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## Assessing Rat Behavioral Response to Novelty

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**Assessing Rat Behavioral Response to Novelty**

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Undergraduate Honors Thesis

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University of Connecticut

## ABSTRACT

The hippocampus is the part of the brain that is involved in memory and navigation. Neurons in the hippocampus, known as place cells, fire in specific locations within this region of the brain as the subject navigates through their environment. As these cells fire, they create a map-like representation of this environment. However if the environment is altered in any way, the place cell firing pattern is adjusted to incorporate this new information. This adjustment will inevitably cause subjects to take more time to complete their task. The goal of our testing was to assess how various manipulations, both spatial and social, of rats' environment will affect the latency of rats' as they ran back and forth on a linear maze for a food reward. Rats ran on the maze for a total of three days per manipulation, with Day 0 being a familiar day in which they ran the maze as they were trained to do so and Days 1 and 2 involving the novel manipulation. Each day the rats ran three sessions, with Session 1 and 3 being familiar and Session 2 incorporating the novel scenario. Latency on familiar trials showed rats taking approximately 15 seconds to complete a trial. As the experiment progressed the rats showed lower latencies at the start of the session (about 10 seconds) with a slowing (to about 15 seconds) as the session continued. This indicates that the rats were learning as they were exposed to the linear maze over time. Furthermore, rats showed a higher latency during the novel trajectory scenarios than in the familiar scenarios. This increase was not seen on Day 2 when the scenario was no longer novel. Finally, when presented with novel social odors, rats showed no change in their latency across sessions. This indicates that the novel trajectory scenarios had more of an impact on rat behavior than the novel social odor scenarios.

## INTRODUCTION

When placed in a novel situation, we are bound to be a little disoriented and confused. Even if we are doing a task we routinely conduct, it will likely take longer for us to complete because we will have to acclimatize to the addition of the new situation. However, each time we are exposed to this novel situation, it is expected that we become more comfortable and can continue with our task with more ease. Assessing the behavioral changes that occur when utilizing this part of our memory can assist in better understanding neurodegenerative diseases, such as Alzheimer's which have been tied to degeneration of the part of the brain that controls the aforementioned processes; the hippocampus (West et al., 1994)

The hippocampus is the region of the brain that processes experiences and spatial navigation (O'Keefe & Nadel, 1978). The cells in the hippocampus fire in certain "place fields", creating a mental representation of the subject's environment. When exposed to a familiar environment, place cell patterns remain relatively constant. But, cells can alter their firing patterns, or "remap," in response to changes in environmental or behavioral contexts (Markus et al., 1995; Schmidt et al., 2013). It has also been shown that the dorsal and ventral hippocampus are functionally different from each other (Fanselow & Dong, 2010) as the dorsal hippocampus seems to be more important for spatial processing and the ventral seems to be more important for anxiety-based behaviors. Therefore in our study, we have attempted to elicit a behavioral response from the rats based on both spatial and social novel manipulations.

The goal of my thesis research was to examine the degree to which our manipulations were in fact meaningful to our rats. To do this we looked at the latency that rats had to complete certain tasks. The idea was to expose the rats to a few different novel scenarios, both spatial and

social. We have examined how the different novel events affect the overall behavior of the rat. This was done by comparing the latency of rats' running a familiar linear maze to the latency of rats' running a maze with the addition of a novel situation. These running times were also compared to the running times found during a second exposure to the same novel situation on the maze.

Due to the information gathered from the previous studies, our expectations are as follows:

- It was expected that during the comparison of latency of familiar sessions to the latency of novel sessions, rats would have a higher latency while running the novel sessions. This is due to the fact that when rats undergo the process of “remapping” their environment (Schmidt et al, 2013) they will require some extra time to process the changes, therefore increasing their latency in running the maze when exposed to the novelty.
- It was expected that during the comparison of latency familiar to novel sessions with the same “novel” manipulation the following day, rats would have a similar latency in both types of sessions. This is due to the fact that as the “remapping” their environment becomes less novel and the novel manipulations are further incorporated into the rats' cognitive map, the rats would need less and less time to run the maze with each subsequent exposure (O'Keefe & Nadel, 1978).
- It was expected that when comparing the latency of rats before they detected the novel social manipulation to the latency of rats after they detected the novel social manipulation that the latency of the post-detection would be higher than that of the pre-detection for the first novel session and would be more similar the following day. This is because after the rats detect the social manipulation, they will have to undergo the remapping process

to incorporate the new information about their environment (Markus et al., 1995) but would acclimate to the novelty by the second day.

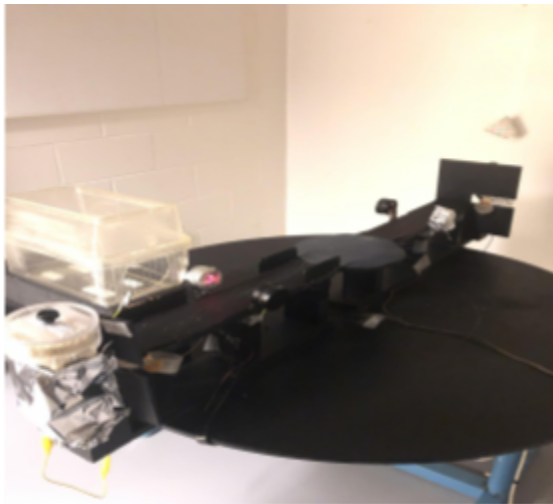
## METHODS

### Subjects:

Ten Fischer344 male rats, approximately 4 months old upon arrival, were single-housed with a 12-hour light/dark cycle. Food consumption was restricted to 85% of their free-feeding body weights to ensure sufficient motivation of the rats to run for their food reward (sugar pellets). Protocols were approved by the University of Connecticut IACUC.

### Procedure:

Initially, the rats were trained to run from one side of the runway to the other for 10 minutes. When rats were able to consistently complete 60 runs in 10 minutes, they moved onto a maze which automatically released sugar pellets (Figure 1). After the same goal was achieved on the



**Figure 1.** This figure shows the runway that the rats will be running on. Sugar pellets are released on the side of the runway from which the rat walks away from to retrieve pellets on the other side. Attached is the clear box in which a novel rat will be present during one of the novelty tests as the testing rat runs on the runway.

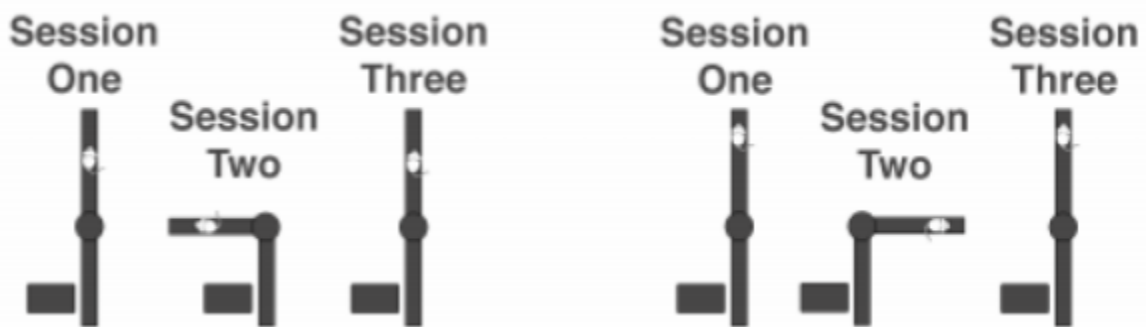
new maze, rats were trained to do three 5-minute trials of 22 runs (one run signified the rat running the maze in only one direction; up or down), with 5 minute breaks between each session. These runs were also represented as trials (including both the up and down direction runs, making for 11 trials). After this, rats underwent surgery for hyperdrive placement.

The hyperdrive consisted of 16 tetrodes which were implanted directly into the hippocampus so

as to allow for extracellular recording of electrophysiological activity post-surgery. This allowed for analysis on the place cell firing pattern (not used in my thesis) and to track the time that rats took on each run post-surgery. The rats were then retrained to complete the three 5-minute trials of 22 runs. After this, experimental recording sessions began during which the novel spatial and novel manipulations were made to the maze environment.

