DEVELOPMENTAL CURVE OF BILATERAL TRANSFER IN MIRROR-TRACING

Keiichiro Tsuji

Bilateral transfer is one of the well-known phenomena in perceptual-motor learning. It can be defined as carry-over to the unpracticed hand of skill achieved by practice with the other. Weber (1844) reported his observation that some children can do legible mirror-writing with the nonpreferred hand after the preferred hand had been used in ordinary writing. Nevertheless, few attempts had been made on its developmental aspect until we started to examine the effect (Tsuji & Ide, 1974). In our previous experiment, the amount of bilateral transfer was measured with seven groups ranging in age from 8 to 30s. Subjects were instructed to trace patterns twice with their nonpreferred hand[2] (pretest) and were divided into two matched groups on the basis of mean tracing time. They were tested again for 6 more trials with nonpreferred hand (posttest) following 16 trials with preferred hand in the experimental group and 15-min. rest in the control group. Performance of the preferred hand significantly differed among the age groups at the initial level, but the differences disappeared as the trials continued. Comparison of the posttest learning curves of experimental and control groups clearly showed that the gain of perfomance in the former group was significantly greater than that in the latter group and bilateral transfer effect was observed in all of the seven age groups. Calculation of the positive transfer showed the highest value of 50% in the 8-yr.-old group. Then the amount was reduced to 20% in the 12- and 14-yr.-old groups respectively, with a constant level of 25% thereafter.

The present study further attempted to extend the range of age, so that a developmental curve of the bilateral transfer effect might be drawn.

METHOD

Subjects

The experiment was conducted for six groups ranging in age from 4 to 9 years.

Twenty subjects were assigned to each group. Mean chronological age was as shown in Table 1. Subjects had no prior experience with mirror-tracing task and were not instructd as to the aim of experiment prior to the session.

Table 1. Age and number of the subjects in each group

Group	Number			Age in years	
	male	female	total	range	mean
G-1	9	11	20	4.2-4.9	4.5
G-2	11	9	20	5.3-5.9	5.5
G-3	11	9	20	6.0-6.9	6.2
G-4	9	11	20	7.0-7.9	7.5
G-5	12	8	20	8.0-8.9	8.3
G-6	12	8	20	9.0-9.9	9.4

Task

Mirror-tracing of irregular patterns was given as a visuo-motor task as in the previous experiment. The patterns were composed of the irregularly directed pathways. From trial to trial the different patterns with the same level of difficulty were used. They were employed randomly in the trials. Each pattern had a path of 300mm long and 5mm wide, with five bends of 50mm linear segments. It contained approximately the same number of the horizontal, vertical, and oblique segments. Figure 1 illustrates the tracing pattern.

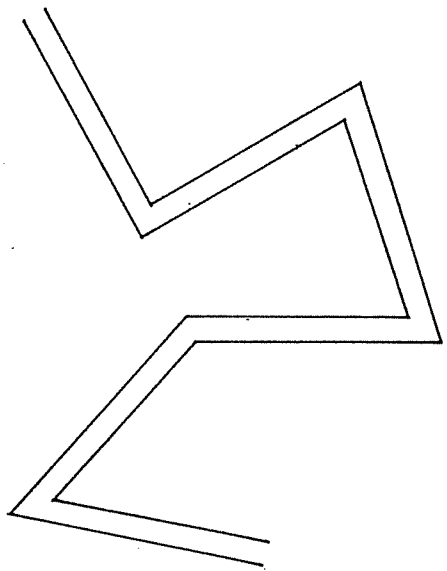


Figure 1. An illustration of the tracing pattern.

Such a revision in the tracing pattern was based on the authors' conception of this phenomenon. As was described in our previous article, the regular, geometrical patterns, e.g. star-shaped one, might be undesirable for the visuo-motor task because the subject, even a young child, would try to reproduce the actual pattern through observing its mirror image when they were visually captured. Thus the performance might be influenced by such a set, which would make the findings less reliable. The similar problem will happen when we repetitively use the same pattern from trial to trial for the same subject. He would become more attentive solely to his proprioceptive cue while tracing. To avoid these problems, we gave the above-mentioned task to the subject. Obviously, the subject would be able to adjust himself to the different patterns in the context of the same rule of transformation, after he has learned a new perceptual-motor coordination for the inverted visual world.

