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Mirror Tracing: The Effect of Different Shapes on Transfer Performance

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Introduction

Learning and memory are essential components to survival in most animals. Memory is how humans learn and maintain skills like tying our shoes, riding a bike, or driving a car. There are two different memory systems: explicit and implicit. Explicit memory, also known as declarative memory, involves conscious recollection, while implicit memory, also known as procedural memory, involves unconscious recollection or automatic memory.[1] Both memory systems are able to exist independently of one another. For example, the implicit memory system is still intact in dementia patients, who cannot consciously recollect.[2] The implicit memory system can be studied through the use of learning many different modalities.

The mirror tracing task is one way that implicit memory can be studied since it is a nonconscious, learned task.[3] This method involves tracing the outline of a shape through a mirrored reflection. One study used this particular method while examining learning during child development, as participants looked through a mirror while tracing a square.[4] Learning can be assessed through performance on the task over time, meaning improved performance can be attributed to learning. With regards to the mirror tracing task, improvement in performance can be evaluated through less errors and a faster performance across trials.

The mirror tracing task is used to gain knowledge about the learning process through the learning of a visual motor task.[5] It can also be used to examine memory and learning across many different groups and in different cognitive scenarios. This task can also examine the relationship between latency and mistakes since it is timed. Latency is the time elapsed on a task, and it is believed that longer time elapsed reduces the rate of errors, hypothesized by researchers in a study on animal behavior.[6] It also has been used to assess and compare the procedural memory of past alcoholics with different levels of sobriety.[7] Distraction and distress scenarios during the mirror tracing task can be used to examine their effects on learning and procedural memory.[8] By assessing different cognitive scenarios like distraction or distress during the mirror tracing task, we are able to see how certain scenarios impact learning and memory differently. Mirror tracing is a commonly used task because of its simplicity and ability to examine many populations in easily manipulated scenarios.

The mirror tracing method often uses different polygons, meaning a plane figure with at least three

1 Henry L. Roediger, "Implicit Memory: Retention without Remembering," *American Psychologist* 45, no. 9 (1990), https://psycnet.apa.org/doi/10.1037/0003-066X.45.9.1043.

2 Barbara E. Harrison et al., "Preserved Implicit Memory in Dementia: A Potential Model for Care," *American Journal of Alzheimer's Disease and Other Dementias* 22, no. 4 (2007), https://doi.org/10.1177/1533317507303761.

3 Klaus Junghanns et al., "Chronic and High Alcohol Consumption Has a Negative Impact on Sleep and Sleep-Associated Consolidation of Declarative Memory," *Alcoholism: Clinical and Experimental Research* 33, no. 5 (2009), https://doi.org/10.1111/j.1530-0277.2009.00909.x.

4 Mona Sharon Julius and Esther Adi-Japha, "A Developmental Perspective in Learning the Mirror-Drawing Task," *Frontiers in Human Neuroscience* 10 (2016), https://doi.org/10.3389/fnhum.2016.00083.

5 Agnes E. Knightly, "The Process of Learning as Shown by the Mirror-Drawing Experiment," *ScholarWorks@UMass Amherst* (1934), https://scholarworks.umass.edu/theses/1672.

6 Gabrielle Gamberale-Stille, Carolina Bragée, and Birgitta Tullberg, "Higher Survival of Aposematic Prey in Close Encounters with Predators: An Experimental Study of Detection Distance," *Animal Behaviour* 1, no. 78 (2009), https://doi.org/10.1016/j.anbehav.2009.04.015.

7 Junghans et al., "Chronic and High Alcohol Consumption."

8 Elizabeth D. Reese et al., "Distress Tolerance Trajectories Following Substance Use Treatment," *Journal of Consulting and Clinical Psychology* 87, no. 7 (2019), https://pubmed.ncbi.nlm.nih.gov/31008636/.

sides, for tracing. Changing the shape of the polygon is one way the mirror tracing task can be manipulated. For example, one study opted to use a square for the task because it does not require diagonal lines, which are considered more complex.[9] Other research has been conducted to compare results across multiple shapes, rather than just the learning of one shape. Salowitz and colleagues compared autistic children and neurotypical developmental children using a circle, star, and square.[10] By using a more diverse range of shapes, researchers were able to investigate the learning differences between populations across varying levels of difficulty. Multiple shapes are often used because they have different levels of complexity (shapes with diagonals are seen as more complex than those with straight lines)[11], so we can assess the varying levels of visual motor activity to see which ones have a greater impact on learning and memory.