The spatial manipulations consisted of the addition of a left turn (Figure 2) or right turn (Figure 3) while the social manipulations consisted of the addition of bedding from a female rat on the maze (Figure 4), coyote urine on the maze (Figure 5), or a novel rat which sat beside the maze in a clear box attached to the runway and in clear view of any rats running the maze (Figure 6). There was never more than one manipulation per recording day and each rat experienced two days of every experimental manipulation. The day before the novel manipulation was incorporated, the rats ran a familiar day in which no changes were made to the maze and the rats ran 3 sessions with 22 runs per session. Before and after each session, the rats sat in a home cage for 5 minutes to rest, totaling in 4 rest sessions. On Days 1 and 2 of each

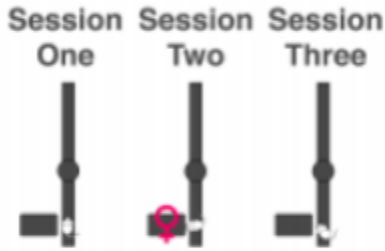
### Spatial Manipulations



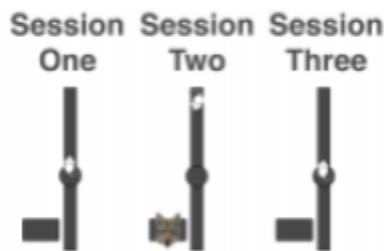
**Figure 2.** Session 1 and 3 are identical, with the rats running the pre-surgery (familiar) trajectory. In session 2 they encounter a novel trajectory, with a 90 degree left turn. This is sequence is repeated the following day (Day 2).

**Figure 3.** Session 1 and 3 are identical, with the rats running the pre-surgery (familiar) trajectory. In session 2 they encounter a novel trajectory, with a 90 degree left right. This is sequence is repeated the following day (Day 2).

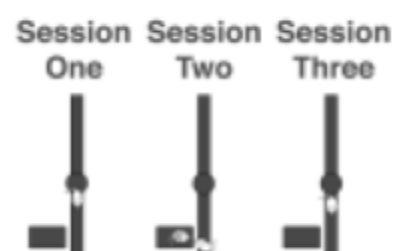
## Social Manipulations



**Figure 4.** Session 1 and 3 are identical, with the rats running the pre-surgery (familiar) trajectory. In session 2 they encounter the novel female bedding and odor. This sequence is repeated the following day (Day 2).



**Figure 5.** Session 1 and 3 are identical, with the rats running the pre-surgery (familiar) trajectory. In session 2 they encounter the novel coyote urine and odor. This sequence is repeated the following day (Day 2).



**Figure 6.** Session 1 and 3 are identical, with the rats running the pre-surgery (familiar) trajectory. In session 2 they encounter the novel rat in the clear box next to the runway. This sequence is repeated the following day (Day 2).

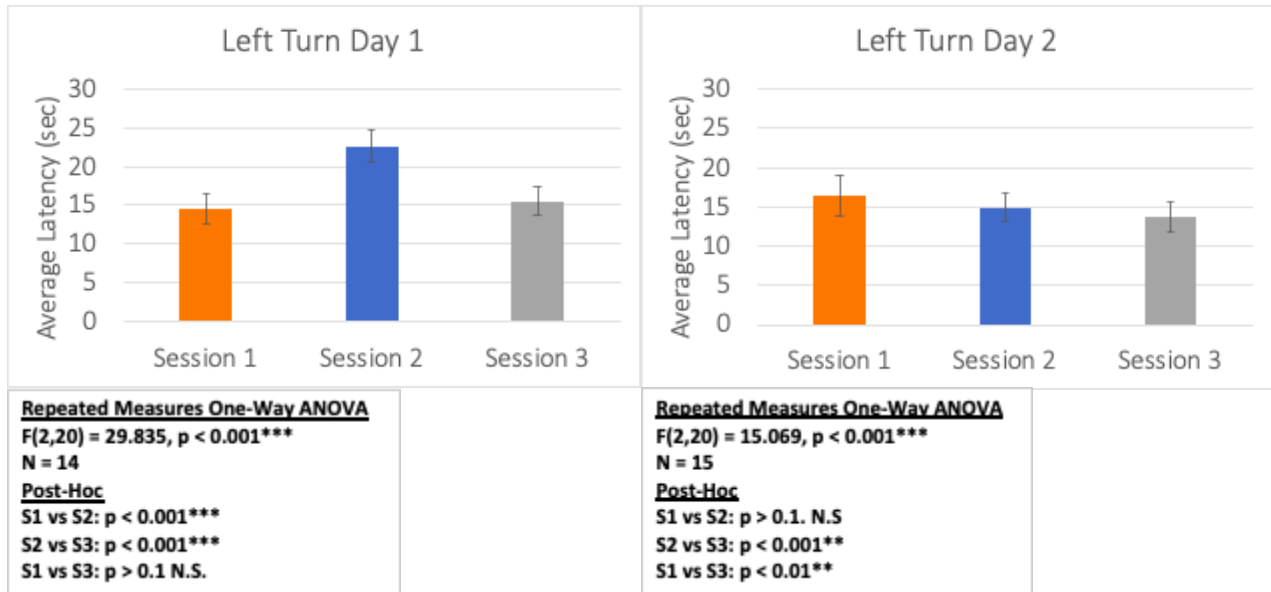
novel manipulation, the rats ran Sessions 1 and 3 in the same way they did on familiar days, but the novel situation was added to the maze for Session 2. During this process we measured how long each individual run takes (as an average) along with the total time for each session. This process was repeated for each novel scenario.

### Analysis:

For the analysis of the data collected, a repeated measure ANOVA followed by a Post-Hoc analysis was done to compare across sessions. Then a two-way ANOVA was conducted to compare across both sessions and trials. For the social scenarios all analysis was done by comparing average latency of rats as they ran only in the up direction (when rats were more likely to notice the novel situation). Further testing was done for the social scenarios via Paired T-Tests comparing the average up direction latency for one trial from before and after they noticed the novel odor or rat. The number of rats used for this analysis was lower than the overall number of rats used for each test, as we could only use rats which had more than 11 overall up trials/runs.