Apparatus

A mirror-tracing apparatus was used with minor adaptation for the children of lower ages.

Procedure

Subjects were tested twice with their nonpreferred hand (pretest). Based on the tracing time of the second trial, the subjects were divided into two matched groups, i.e., the experimental and control groups.

In the experimental group, the subject was instructed to practice tracing 8 times with his preferred hand following 120-sec. rest. After he completed the 8 trials, he was given a 120-sec. rest again and then was given 4 more trials with his nonpreferred hand (posttest). Intertrial interval was 30 sec.

In the control group, on the other hand, 10-min. rest was arranged between pretest and posttest instead of the trials with preferred hand. Intertrial interval was also 30 sec.

All the subjects were asked to trace the path while looking directly at the pattern after they finished the procedure mentioned above.

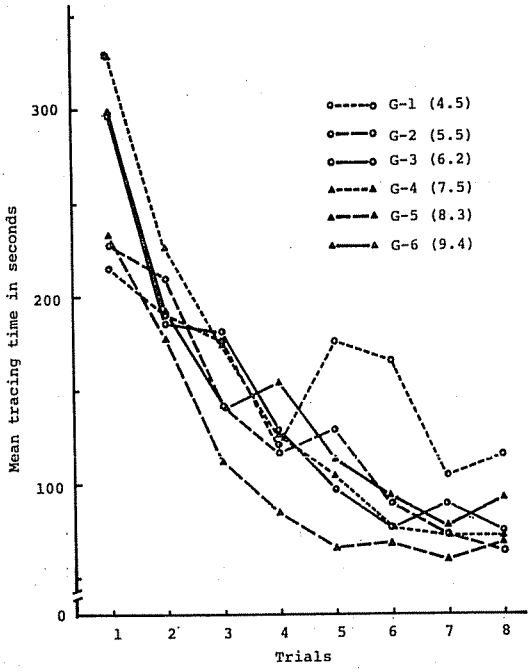
Measure

Tracing time was measured in the present experiment. Some investigators used the error score, e.g. the frequency of straying off pathway. However, the error score was so susceptible to incidental factors that its validity was questioned. In fact, it was inadequate (Suzuki, *et al.*, 1972).

RESULT

Performance of preferred hand as a function of trials for experimental group.

Mean time of tracing with preferred hand was plotted as a function of trials for each group, as is shown in Figure 2.



Fignre 2. Mean tracing time with preferred hand as a function of trials for each of the six age groups.

Tracing time which widely differed in Trial 1 decreased and reached an approximate asymptotic level by the end of Trial 8 with an exception of 4-yr.-olds. In that group, the final trial took the longest time, owing mainly to the abrupt increase in time on Trials 5 and 6, although the initial tracing time was minimum among the six groups.

In our previous study the initial tracing time which widely differed among groups showed the inverse correspondence with age. However, the first and the second youngest groups (4- and 5-yr.-olds) showed the remarkably shorter time than the oldest group (9-yr.-olds). A similar tendency was observed when we compared the initial tracing time with nonpreferred hand among groups.

Amount of bilateral transfer as a function of age.

Tracing time abruptly decreased between pretest and posttest for each experimental group, while no comparable decrease occurred for the control group. Although the time the second trial of the pretest was not significantly different between the experimental and control groups, time of the experimental group on Trial 1 of the posttest was significantly shorter than the time of the control group for all age groups(Table 2). Thus the transfer effect was observed for those groups.

Table 2. Statistical test of the difference (t-score) between experimental and control groups in the second trial of pretest and the first trial of posttest.

Group	Trial 2 of pretest	Trial 1 of posttest	p
G-1	0.32	4.09	$<.005$
G-2	1.04	4.00	$<.005$
G-3	0.90	3.09	$<.010$
G-4	0.32	3.28	$<.005$
G-5	0.39	3.88	$<.005$
G-6	1.34	2.55	$<.025$

Here, we calculated the amount of positive transfer by the following formula which Murdock (1957) proposed[3]

$$T=\frac{E+C}{E-C}\times 100,$$

where E, C indicate the mean time of Trial 1 of the posttest in the experimental and control groups respectively. Figure 3 shows these values as 50.3, 51.7, 57.3, 46.2, 29.8, 24.5 for 4-yr.- through 9-yr.-olds, respectively. The transnsfer effect reached the maximum for the 6-yr.-olds and then declined.

