90 revolutions per min (rpm).

The subjects pursued a 10 mm diameter concave target placed 100 mm from the center of the disc turning at 50 rpm clockwise when they used the right hand and anticlockwise when they used the left hand, using a 3-mm diameter L-type steel pen. We judged that the target was suitable in changing from 45 to 55 rpm in a preliminary experiment. A practice time of about 5 min with the dominant and non-dominant hands was taken before the test. The total sum of the differences between the steel pen and the target for 60 sec in units of 1/10 sec was used as an evaluation parameter for the test.

Statistical analysis

Data were analyzed using SPSS (Version 11.0 for Windows). To examine the variance among trials of measurements, linear regression coefficients were computed for both hands and then the difference was examined. To examine significant differences among trial means (10×2 matrix: trial number×the dominant/non-dominant group), two-way analysis of variance (ANOVA) with repeated measures of two factors was used. When significant interaction and main effects were found, a multiple-comparison test was carried out using Tukey's Honestly Significant Difference (HSD) method for pair-wise comparisons. In addition, the size of the mean differences (effect size) between the 1st trial and each trial was examined. Coefficients of variance were calculated to examine individual differences between trials. Pearson's correlations between each variable were calculated. Results are presented as mean and standard deviation unless otherwise specified. An alpha level of 0.05 was used to indicate significance for all tests.

Results

Table 1 shows the means of each trial for the dominant and non-dominant hands. Figure 2 shows a graphic representation of a performance curve. The means increased at every trial in both hands, and a significant and high linear tendency was identified (r=0.98, 0.98). The regression coefficient was significantly higher in the dominant hand. In the results of the two-way ANOVA, no interaction was significant ($F_{9,261}=1.84$, $p>0.05$), but the main effects of the trials ($F_{9,261}=34.30$, $p<0.05$) and hands ($F_{1,29}=17.22$, $p<0.05$) were significant. With *post hoc* analyses, in the dominant hand, the means of each trial were lower in the 1st trial than after the 3rd trial, the 2nd trial than after the 4th trial, the 3rd trial than after the 6th

Table 1 Mean time on target (in seconds) during each trial for the dominant and non-dominant hands

Trial	Dominant Hand				Non-dominant Hand			
	M	*SD*	*CV*	*ES*	*M*	*SD*	*CV*	*ES*
1	11.7	12.53	107.2		6.5	5.71	88.3	
2	15.1	13.37	88.4	0.27	7.6	5.81	76.3	0.20
3	18.8	15.23	81.1	0.51	9.4	10.56	111.9	0.35
4	21.6	15.20	70.3	0.71	11.9	12.60	106.0	0.55
5	23.7	16.22	68.4	0.83	12.9	11.17	86.7	0.72
6	25.0	15.95	63.8	0.93	13.6	11.20	82.6	0.80
7	27.1	16.01	59.1	1.07	18.0	13.34	74.3	1.12
8	27.4	15.19	55.4	1.13	17.8	11.79	66.4	1.22
9	29.7	16.09	54.2	1.25	18.5	12.68	68.5	1.23
10	32.6	16.85	51.7	1.41	20.0	13.08	65.6	1.34

Note.—*CV*: coefficient of variance, *ES*: effect size. $ES=(M \text{ of each trial} - M \text{ of the 1st trial})/\sqrt{(SD \text{ of each trial})^2 \times (N \text{ of each trial} - 1) + (SD \text{ of the 1st trial})^2 \times (N \text{ of each trial} - 1)/(N \text{ of each trial} + N \text{ of the 1st trial} - 2)}$.

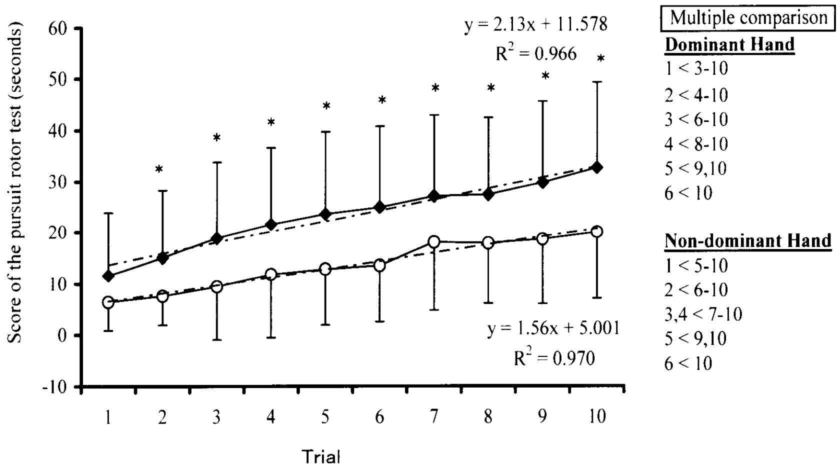

Fig. 2 Trial means of the pursuit rotor test in the dominant (◆) and non-dominant (○) hands. $*p<0.05$. 1<3–10: The means were significantly lower in the 1st trial than the 3rd to 10th trials.

trial, the 4th trial than after the 8th trial, and the 5th trial than after the 9th and 10th trials. In the non-dominant hand, the means of each trial were lower in the 1st trial than after the 5th trial, the 2nd trial than after the 6th trial, the 3rd and 4th trials than after the 7th trial, and the results after the 5th trial equaled those of the dominant hand. There were no significant differences from the 7th to 10th trials in both hands. In addition, the dominant hands showed significantly high values in all trials except for the 1st trial.