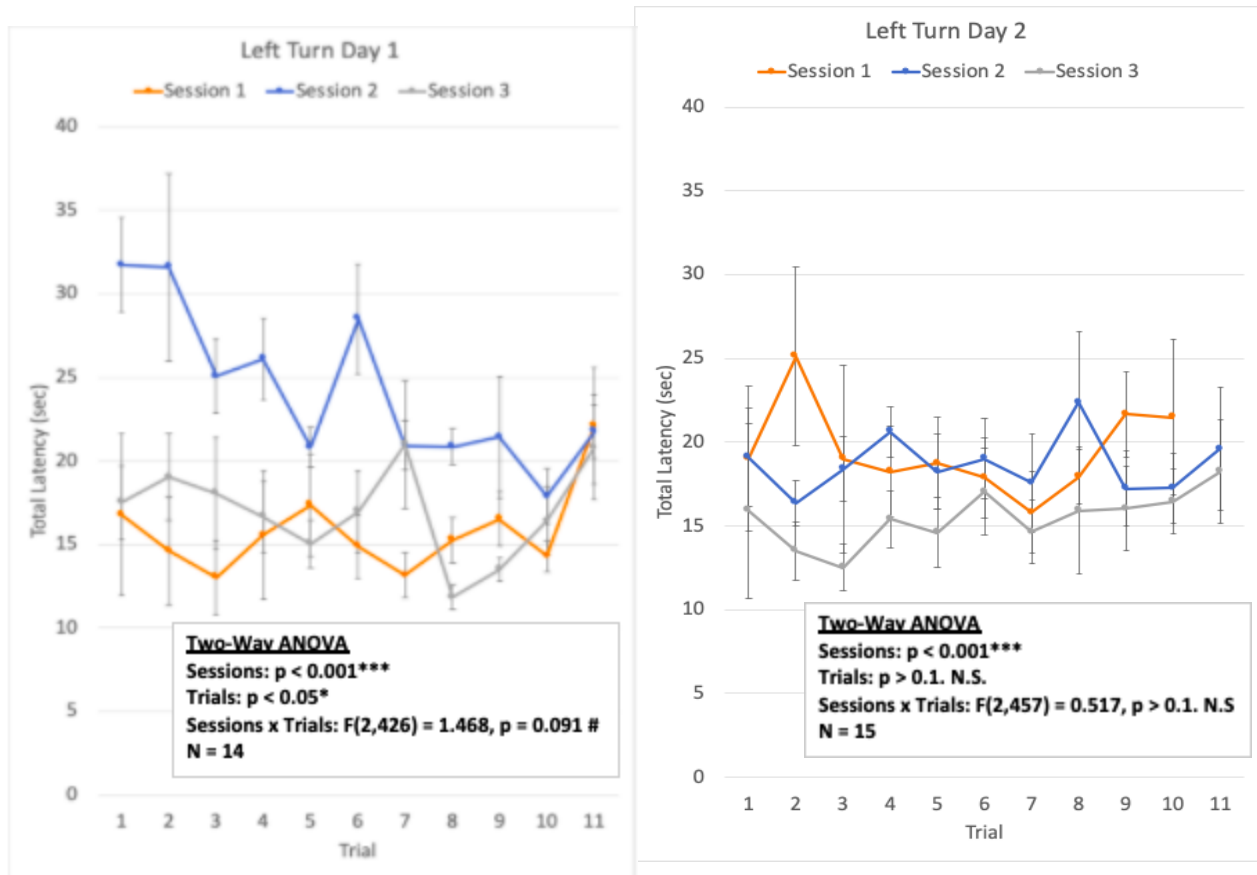


## RESULTS



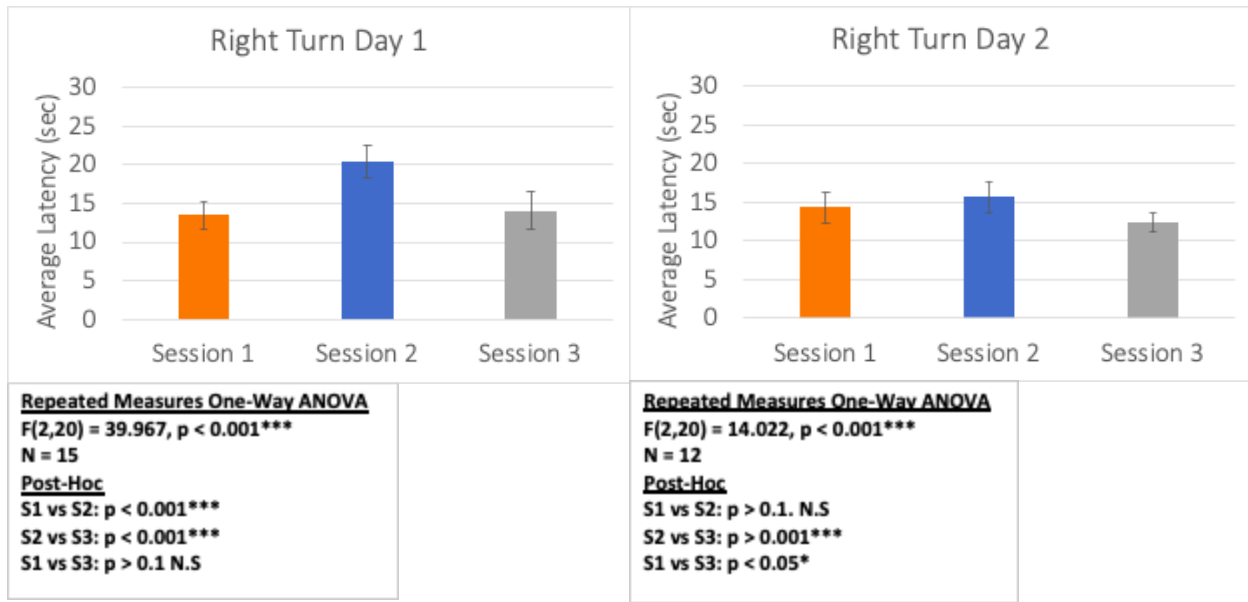
**Figure 7. Average latency across sessions of left turn day 1 and left turn day 2.** The average latency (sec) + SEM of the rats for Sessions 1-3 for both Days 1 and 2 of the left turn novel spatial manipulation (as pictured in Figure 2) are shown in Figure 7. Significant differences between sessions are denoted by \*, \*\*, or \*\*\*, which indicate p values less than 0.05, 0.01, and 0.001 respectively.

As shown by the repeated measures one-way ANOVA of Day 1 of left turn, there was a significant difference between all three sessions ( $p < 0.001$ ). When Post-Hoc analysis was conducted, it was found that the average latency of Session 1 was significantly less than Session 2 ( $p < 0.001$ ). In comparing Session 2 and 3, Session 2 has the higher latency ( $p < 0.001$ ). Finally, there was no significant difference between Sessions 1 and 3 ( $p > 0.10$ ). Meaning Session 2 had a higher latency than that of the latencies in familiar sessions (Sessions 1 and 3). However this was not the case on Day 2. There was still a significant difference across all sessions ( $p < 0.001$ ) but here, Session 1 and 2 showed no significant difference in latency ( $p > 0.10$ ) while Session 3 was shown to have a lower average latency than both Sessions 1 ( $p < 0.01$ ) and 2 ( $p < 0.001$ ). This indicates that on Day 2 of the novel left turn, Session 2 no longer has a significantly higher latency than that of Sessions 1 and 3 (as was seen on Day 1 of left turn) and within Day 2, the rats got faster over each successive session.



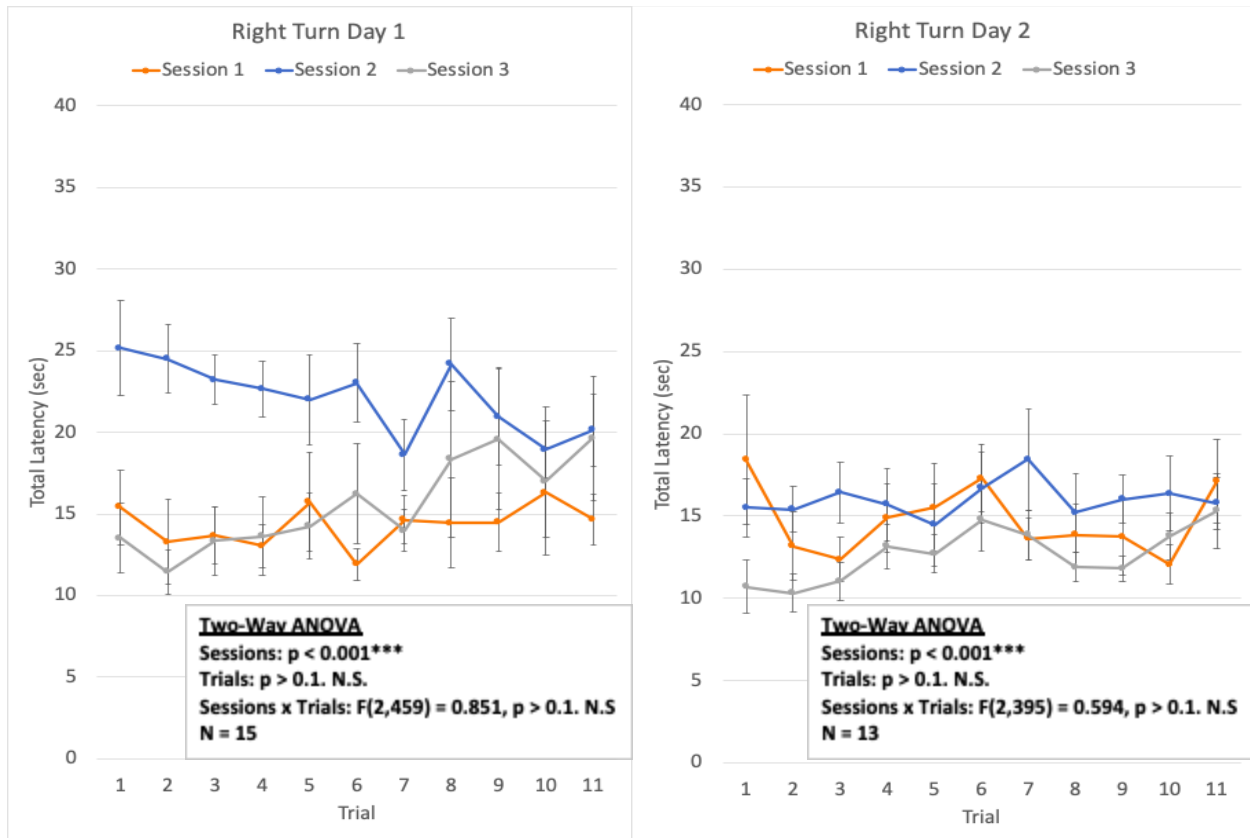
**Figure 8. Total latency across session and trial of left turn day 1 and left turn day 2.** The total latency (rats running in one trial consisting of both the up + down direction latencies) + SEM of the rats for Sessions 1-3 and Trials 1-11 for both Days 1 and 2 of the left turn novel spatial manipulation (as pictured in Figure 2) are shown in Figure 8.