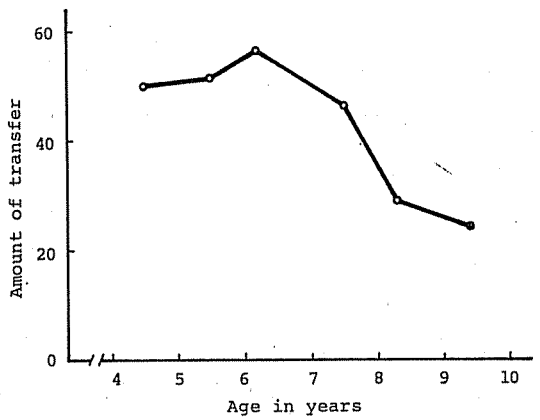


Figure 3. Amount of bilateral transfer as a function of age.

DISCUSSION

The main purpose of our study was to plot a developmental curve for amount of bilateral transfer as was described earlier. For that purpose we combined the data of the present experiment with those of the previous experiment (Tsuji & Ide, 1974) by using the scores of the 8-yr.-olds tested in both experiments as a base for conversion. Thus we obtained a curve shown in Figure 4.

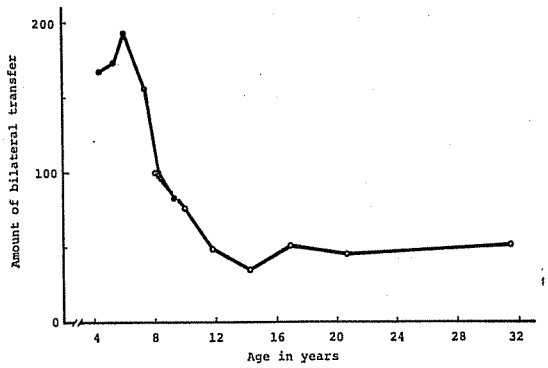


Figure 4. Amount of bilateral transfer as a function of age.

The amount of transfer peaked at 6-yr. and then declined with increase in age to 12-yr. Thereafter a constant level was maintained to age 30s.

Murdock's formula which presupposes the equal level of the performance in the pretest compares time on Trial 1 of the posttest between the experimental and control groups. Both groups were matched on the basis the mean time at the pretest in the earlier experiment. However, as was described earlier, the matching was done on the basis of Trial 2 of the pretest in the present experiment, because the younger subjects could not adjust themselves to the experimental situation on Trial 1. Such a difference in procedure did not seem to make it invalid to combine the two data.

Examination of the learning curves showed that the performance at posttest for the experimental group was similar in level and differed nonsignificantly among the age groups, while the differences among the age groups were significant for the control. This seemed that the amount of transfer might have been erroneously calculated. One possible factor would be the difference in the effect of rest time on performance at posttest. Examining this factor indirectly by comparing

the effect among different intervals, we could deniy its possibility. We also measured the time of tracing with nonpreferred hand under direct observation. The times thus obtained were significantly shorter than the values which the experimental group of the corresponding ages reached. The performance, therefore, could further be improved, if more transfer had actually occurred. Thus, it may be said that the curve obtained in our experiments successfully describes the developmental change of bilateral transfer in mirror-tracing. Now that we have fulfilled our primary purpose, our next step will be to clarify the variables which may determine the process.

We further tried to collect data over wider range of age by applying the experimental procedure to the 3-yr.-olds as the lower age and 70s and 80s as the higher age. Our attempt, however, proved to be unsuccessful for several reasons.

In the advanced age group (over 60-yr.-olds), almost all of the subjects exhibited the trembling in the upper limb and could not move the hand freely from overstrain. This consequently took extremely long time to finish the trial. As was shown in our previous article, their traces were like the handwriting of a paralyzed patient, probably because the subjects failed to regulate their motor activity to the inverted visual world. The subjects tended to manifest discomfort or a rejective attitude toward the testing situation. Thus only a few completed the session. Such difficulty in mirror-tracing may have resulted partly from a lack of flexibility required to shape a new visuo-motor coordination and partly from the disturbances in the motor function. In the younger children (3-yr.-old), another problem arose. In spite of our attempt to make the task easier, the subjects often gave up trying to follow the instruction and looked directly at the pattern when they were perplexed about the direction of tracing.