In our study, we used a mirror tracing transfer task in order to examine learning across different shapes. The mirror tracing transfer task involves the learning of one particular shape and then transferring to a much more advanced shape in order to assess learning and retention of the skill, rather than just practice. Without transfer, memorization can explain improved performance, rather than learning. By moving on to a more difficult shape, participants have to employ nonconscious, learned skills. Participants were randomly assigned to practice the mirror tracing task on either a circle or a square, similar shapes to those used in the study with autistic children.[12] A circle does not have straight lines, so it was viewed as the more complex shape. Participants then transferred their skills to a more complex shape—the transfer test, so we could assess which shape had a greater impact on learning. We examined how shape during training affected performance on the transfer test, and we examined how latency (time elapsed on the task) affected the number of mistakes made in order to examine the effect of different visual motor skills on learning.

We hypothesized that those who trained on a circle would have a higher performance on the transfer test, as compared to those who trained on a square. In the later study examining the effect of latency on errors, we hypothesized that latency would negatively correlate with the number of errors made during the transfer test in the mirror tracing task.

Methods

Participants

Our study featured a 64-participant convenience sample from an undergraduate laboratory class in behavioral neuroscience at Arcadia University. The study consisted of both males and females ranging from 19 to 22 years old. Refer to the table below to examine the demographic table of our participants.

Apparatus

			19 YO	20YO	21 YO	22 YO	R. Handed	L. Handed
	Factor	Total Sample	Total Sample	Total Sample	Total Sample	Total Sample	Total Sample	Total Sample
Gender	n	64	29	24	7	3	55	8
	% Male	12.50%	6.90%	16.67%	28.57%	0%	12.73%	12.50%
	% Female	82.81%	93.10%	83.33%	71.43%	100%	87.22%	87.50%
	% Other	4.69%	0%	0%	0%	0%	0%	0%
	n	64	29	24	7	3	55	8
Race	% White	85.94%	89.66%	79.19%	85.71%	100%	87.27%	75%
	% African American	6.25%	3.45%	8.33%	14.29%	0%	5.45%	16.67%
	% Hispanic	3.13%	0%	8.33%	0%	0%	1.82%	16.67%
	% Asian	4.69%	6.90%	4.17%	0%	0%	5.45%	0%

Figure 1. depicts the demographics of the participants in this study. n = number. YO = years old. R = right. L = left.

9 Julius and Adi-Japha, "A Developmental Perspective."

10 Nicole M. G. Salowitz, Petra Eccarius, Jeffrey Karst, Audrey Carson, Kirsten Schohl, Sheryl Stevens, Amy Vaughan Hecke, and Robert A. Scheidt, "Brief Report: Visuo-Spatial Guidance of Movement During Gesture Imitation and Mirror Drawing in Children With Autism Spectrum Disorders," *Journal of Autism And Developmental Disorders* 43, no. 4 (2013), https://pubmed.ncbi.nlm.nih.gov/22898762/.

11 Julius and Adi-Japha.

12 Salowitz et al., "Brief Report: Visuo-Spatial Guidance of Movement."

We used an internet-based mirror tracing game, created by the University of Illinois, for both the training and the transfer test. We used a square and circle shape during training, and we used an advanced shape for the transfer test, all found on the website.[13]

Procedure

The participants were first instructed to select the shape to which they were randomly assigned. The first tracing was non-mirrored, and the next tracing was mirrored. The participants began each trial by clicking on the shape, which started the clock. The participants then moved the cursor within the boundaries along the shape as quickly as possible with the fewest errors possible. The clock stopped when the participant clicked again. The results were then displayed. This process was repeated one more time with the same shape. For seven weeks, this process was repeated once a week. On week 9, participants completed the same process for the transfer test on the advanced shape assigned.