After the two-way ANOVA was conducted for Day 1 of the novel left turn, it was found that there was both a main effect of sessions ( $p < 0.001$ ) and main effect of trials ( $p < 0.05$ ) indicating that the comparison of the latency on different sessions and on different trials was significant. The interaction on Day 1 was trending towards significance ( $p = 0.091$ ) with Session 2 showing a general downward trend in latency. On Day 2, it was found that there was a main effect of sessions ( $p < 0.001$ ) but no main effect of trials ( $p > 0.10$ ) indicating that the comparison of the latency on different sessions was significant but was not significant on different trials. Furthermore, there was no interaction between sessions and trials ( $p > 0.10$ ).



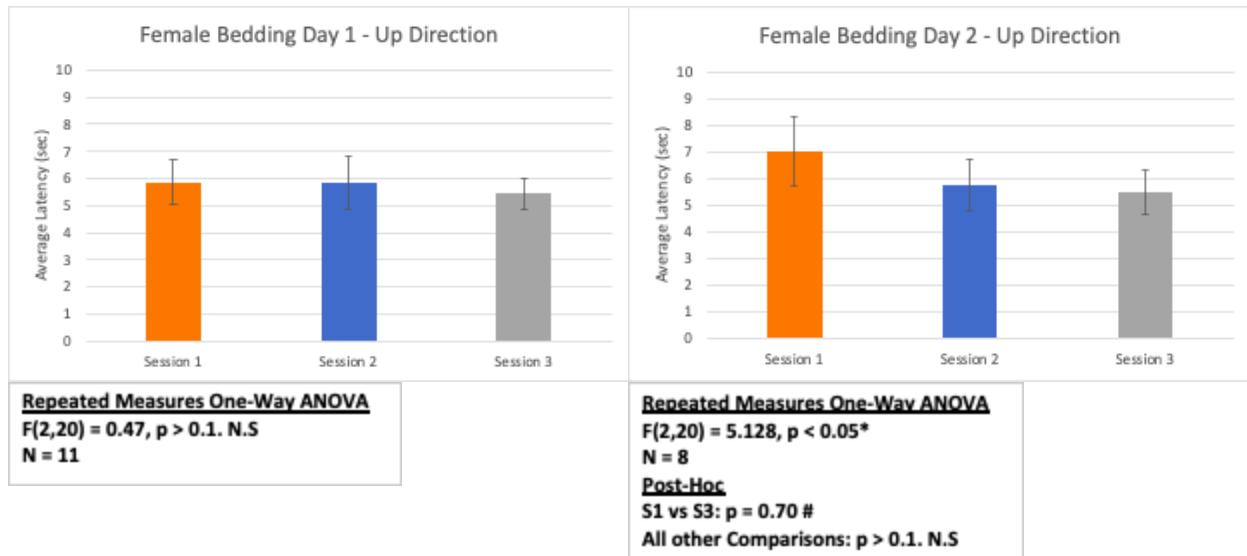
**Figure 9. Average latency across sessions of right turn day 1 and right turn day 2.** The average latency (sec) + SEM of the rats for Sessions 1-3 for both Days 1 and 2 of the right turn novel spatial manipulation (as pictured in Figure 3) are shown in Figure 9. Significant differences between sessions are denoted by \*, \*\*, or \*\*\*, which indicate p values less than 0.05, 0.01, and 0.001 respectively.

Similarly to the left turn manipulations, the repeated measures one-way ANOVA of Day 1 for right turn indicated that there was a significant difference between all three sessions ( $p < 0.001$ ). When Post-Hoc analysis was conducted, the average latency of Session 1 was significantly less than that of Session 2 ( $p < 0.001$ ). In comparing Session 2 and 3, Session 2 has the higher latency ( $p < 0.001$ ). Finally, there was no significant difference between Sessions 1 and 3 ( $p > 0.10$ ). This means that Session 2 had a higher latency than that of the latencies in familiar sessions (Sessions 1 and 3). However on Day 2, although there was still a significant difference between sessions ( $p < 0.001$ ), Post-Hoc analysis showed Session 1 and 2 showed no significant difference in latency ( $p > 0.10$ ) but Session 3 had a lower average latency than both Sessions 1 ( $p < 0.05$ ) and 2 ( $p < 0.001$ ). This indicates that on Day 2 of the novel left turn, Session 2 no longer has a significantly higher latency than that of Sessions 1 and 3 (as was seen on Day 1 of left turn) and within Day 2, the rats got faster over each successive session.



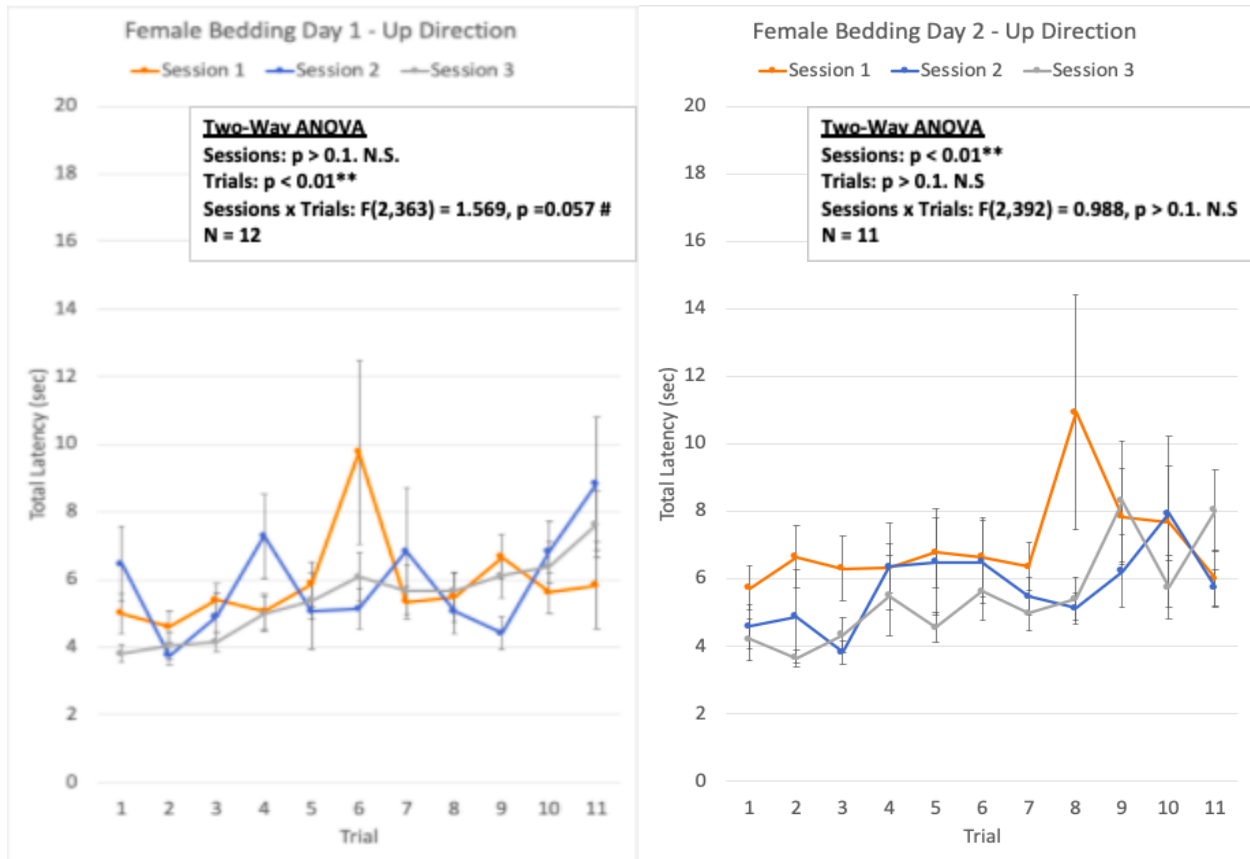
**Figure 10. Total latency across session and trial of right turn day 1 and right turn day 2.** The total latency (rats running in one trial consisting of both the up + down direction latencies) + SEM of the rats for Sessions 1-3 and Trials 1-11 for both Days 1 and 2 of the right turn novel spatial manipulation (as pictured in Figure 3) are shown in Figure 10.

