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The Effect of Attentional Focus for Novices in a Mirror-Drawing Task

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Focus of attention can affect motor learning efficiency. In particular, external focus, i.e. focus on the consequence of actions, was shown to improve learning speed and learning retention more than internal focus, which is focus on the action *per se*. Previous studies suggest that external focus can avoid interference with automatic action control and thus improve motor learning. Meanwhile, some theories on motor learning suggest that a novice should first coordinate action components, which implies that internal focus, rather than external focus, may be critical for novice. The goal of this study was to investigate the effect of attentional focus in a mirror drawing task. The mirror drawing task is rare in daily life and relies on eye-hand coordination, and therefore is selected to probe novice in motor learning in this study. The external focus group was instructed to follow their drawing behavior from the mirror, while the internal focus group to feel their wrist during drawing. Two experiments were carried out. Experiment 1 showed significant improvement of mirror drawing speed from one trial experience; however, no significant difference was observed between external and internal groups. Nevertheless, correlation analyses indicated that external focus group showed more consistent response speed across two trials than the internal group. Experiment 2 asked participants to practice 15 times for the first day, and tested retention and transfer at the second day. Results showed that after practice, external focus group completed drawing faster than internal focus group in the last 5 practice trials, as well as in the transfer test. Our results thus replicated that external focus can facilitate motor learning. For novices who were in the coordination stage, there was no evidence showing that internal focus of attention can facilitate motor learning.

Keywords: *Attention focus, mirror drawing task, motor learning, novice, transfer*

Extended Abstract

The focus of attention can affect motor learning efficiency. In particular, we may focus our attention on the consequence of our action (external focus) or on the action itself (internal focus). Studies have shown better improvement in motor learning efficiency under an external rather than internal focus. The constrained action hypothesis (McNevin, Shea, & Wulf, 2003; Wulf, McNevin, & Shea, 2001; Wulf & Prinz, 2001) posits that internal focus can interfere with automatic processing during motor learning, leading to poorer learning performance compared to external focus. The advantage of external versus internal focus in motor learning has been demonstrated in many sports, including tennis (e.g., Hadler et al., 2014), basketball (Zachry et al., 2005), and golf (Wulf et al., 1999). This advantage of external focus has also been observed in novices (Hadler et al., 2014), those with some prior practice (Wulf et al., 1999), and those with expertise (Zachry et al., 2005). Wulf and Lewthwaite (2016) therefore proposed the OPTIMAL (optimizing performance through intrinsic motivation and attention for learning) theory to summarize the effects of attentional focus and motivation on motor learning.

However, Peh, Chow, and David (2011) argued that a novice who has no experience in a certain motor skill

may require internal focus at first. According to Newell (1985), motor learning can be divided into three stages: coordination, control, and skill. The novice needs to coordinate different muscles to fulfill the requirements of the new motor skill, which may require internal focus. Peh et al. (2011) argued that the coordination stage exists only for a new motor pattern. A person may be a novice in golf, but the swing is not considered a new motor pattern because the person may experience swings on other occasions in daily life. In this case, most "novices" in previous studies (e.g., Hadler et al., 2014) are actually at the second stage, "control," rather than at the first stage, "coordination." In other words, whether coordination can benefit from internal focus remains unknown.

The goal of the current study was to use a mirror drawing task to examine whether the first stage of motor learning, like the later stages, benefits more from external than internal focus (McNevin et al., 2003; Wulf et al., 2001; Wulf & Prinz, 2001) or vice versa (Peh et al., 2011). Mirror drawing is a reverse eye-hand coordination task using the reflection in a mirror, which is rare in daily life, allowing us to probe the first stage, "coordination," under different attentional focus manipulations. Figure 1 shows the equipment for the mirror drawing and the figure to be drawn in this experiment. In Experiment 1, participants were asked to complete only two trials to maintain their novice status, while Experiment 2 tested different motor learning processing, including practice, retention, and transfer over a two-day procedure.

In Experiment 1, 111 right-handed participants were recruited who had no prior experience in mirror drawing and who were randomly assigned to either the internal or external focus group. Five participants failed to complete the mirror drawing task in 8 minutes, and their data were thus excluded from further analysis, leaving 53 participants in each attentional focus group. All participants completed the informed consent form approved by the IRB. The internal focus group was instructed to "put your attention on your wrist during the mirror drawing," while the external focus group was asked to "put your attention on the results in the mirror during the mirror drawing." Only two trials were applied to maintain their novice status. The time to complete each trial was recorded by the experimenter. Any stroke that went out of the boundary of the drawing pattern was considered an error.