Statistical Analysis

We ran a separate one-way ANOVA on both total number of errors and latency during the transfer task to determine the effect of shape on performance in the mirror tracing task. In a later analysis, we ran a Pearson's bivariate correlation in order to analyze the effect of latency on errors.

Results

In the present study, we investigated the effect of shape (square or circle) on performance on the mirror tracing transfer test (latency and number of errors made). A one-way ANOVA revealed that assigned shape, square (M=86.9200) and circle (M=92.7097), had no impact on the amount of time it took to complete the transfer test ($F(1,54) = .241$, $p = .626$). An additional one-way ANOVA also revealed that shape, square (M=30.4800) and circle (M=31.8710), had no impact on the amount of errors made during the transfer test ($F(1,54) = .110$, $p = .741$).

We were also interested in determining the impact of latency (time it took to complete the task) on the number of errors made during the transfer task. A Pearson's Bivariate Correlation revealed that latency had a significant impact on the amount of errors made ($R(56)=.393$, $p = .003$).

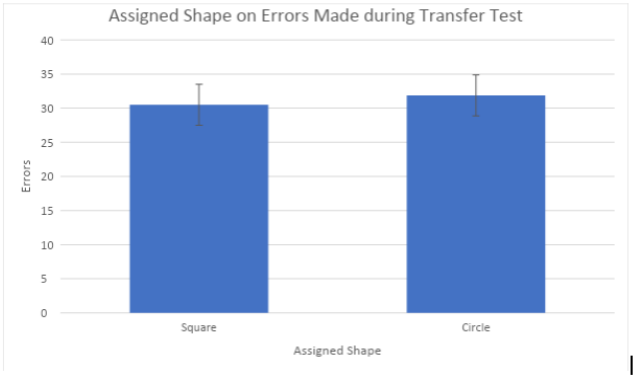

Figure 2. depicts the effect of shape on errors made during the transfer test in mirror tracing. There was no significant difference between shapes.

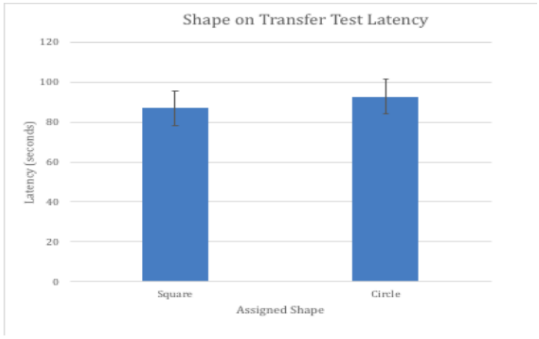

Figure 3. depicts the effect of shape on latency during the transfer test in mirror tracing. There was no significant difference between shapes.

The Effect of Latency on Errors in the Transfer Test

Discussion

In our study, we investigated how mirror tracing training on different shapes (circle or square) impacted performance on the transfer test. Our purpose was to assess implicit memory through the learning of different shapes. We hypothesized that training with a circle will result in better performance on the transfer test (as measured by latency and number of errors)

13 "Mirror Tracing Game," Project Neuron, University of Illinois, 2009. https://projectneuron.illinois.edu/games/mirror-tracing-game.

than those who trained using a square. Our hypothesis was not supported, as each one-way ANOVA analysis revealed no statistical significance between each shape. In a later analysis, we investigated the effect of latency (time elapsed) on errors. We hypothesized that latency would negatively correlate with the number of errors during the transfer test. Our hypothesis was not supported. A Pearson's Bivariate Correlation revealed a statistically significant positive correlation.