After the two-way ANOVA was conducted for Day 1 of the novel right turn, it was found that there was a main effect of sessions ( $p < 0.001$ ) but no main effect of trials ( $p < 0.05$ ) indicating that the comparison of the latency on different sessions was significant but was not significant on different trials. The interaction on Day 1 was also not significant ( $p > 0.10$ ). On Day 2, it was found that there is a main effect of sessions ( $p < 0.001$ ) but no main effect of trials ( $p > 0.10$ ) indicating that the comparison of the latency on different sessions was significant but was not significant on different trials. Furthermore, there was no interaction between sessions and trials ( $p > 0.10$ ).



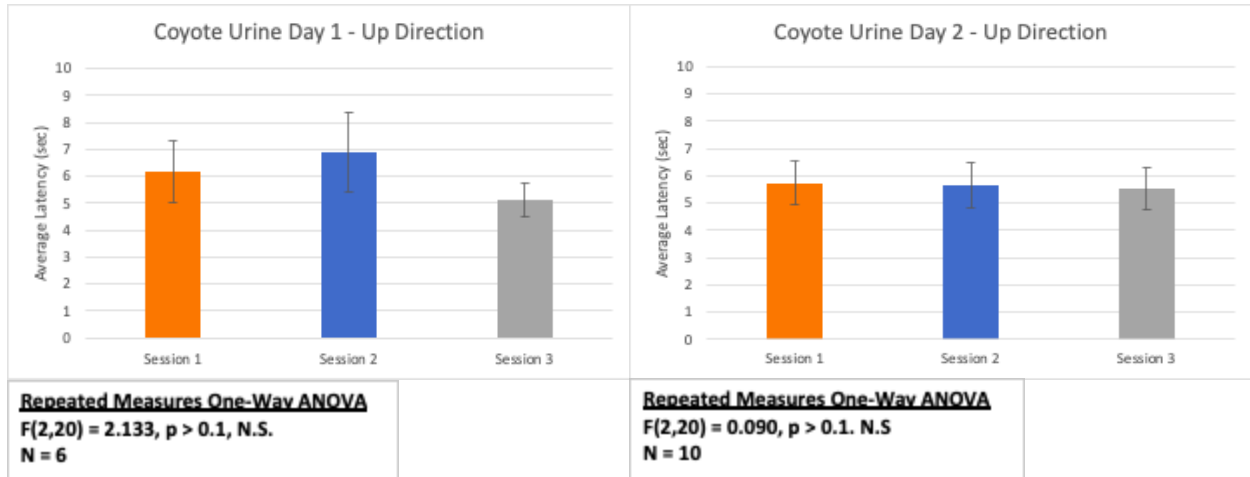
**Figure 11. Average latency across sessions of female bedding day 1 and female bedding day 2.** The average latency (sec) + SEM of the rats for Sessions 1-3 for both Days 1 and 2 of the female bedding novel social manipulations (as pictured in Figure 4) are shown in Figure 11. Significant differences between sessions are denoted by \*, \*\*, or \*\*\*, which indicate p values less than 0.05, 0.01, and 0.001 respectively.

While conducting the repeated measures one-way ANOVA of Day 1 of female bedding, it was indicated that there was no significance across sessions ( $p > 0.10$ ). This indicates that despite the introduction of the novel female bedding during Session 2, the rats ran in a similar manner across all three sessions. In the case of Day 2, there was a significant difference across sessions ( $p < 0.05$ ). During Post-Hoc analysis, only Sessions 1 and 3 were trending towards a significant difference ( $p = 0.70$ ), with Session 1 trending towards having a higher average latency in the up direction than Session 3. There was no significant difference between Sessions 1 and 2 or between 2 and 3. As Day 2 only showed a trend towards a significant decrease in latency from Session 1 to Session 3, this shows that similarly to Day 1, rats ran all sessions in a similar fashion even though Session 2 included the novel social manipulation.



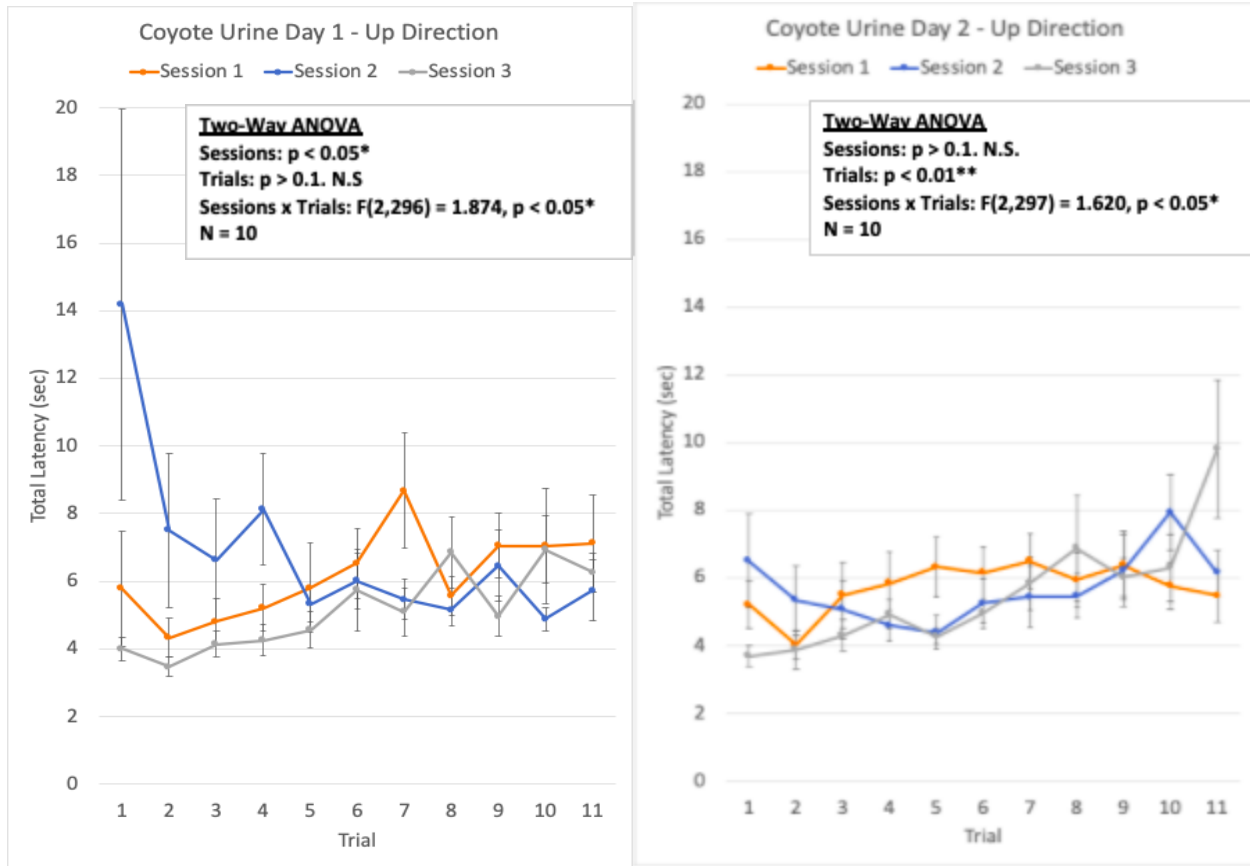
**Figure 12. Total latency across session and trial of female bedding day 1 and female bedding day 2.** The total latency (rats running in just the up direction latency) + SEM of the rats for Sessions 1-3 and Trials 1-11 for both Days 1 and 2 of the novel female bedding social manipulation (as pictured in Figure 4) are shown in Figure 12.