Bilateral transfer may be closely related to lateral differentiation of the body function. The determination of the handedness may be a result of lateral differentiation of the function which is acquired through the interaction of maturity, learning and exercise (Hildreth, 1949). In neonates, the hand movement is a part of the diffuse, gross movement of the body which may be induced by stimulation from inside or outside. Gesell and Ames (1947) extensively researched the process in which the handedness was established with the subjects ranging in age from 8

mo. to 10 yrs. The dominant side of the hand shifted frequently before the children finally established the stable handedness. Symmetrical movement was frequently alternated by asymmetrical movement during the first year of life. However, the frequency of alternation slowed down and showed the symmetrical period from 1- to 1.5-yr., from 2.5- to 3.5-yr., respectively. From 4 yrs. the dominant side tended to be used as preferred hand and a more stable period gradually emerged from 7 yrs. on.

In this connection some subjects were actually observed showing a high tonic state of the upper limb on the opposite side while tracing a pattern. This tonus appeared the more remarkable when the subject wavered in choosing which way to move his hand and extended to the legs or the trunk of the opposite side in the extreme case. The strong tonic state was observed in the 4-, 5-, and 6-yr. -olds more frequently than the older groups. It gradually disappeared as the subject became skillful in his tracing.

The development of bilateral transfer, therefore, should be analyzed in connection with the lateral differentiation of body function. For this purpose the asymmetry in the spontaneous EEG and the bilateral effect of evoked EMG should be helpful indices.

REFERENCES

Gesell, A. and Ames, L.B. 1947. The development of handedness. *Journal of Genetic Psychology*, **70**, 155—175.

Hildreth, G. 1949. The development and training of hand dominance: III. Origins of handedness and lateral dominance. *Journal of Genetic Psychology*, **75**, 255—275.

Hildreth, G. 1950. The development and training of hand dominance: IV. Developmental problems associated with handedness. *Journal of Genetic Psychology*, **76**, 39—100.

Humphries, M. and Shephard, A.H. 1959. Age and training in the development of perceptual-motor skills. *Perceptual and Motor skills*, **9**, 3—11.

Murdock, B.B., Jr. 1957. Transfer designs and formulas. *Psychological Bulletin*, **54**, 313—326.

Suzuki, T., Suzuki, M., Osada. M., Tsuji, K., and Hayashibe, K. 1973. The amount

of bilateral transfer as a function of practice with preferred hand in the mirror-tracing. *Bulletin of Nagoya University College of General Education*, **19**, 47—58 (in Japanese).

Tsuji, K. and Ide, Y. 1974. Development of bilateral transfer of skills in the mirror-tracing. *Japanese Psychological Research*, **16**, 171—178.

ABSTRACT

Bilateral transfer in the mirror-tracing was examined for six groups ranging in age from 4 to 9 yrs. Each group consisted of 20 subjects. Subjects traced the patterns twice with their nonpreferred hand (pretest) and were divided into matched groups on the basis of the time required for finishing the second trial. They were tested again with nonpreferred hand for 4 trials (posttest). Between pre- and posttest 8 trials with preferred hand were inserted in the experimental group, while 10-min. rest was given in the control group. By comparing the first trial of the posttest between the two groups, the positive transfer effect was observed for all age groups. The amount of transfer obtained by the Murdock's formula was 50.3, 51.7, 57.3, 46.2, 29.8, 24.5 from 4-yr.-old through 9-yr.-old groups, respectively. To sketch a developmental curve over wider range of age, the data were combined with those of the previous experiment. The curve showed the peak at 6 yrs. of age and then reduced to 14 yrs. with a constantly kept level thereafter.

FOOTNOTES

1) The data in the present article were mainly based on the Master thesis submitted by Yoko Ide under the guidance of the author. Part of the present article was reported as a cowork with her at the 39th Annual Convention of the Japanese psychological Association. The author is much indebted to the staff-members of the Takenoko Kindergarden (Okazaki, Aichi Prefecture) for their cooperation in carrying out the experiment.

2) Preferred hand was determined as the side used for drawing and writing.

3) We prosposed a new formula in the previous article, but the author used the Murdock's one here for the convenience of comparison.