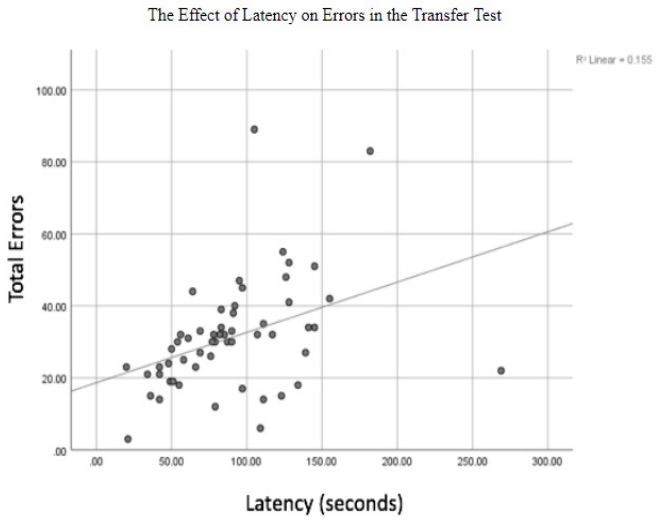

Figure 4. depicts the effect of latency on errors made during the transfer test in the mirror tracing task. A Pearson's Bivariate Correlation revealed that latency had a significant effect on total errors made during the transfer test, p<.01.

Further analysis revealed a positive correlation between latency and errors, refuting our hypothesis. In one study, mirror tracing was used to assess learning under distress. With each error, distress was added (using a buzzer sound), so the greater the latency, the greater the number of errors were revealed, due to distress.[14] Researchers in a study analyzing animal behavior between predator and prey also hypothesized a negative correlation between distance of a predator seeing prey (more latency) and survival rate of the prey (less errors by predator). The study revealed that the allowance of more time sometimes had a positive correlation for more errors made by the predators, perhaps due to distraction.[15] Perhaps the increased latency in our study involved higher levels of distraction (instead of higher levels of focus), enabling more opportunity for mistakes.

As stated previously, our results did not reveal a significance between training on different shapes. In a study examining mirror tracing in children with autism, as compared to children with neurotypical development, a similar result was found. It was revealed that there was not a significant difference between tracing a circle, square, or star, and those on the Autism spectrum either did much better or much worse at mirror tracing, with no difference between shapes.[16] The results of this study are important to note because they had similar, non-significant findings when using a limited number of shapes. Perhaps a limitation to our study, and the study comparing participants with autism to neurotypical participants, was using only a square and circle, as more research has been conducted with different polygons (commonly-star, diamond, square, or a triangle).[17] The use of more complex polygons may have had a larger impact on learning as compared to simple shapes.

A potential limitation to our study could have been that the testing environment was not distraction free, so distraction may be the source for some errors or increased latency. This limitation can be supported by a study examining the frustrations of distraction. It was revealed that those who were more frustrated by distraction performed worse on the mirror tracing task.[18] Our demographics were also a source of limitation, as a majority of participants were female. Studies with a more even spread of males and females are able to examine additional factors of mirror tracing.[19] In the future, a distraction free testing location and larger

14 Reese et al., "Distress Tolerance Trajectories."
15 Gamberale-Stille, Bragée, and Tullberg, "Higher Survival of Aposematic Prey in Close Encounters with Predators."
16 Salowitz et al.
17 Julius and Adi-Japha.
18 Meindl, P. et al., "A Brief Behavioral Measure of Frustration Tolerance Predicts Academic Achievement Immediately and Two Years Later," *Emotion,* 19, no. 6 (2019), https://doi.org/10.1037/emo0000492.
19 Michael W. Oboyle and Edward J. Hoff, "Gender and Handedness Differences in Mirror-Tracing Random Forms." *Neuropsychologia* 25, no. 6 (1987), https://doi.org/10.1016/0028-3932(87)90102-3.

variation of demographics would help provide a stronger study.

In future studies, we could investigate the effects the environment has on performance and the difference of more complex polygon shapes on learning in a mirror tracing transfer test. By testing in a controlled environment compared to a distraction rich environment, it would allow us to further investigate the effects of distractions and latency on learning and mistakes. As investigated by Reese and colleagues,[20] we can manipulate testing environments to evoke different emotions and stress levels in participants to examine their effects on learning and memory. We would be able to examine how different cognitive scenarios affect latency and mistakes made. Complex figures for training and a variation of training environments would allow us to gain more knowledge about shape and scenario on learning and memory.

20 Reese et al.

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