After the two-way ANOVA was conducted for Day 1 of the novel female bedding, it was found that there was no main effect of sessions ( $p > 0.10$ ) but there was a main effect of trials ( $p < 0.01$ ) indicating that the comparison of the latency on different sessions was not significant but was significant on different trials. The interaction on Day 1 was also trending towards significance ( $p = 0.057$ ) which was seen in an upward trend in latency for all three sessions in Figure 12. On Day 2, it was found that there was a main effect of sessions ( $p < 0.01$ ) but no main effect of trials ( $p > 0.10$ ) indicating that the comparison of the latency on different sessions was significant but was not significant on different trials. Furthermore, there was no interaction between sessions and trials ( $p > 0.10$ ).



**Figure 13. Average latency across sessions of coyote urine day 1 and coyote urine day 2.** The average latency (sec) + SEM of the rats for Sessions 1-3 for both Days 1 and 2 of the coyote urine novel social manipulations (as pictured in Figure 5) are shown in Figure 13. Significant differences between sessions are denoted by \*, \*\*, or \*\*\*, which indicate p values less than 0.05, 0.01, and 0.001 respectively

While conducting the repeated measures one-way ANOVA of Day 1 and Day 2 of coyote urine, it was indicated that there was no significance across sessions ( $p > 0.10$  for both days). This means that rats had a consistent run-time in the up-direction across all three sessions. This shows that despite the introduction of the novel coyote urine during Session 2, the rats ran in a similar manner across all three sessions for both Day 1 and Day 2.

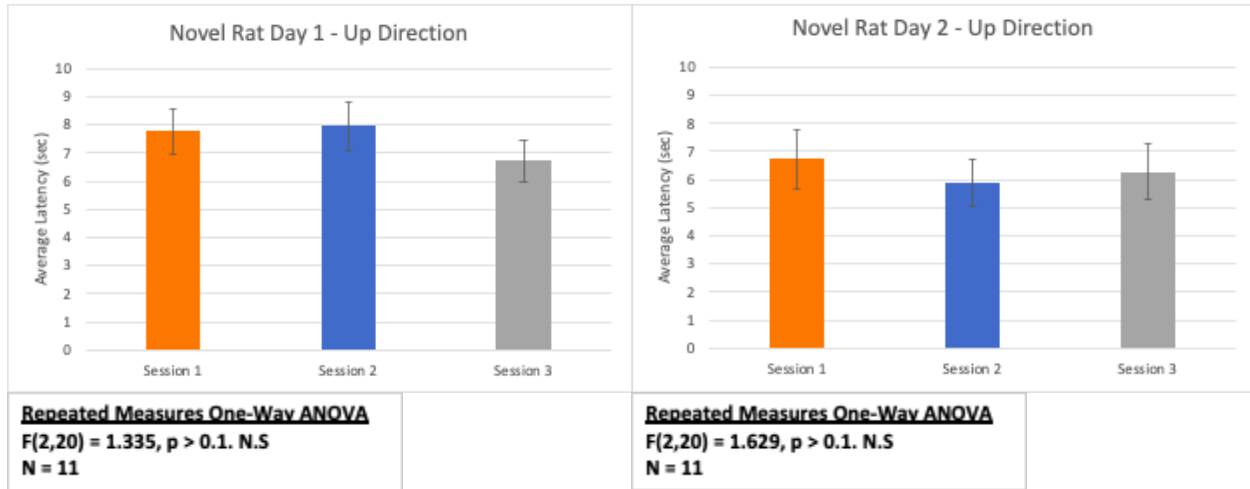


**Figure 14. Total latency across session and trial of coyote urine day 1 and coyote urine day 2.** The total latency (rats running in just the up direction latency) + SEM of the rats for Sessions 1-3 and Trials 1-11 for both Days 1 and 2 of the novel coyote urine social manipulation (as pictured in Figure 5) are shown in Figure 14.

After the two-way ANOVA was conducted for Day 1 of the novel coyote urine, it was found that there was a main effect of sessions ( $p < 0.05$ ) but there was no main effect of trials ( $p > 0.10$ ) indicating that the comparison of the latency on different sessions not significant but was not significant on different trials. The interaction on Day 1 was also significant ( $p < 0.05$ ) which is seen in an upward trend in latency for Sessions 1 and 3 and a downward trend in latency for Session 2 in Figure 12. On Day 2, it was found that there was no main effect of sessions ( $p > 0.10$ ) but there was a main effect of trials ( $p < 0.01$ ) indicating that the comparison of the latency on different sessions was not significant but was significant on different trials.