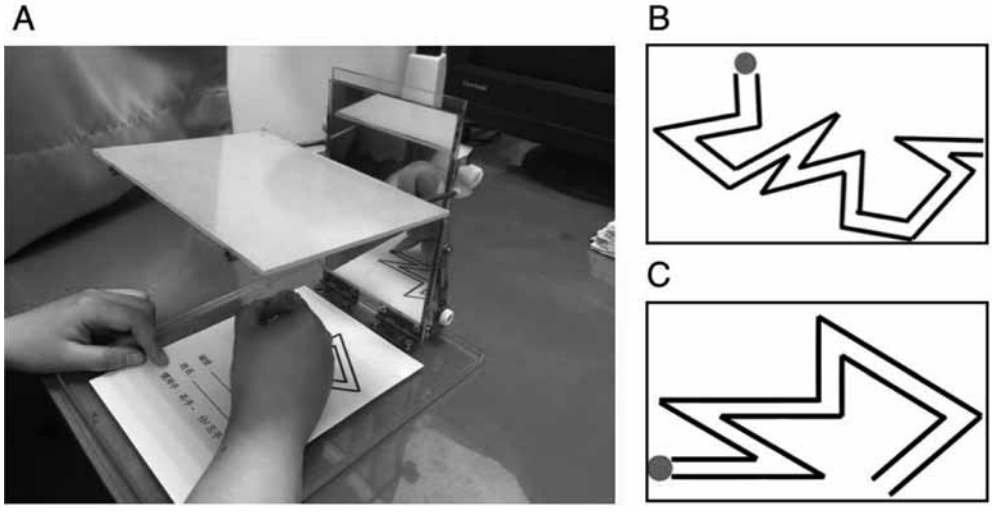

Figure 1. **(A) The equipment used to implement the mirror drawing in this experiment. (B) The drawing pattern used in Experiment 1 and in the transfer test in Experiment 2. (C) The drawing pattern used in the practice and retention test in Experiment 2. The dots in (B) and (C) are the starting points for the mirror drawing.**

Table 1. **Results of Experiment 1**

	First trial		Second trial	
	Duration (second)	**Number of error**	**Duration (second)**	**Number of error**
Internal focus group	142.48 (81.15)	7.2 (7.6)	81.67 (37.66)	3.7 (4.3)
External focus group	130.36 (91.11)	7.2 (8.7)	82.17 (66.79)	4.2 (7.7)

Note: Numbers in parentheses show the standard deviation

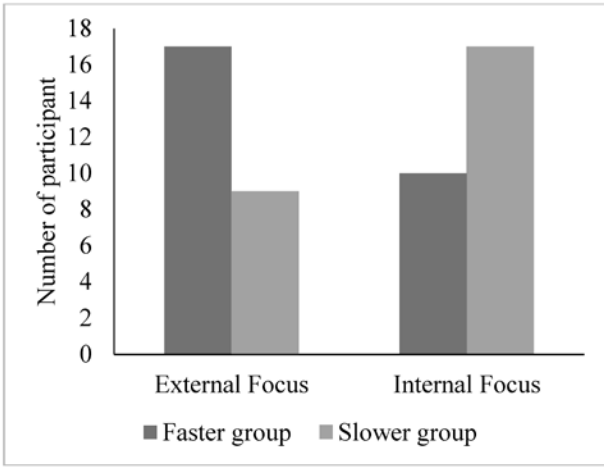

Figure 2. **Number of participants in the faster/slower group in each attentional focus condition in the second trial of Experiment 1.**

Table 1 shows the results of Experiment 1. Both the response speed and the number of errors were improved in the second trial compared to the first trial, $F(1,104) = 50.77$, $p < .001$, $\eta^2_p = .327$ for the duration analysis, and $\chi^2(1) = 129.18$, $p < .001$ for analysis of the number of errors. Nevertheless, attentional focus (external vs. internal) did not show any statistically significant difference, and there was no significant interaction between attention focus and the trial number.

Although response duration and errors did not reveal an effect of attentional focus, other indices implied that external focus has advantages over internal focus in mirror drawing. First, the correlation between the duration of the two trials was higher for the external focus group ($r = .70$, $p < .001$) than for the internal focus group ($r = .51$, $p < .001$), $z = 2.10$, $p = .018$, suggesting that participants with external focus responded more consistently in these two trials. In addition, when we took the median of each trial as the cut-off point and divided participants into a faster group (time shorter than the median) and a slower group (time longer than the median), in the second trial, as shown in Figure 2, more participants with external focus belonged to the faster group than to the slower group, $\chi^2(1) = 4.18$, $p = .04$. Therefore, the participants with external focus were more likely to speed up in the second trial, implying an advantage of external versus internal focus.

