

JoVE: Science Education
Motor Learning in Mirror Drawing
--Manuscript Draft--

Manuscript Number:	10064
Full Title:	Motor Learning in Mirror Drawing
Article Type:	Manuscript
Section/Category:	Manuscript Submission
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Psychology Education Title

Motor Learning in Mirror Drawing

Overview: Colloquially, the terms ‘learning’ and ‘memory’ encompass a broad range of behaviors and mental systems, everything from learning to tie a shoe to mastering calculus (and a lot in between). Experimental psychologists have divided up learning mechanisms into groups that seem to have different properties, and that seem to rely on different brain systems. A major division is between *declarative* and *non-declarative* memory, roughly, the sorts of things a person can express verbally—explicitly, like a birthdate, or what one ate for lunch—and things they cannot quite put into words—things they know implicitly, like how to get home despite not knowing the street names, or how to flip an omelet.

In the domain of non-declarative memory, a crucial kind of learning involves *motor learning*, sometimes also called ‘procedural memory.’ Learning to drive a car is a good example. At first it is usually arduous, and seems to involve explicit attempts to remember what to do next. Eventually it becomes second nature though, something that a person just kind of knows how to do—and does better and better with time—but that can be hard to explain to someone else.

Mirror drawing is a common laboratory paradigm for investigating the acquisition of learned motor skills, the kind involved in driving, for example. This video demonstrates standard procedures for mirror drawing.

Procedure

1. Stimuli

- 1.1.** This experiment requires a mirror that can stand on a table on its own, 2 feet by 2 feet (though larger is fine), as well as a flat rigid surface at least as big as an 8.5x11 piece of paper, that can stand on its own while slightly tilted. A piece of wood with a stand or a piece of foam core is good. We will call this the ‘occluder.’ The experiment also requires a pencil.
- 1.2.** Place the mirror about 12 inches from the edge of a table, standing upright. Place the occluder so that it is about 6 inches from the edge of the table, occluding the view of the space between the table and the screen.
- 1.3.** Print out several pieces of white paper with a large star on it, and a slightly smaller star within the bigger one. It will look like this:

Figure 1

- 1.4.** Place the paper with the star on it between the occluder and the mirror.

2. Running the experiment

- 2.1 One participant is tested in several sessions, usually over several days (but not necessarily).
- 2.2 During each testing session, the participant sits in front of the occluder.
- 2.3 Instruct them to place the pencil tip down at any point on the star, between the two borderlines. Without lifting the pencil up, they should trace around the star, coming fully back around, and trying to stay within the borders. Errors will be counted as the number of times they cross a border.
- 2.4 After each session give the participant a break for at least 10 minutes.
- 2.5 Label each piece of paper with the session number (e.g. Day 1, Session 1).

3. Analysis

- 3.1 Count the number of times the participant crossed the borderlines in each experimental session. Generally, the number of errors will decline over time, reflecting motor learning.

Representative Result

The results are graphed by plotting the number of errors in a session as a function of sequence.

Figure 2

Note that performance improved over time. This is evidence of motor learning taking place. The strongest evidence is in the sessions following the long break. Here, the participant's starting point is better than their starting point before the break. In other words, they retained what they learned, rather than forgetting it. Second, the rate of improvement—the slope of the curve—is steeper after the break. The participant learns more quickly owing to the learning that has already taken place.

Applications

Mirror drawing has many applications for investigating the mechanisms of motor learning. For example, if a researcher wanted to investigate whether sleep supports motor learning, they might compare a group of participants who complete blocks of mirror drawing sessions, separated by a nap, with another group for whom the sessions are separated by a break without sleep. If the nap group showed fewer errors in the first session after the break than the no-nap group, it would suggest that napping promotes retention of recently learned motor skills. A similar conclusion could be reached if the nap group showed a greater rate of improvement after the nap than the group without the nap.

Perhaps the most famous application of mirror drawing is in the case of patient Henry Gustav Molaison (H.M.). Surgeons removed most of H.M.'s hippocampus in order to prevent life-threatening seizures. Fortunately, the surgery worked, and his seizure's subsided. The

hippocampus (**Figure 3**) is now known to play a crucial role in the formation of new memories, and H.M. suffered severe anterograde amnesia. He was unable to form *new explicit* memories. He could not remember events that took place just moments ago, for example a doctor having just visited his hospital room. Amazingly, when it came to mirror drawing, H.M. performed just like everyone else—he improved, and he showed retained improvements and more rapid improvements on subsequent testing days. This famous study, done by psychologist Brenda Milner, in many ways led to the recognition of a distinction between explicit and implicit memory and the brain mechanisms supporting them. For example, follow up experiments with patients suffering from Alzheimer’s disease—which tends to have its earliest and most severe effects in the hippocampus—have suggested that they, like H.M., often possess a preserved ability for motor learning, despite rampant memory impairment in general.