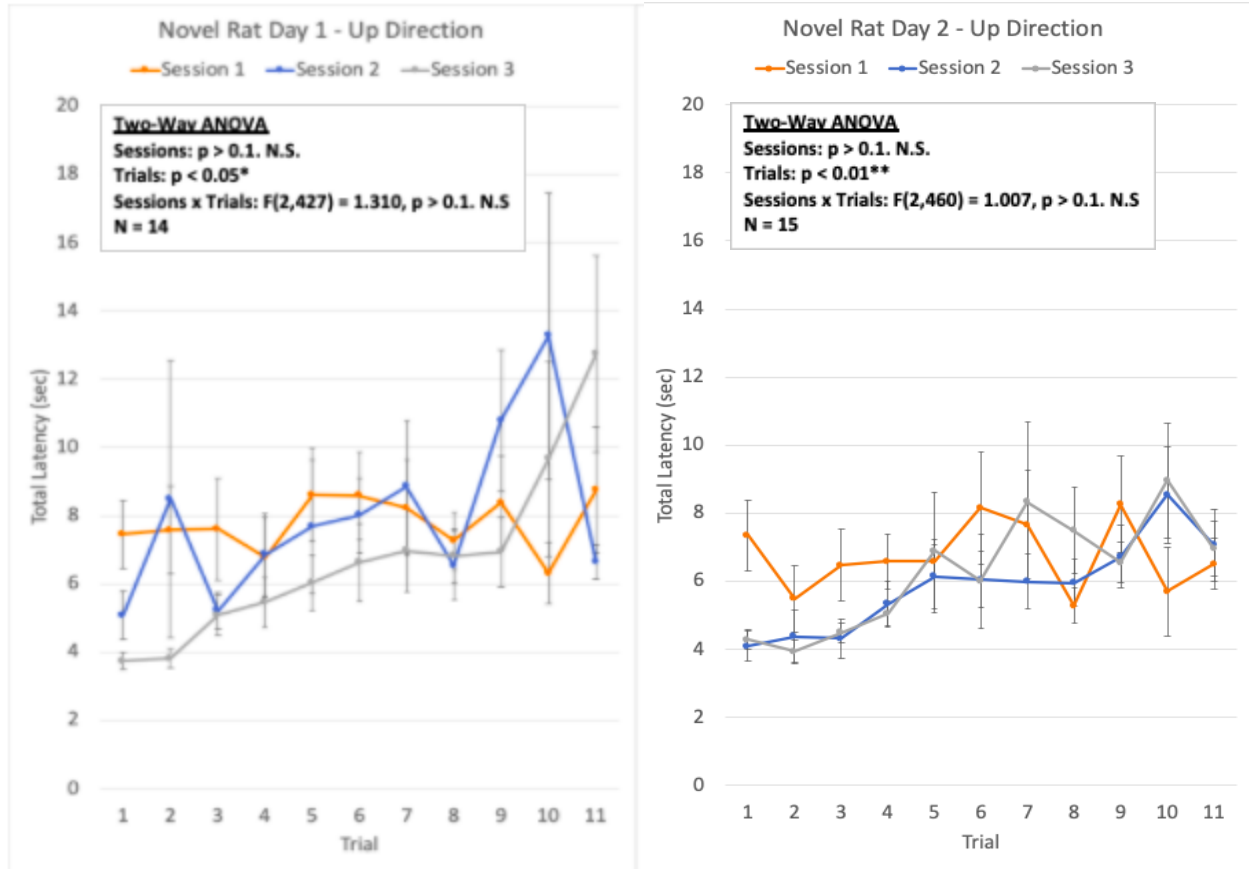


Furthermore, there was an interaction between sessions and trials ( $p > 0.05$ ), indicating that there was an upward trend of latency across all three sessions.



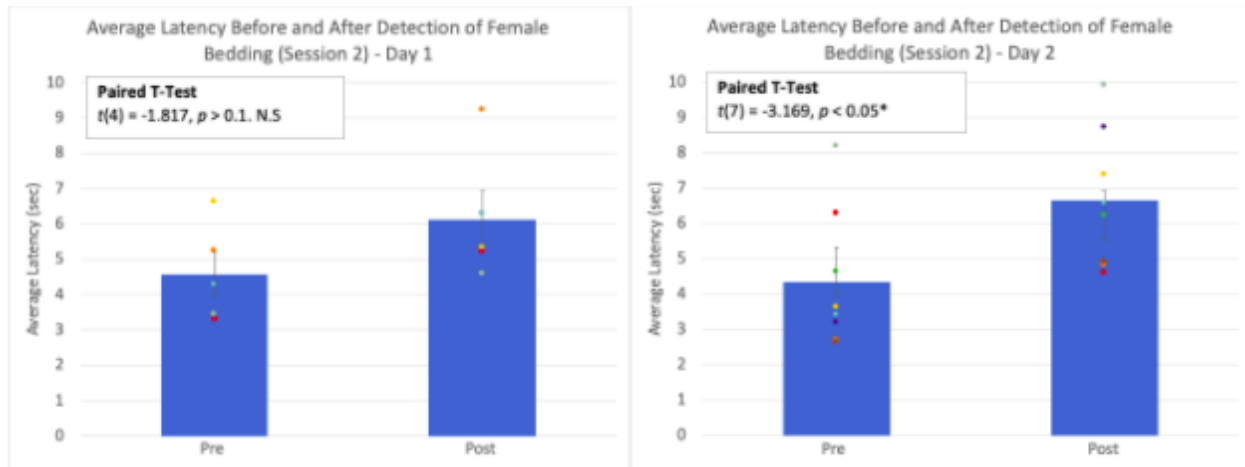
**Figure 15. Average latency across sessions of novel rat day 1 and novel rat day 2.** The average latency (sec) + SEM of the rats for Sessions 1-3 for both Days 1 and 2 of the novel rat social manipulations (as pictured in Figure 6) are shown in Figure 15. Significant differences between sessions are denoted by \*, \*\*, or \*\*\*, which indicate p values less than 0.05, 0.01, and 0.001 respectively.

While conducting the repeated measures one-way ANOVA of Day 1 and Day 2 of the novel rat manipulations, it was indicated that there was no significance across sessions ( $p > 0.10$  for both days). This means that rats had a consistent run-time in the up-direction across all three sessions. This shows that despite the introduction of the novel rat during Session 2, the rats ran in a similar manner across all three sessions for both Day 1 and Day 2.



**Figure 16. Total latency across session and trial of novel rat day 1 and novel rat day 2.** The total latency (rats running in just the up direction latency) + SEM of the rats for Sessions 1-3 and Trials 1-11 for both Days 1 and 2 of the novel rat social manipulation (as pictured in Figure 4) are shown in Figure 16. Significant differences between sessions are denoted by \*, \*\*, or \*\*\*, which indicate p values less than 0.05, 0.01, and 0.001 respectively.

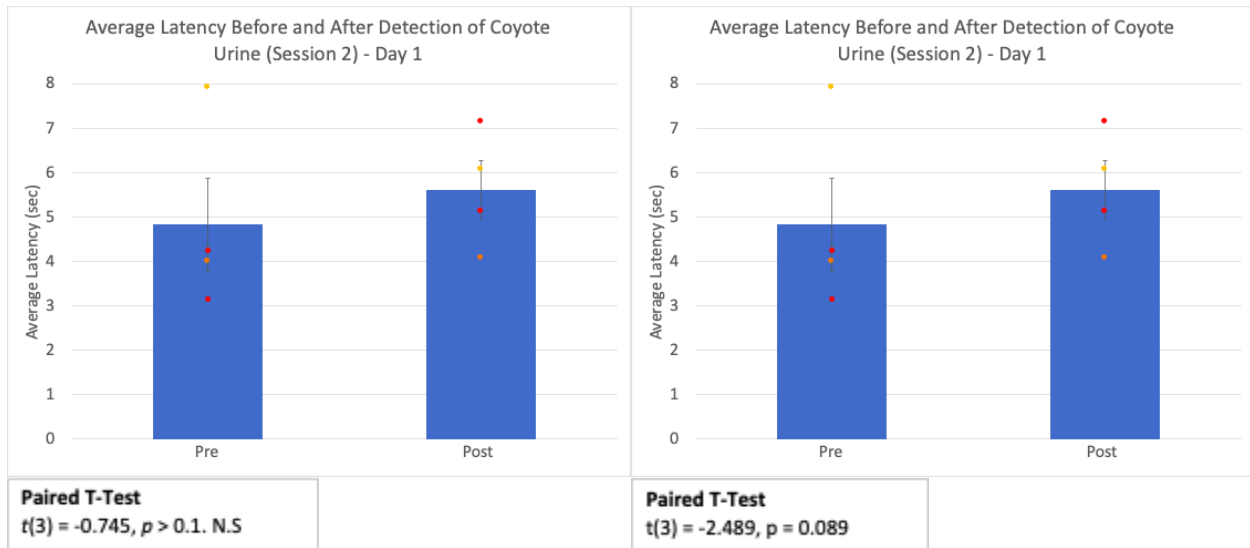
After the two-way ANOVA was conducted for Day 1 of the novel rat, it was found that there was no main effect of sessions ( $p > 0.10$ ) but there was a main effect of trials ( $p < 0.05$ ) indicating that the comparison of the latency on different sessions was not significant but was significant on different trials. The interaction on Day 1 was also not significant ( $p > 0.10$ ). On Day 2, it was found that there was no main effect of sessions ( $p > 0.10$ ) but there was a main effect of trials ( $p < 0.01$ ) indicating that the comparison of the latency on different sessions was not significant but was significant on different trials. Furthermore, there was no interaction between sessions and trials ( $p < 0.10$ ).



**Figure 17. Average latency of rats (only up direction) before and average latency of rats (only up direction) after the detection of the novel female bedding odor on session 2 on day 1 and day 2.** The average latency (rats running in just the up direction latency) of all trials before and all trials after novel odor detection + SEM + individual latencies of the rats for Session 2 for both Days 1 and 2 of the novel female bedding social manipulation (as pictured in Figure 4) are shown in Figure 17.