Experiment 2 further examined the effect of attentional focus on practice, retention, and transfer in the mirror drawing task. Thirty-four participants, 17 in each attentional focus condition, were invited for a two-day experiment. They completed 15 practice trials on the first day, and on the second day, they completed two trials with the same drawing pattern (Figure 1C, retention test) and another two trials with a different drawing pattern (Figure 1B, transfer test). The instructions for external

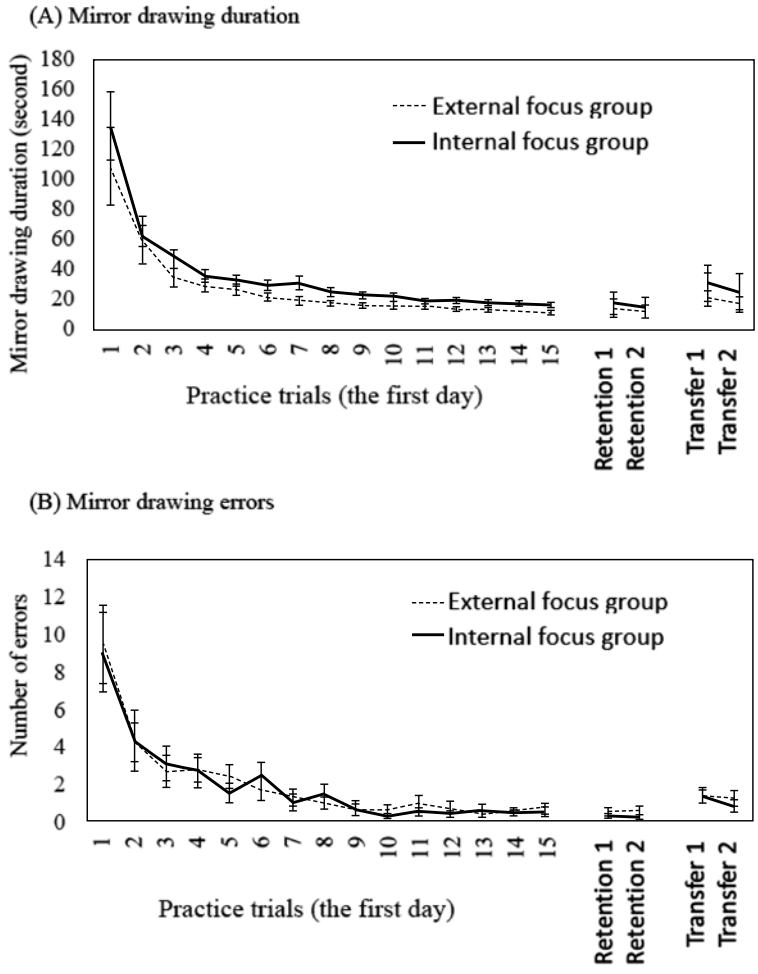

Figure 3. **The results of Experiment 2: duration to complete the mirror drawing (A) and number of errors (B).**

and internal focus were the same as in Experiment 1, and were given only on the first day during the practice phase.

Figure 3 shows the results. On the first day, the number of practice trials showed a significant effect, $F(14,448) = 35.786$, $p < .0001$, $\eta^2_p = .525$, whereas there was no significant effect of focus of attention, nor any significant interaction between practice and focus of attention. However, when the practice reached its ceiling, such as in the final 5 practice trials, the response duration was faster for the external focus group (mean 13.38 seconds) than the internal focus group (mean 18.12 seconds), $t(32) = 2.13$, $p = .05$, Cohen's $d = 0.69$. While the retention test showed no significant effect, the transfer test did, $t(32) = 2.73$, $p = .01$, Cohen's $d = 0.94$, indicating that those who received the external focus instruction on the first day completed the more complicated transfer test faster (19.43 second) than those who received the internal focus instruction on the first day (27.84 second). The number of errors showed only a practice effect ($\chi^2(14) = 78.95$, $p < .001$) but no retention or transfer effect. Therefore, in the practice phase, the first few trials showed only the practice effect, replicating the observations in Experiment 1. After extensive practice, however, participants with external focus could perform faster than those with internal focus, replicating previous findings on the advantage of external focus on motor learning (e.g., Wulf et al., 1999). Furthermore, external focus facilitated greater transfer than internal focus, also replicating previous results (e.g., Hadler et al., 2014).

In summary, we used a mirror drawing task to probe

how attentional focus affects motor learning efficiency, especially at the coordination stage. Experiment 1 showed that attentional focus did not alter the first two trials; rather, people with external focus tended to perform more consistently in the two trials and were more likely than those with internal focus to belong to the faster group in the second trial. Experiment 2 showed that after extensive practice, people with external focus could complete the mirror drawing faster than those with internal focus and could complete the transfer task faster on the second day. Altogether, there was no evidence showing an advantage of internal focus over external focus in motor learning. Therefore, we conclude that even at the first coordination stage, motor learning benefits from external rather than internal focus of attention.