The coefficient of variance showed a decreasing tendency at every trial in the dominant hand, but in the non-dominant hand it decreased after markedly increasing until the 4th trial (Table 1). The size of the mean differences (effect size) showed values over 1.0 after the 7th trial in both hands (Table 1). The correlations between the measurements of the 1st and 10th trials were significant and moderate in both hands (Dominant hand: r=0.56, Non-dominant hand: r=0.66, $p<0.05$). In addition, the correlations between both hands were significant and low or moderate in the 1st and 10th trials (1st trial: r=0.38, 10th trial: r=0.55, $p<0.05$).

Discussion

The means of the pursuit rotor test increase at an almost constant rate for every trial in the dominant and non-dominant hands, and the former increase-rate was significantly higher. In addition, the dominant hand was superior in all trials except for the 1st trial. It is considered that a functional role related to movement performances differs in the nerve mechanism for exercise (Cerebellum and basal ganglia). The cerebellum is, generally, associated with skilled motor behavior and the basal ganglia, in particular the striatonigral system, with motor behavior itself (Kornhuber, 1974). Chi et al. (1977) reported that the dominant hand is superior in the exertion values. The dominant hand in this study was also confirmed to be superior in the pursuit rotor test. The present pursuit rotor test was performed by submaximal muscular exertion with moderate revolutions (50 rpm). Achievement in this test requires strong hand-eye coordination (see Method) and the functional exertion is controlled by feedback such as 'sense of touch', 'matching of target', and so on. The dominant hand in daily life is excessively used, such as in writing a letter, using scissors, etc. Therefore, the non-dominant hand as compared with the dominant hand is inferior in nerve mechanism with exercise, i.e., peripheral muscular responses to the changing target and the exertion of nerve-muscle function, and requires more time to specify a movement dimension (Stelmach et al., 1987). The above functional developmental difference is considered to produce differences in the exertion values or performances between the dominant and non-dominant hands. It may be noted that a right and left difference was not found in the 1st trial and the improvement rate of the dominant hand was high. We inferred that because no subject had previously experienced a pursuit rotor test, factors such as the above development difference of nerve mechanism on exercise, adaptability to a new task, and the learning-ability difference in the nerve mechanism in both hands appeared as a difference in the increase rate of performance at every trial.

Significant differences among trial means were found in both hands, but the means almost stabilized after the 7th trial. Butki (1994) performed pursuit rotor movements with 15 trials with 10-sec intervals using 45 rpm (one trial was 1 min) with the dominant hand, and reported that the means were almost consistent after the 9th trial. Also, in the results of the present pursuit rotor test, the means improved at every trial until the 6th trial. This was different from the results of the pegboard test and coordinated exertion of force test using the same upper limbs (Nagasawa and Demura, 2002; Strenge et al., 2002). Seven to ten trials may be needed to obtain stabilized measurements. Nakamura et al. (1995) reported that the learning effect of pursuit movements is associated in both the knowledge of a target-locus (declarative memory) and the improvement of the procedure to pursue movement of a target (procedural memory). Although the present pursuit rotor test was the same (the same locus and speed) in all trials and each subject performed practice trials for 5 min, measured values improved at every trial until the 6th trial. Of the two types of memory mentioned above, the latter improvement is considered to have advanced learning and improved the exerted values.

Individual differences tended to differ in the dominant and non-dominant hands. Additionally, the effect sizes of difference between the 1st trial and the other trials were large after the 7th trial in both hands. Lateral dominance becomes more prominent by excessive use of the dominant hand in daily life and exercise activities (Chi et al., 1977). Butki (1994) reported that subjects needed 4 trials to gain some familiarity and show a significant improvement. It is considered that the non-dominant hand as compared with the dominant hand shows slower development in the nerve mechanism on exercise from the point of view of a frequency of use. The non-dominant hand is slower to adapt to a task and has small individual differences. However, subjects with superior eye and hand coordination quickly get accustomed to the task and rationally accomplish it as the trial is repeated, and individual differences are larger. Namely, individual differences may exist from experience and adaptation to the pursuit rotor task, and it appeared as an increase of individual differences in performance in the 1st to 3rd or 4th trials. It was clarified that the means after the 7th trial where the variance between trials stabilizes are larger in both hands as compared with that of the 1st trial.

Correlations between the measurements in both hands were not high. The practice effect can be judged to differ in both hands.

Nagasawa and Demura (2002) reported that reliability was higher in the 30-sec test than the 60-sec test for the target-pursuit test using a grip. In short, it is possible that the influence on the measurements differs by the length of measurement time even if a target of the same locus and speed cycle is used. It will be necessary to examine this using different experimental conditions (e.g., different test time, the practice effect over 10 trials).

In summary, the means improve at every trial in both hands, but the improvement rate decreased after the 7th trial. The improvement rate of the dominant hand is large. Variability of individual differences varies in both hands. The relationships among their measurements were not high. The practice effect of the pursuit rotor test by repeated trial may differ in both hands.

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