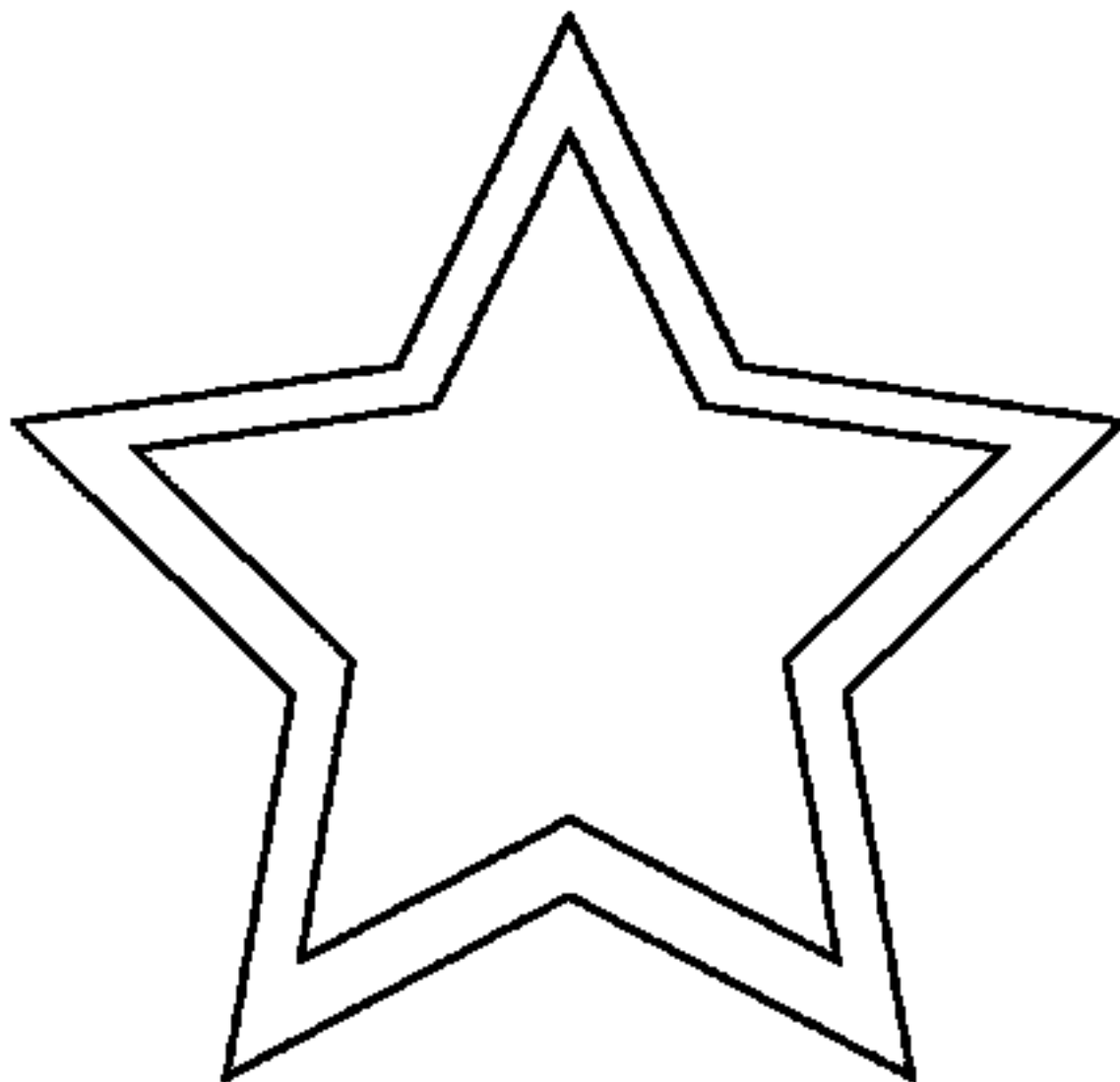
Legend:

Figure 1 — Star stimulus for use in mirror drawing. The participant’s task will be to trace the star, trying to stay within the boundary of the two outlines.

Figure 2 – Mirror drawing errors as a function of session number. In this version of the experiment, the participant received a long break of 2 hours between sessions 5 and 6, instead of the usual 10-minute break between the other sessions.

Figure 3: Prefrontal Cortex and a Portion of Cortex Occipital of the Intra-parietal Sulcus

Star Stimulus for Use in Mirror Drawing



Mirror Drawing Errors