In the previous section (Figure 11 and 12) we looked for a novelty effect by comparing latency on the familiar session to one in which the novel female bedding odor was placed alongside the maze (Sessions 1 & 3 vs Session 2). An examination of the rats' behavior indicated that some rats did not notice the novel odor until a few runs into the session. Therefore we counted trial 1 as the first trial in which the rats had stopped to examine the novel odor so that the data would be standardized across all rats. However, this meant that for some rats we had more trials than the usual 11 trials allotted for Session 2. In order to compare the effect on latency of the rats noticing the female bedding, we took an average of the latency of all trials before the rats noticed the novel odor and an average of the latency of all trials after the rats noticed the novel odor. Consequently the following analysis was a paired T-Test, where we compared these averages. On Day 1, it was found that there was no significant difference between the two data sets ( $p > 0.10$ ). This means that the rats did not change their running time even when introduced to the novel odor. However on Day 2, the paired T-Test revealed that there

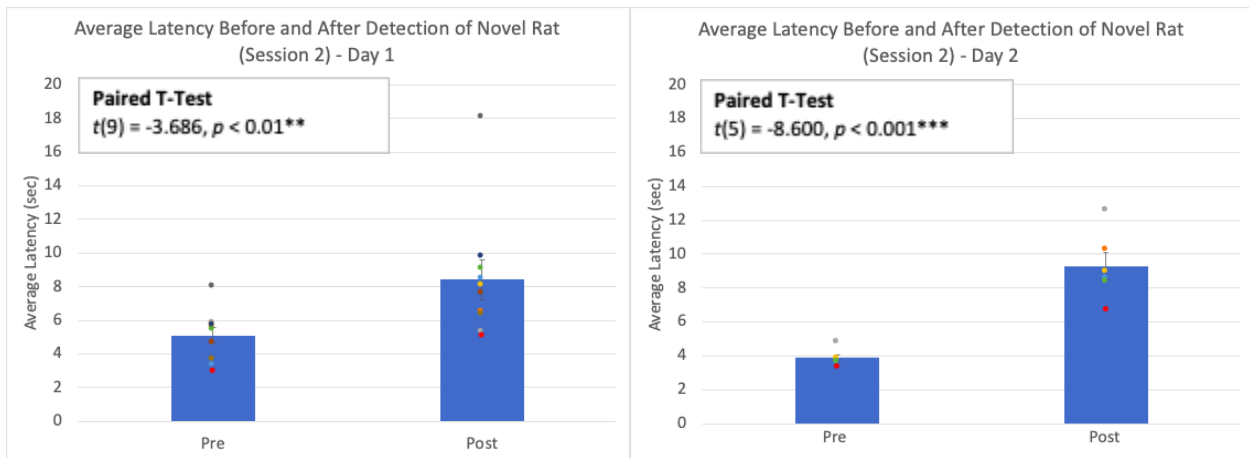
was a significant increase of average latency from before odor detection to after ( $p < 0.05$ ), indicating that after rats noticed the novel female bedding, they took more time to run the maze.



**Figure 18. Average latency of rats (only up direction) before and average latency of rats (only up direction) after the detection of the novel coyote urine odor on session 2 on day 1 and day 2.** The average latency (rats running in just the up direction latency) of all trials before and all trials after novel odor detection + SEM + individual latencies of the rats for Session 2 for both Days 1 and 2 of the novel coyote urine social manipulation (as pictured in Figure 5) are shown in Figure 18.

In the previous section (Figure 13 and 14) we looked for a novelty effect by comparing latency on the familiar session to one in which the novel coyote urine odor was placed alongside the maze (Sessions 1 & 3 vs Session 2). An examination of the rats' behavior indicated that some rats did not notice the novel odor until a few runs into the session. Therefore we counted trial 1 as the first trial in which the rats had stopped to examine the novel odor so that the data would be standardized across all rats. However, this meant that for some rats we had more trials than the usual 11 trials allotted for Session 2. In order to compare the effect on latency of the rats noticing the coyote urine, we took an average of the latency of all trials before the rats noticed the novel odor and an average of the latency of all trials after the rats noticed the novel odor. Consequently the following analysis was a paired T-Test, where we compared these averages. On Day 1, it was found that the post-detection latency was higher than the pre-detection latency ( $p > 0.10$ ). This

means that the rats did not change their running time even when introduced to the novel odor. However on Day 2, the paired T-Test revealed that the difference between the average latency before and after odor detection was trending towards significance ( $p = 0.089$ ). However, considering the large amount of overlap of the before and after latencies as well as the low sample size, it does not seem as if the addition of the coyote urine odor made a difference in running time.



**Figure 19. Average latency of rats (only up direction) before and average latency of rats (only up direction) after the detection of the novel rat presence on session 2 on day 1 and day 2.** The average latency (rats running in just the up direction latency) of all trials before and all trials after the presence of the novel rat was detected + SEM + individual latencies of the rats for Session 2 for both Days 1 and 2 of the novel rat social manipulation (as pictured in Figure 6) are shown in Figure 19.

In the previous section (Figure 15 and 16) we looked for a novelty effect by comparing latency on the familiar session to one in which a novel rat was placed alongside the maze (Sessions 1 & 3 vs Session 2). An examination of the rats' behavior indicated that some rats did not notice the novel odor until a few runs into the session. Therefore we counted trial 1 as the first trial in which the rats had stopped to examine the novel odor so that the data would be standardized across all rats. However, this meant that for some rats we had more trials than the usual 11 trials allotted for Session 2. In order to compare the effect on latency of the rats noticing the novel rat, we took an average of the latency of all trials before the rats noticed the novel rat

and an average of the latency of all trials after the rats noticed the novel rat. Consequently the following analysis was a paired T-Test, where we compared these averages. On Day 1, it was found that the post-detection latency was higher than the pre-detection latency ( $p < 0.01$ ). This means that the rats had a slower running time after they noticed the novel rat. Similarly, on Day 2 the paired T-Test revealed that the difference between the average latency before and after odor detection was also significant ( $p < 0.001$ ) so, the post-detection latency was higher than the pre-detection latency meaning that the rats had a slower running time after they noticed the novel rat.

## DISCUSSION

- It was expected that during the comparison of latency of familiar sessions to the latency of novel sessions, rats would have a higher latency while running the novel sessions. This is due to the fact that when rats undergo the process of “remapping” their environment (Schmidt et al, 2013) they will require some extra time to process the changes, therefore increasing their latency in running the maze when exposed to the novelty.
  - This hypothesis was supported, as was seen in Figures 7, 8, 9, and 10, in regard to the novel spatial manipulations. In Figure 7 and 9, Day 1 for both left and right turn showed that Session 2 had a significantly higher latency than Session 1 and 3 but Session 1 and 3 were not significantly different. This indicates that the addition of the novel spatial manipulation increased the latency of rats running the maze. In Figure 8 and 10, the main effect of session also supports this idea. For left turn it was seen that the interaction between sessions and trials was trending towards significance and showing a downward trend of Session 2 in which the latency of the final trials became increasingly similar to the latency of Sessions 1

and 3. For right turn, although no interaction was shown, there was also no main effect of trials which indicates that there was no significant difference in latency across all the trials. This indicates that the act of taking the turns did not have an effect on the running time, as eventually rats were able to run as fast as they were in familiar trials, but instead the incorporation of this new environment change into the rats' mental map can be attributed to the increase in latency.

- However, in the case of the social/odor manipulations, as seen in Figures 11, 13, and 15, it was found that there is no significant difference in latency between Session 2 and Sessions 1 and 3 for Day 1
  - For female bedding Day 1 in Figure 12, there was no main effect of session but there was a main effect of trials with a trend towards an interaction indicating an upward trend in latency. This gradual increase in latency seen across all sessions indicates that because the rats were not greatly affected by the addition of the social manipulation, they were getting slower within their sessions due to fatigue or lack of interest in the food reward over time.
  - For coyote urine Day 1 in Figure 14, although there was a main effect of sessions and a significant interaction, Trial 1 of Session 2 had a very large SEM and a high average latency. So although this may seem to show similar results to the spatial manipulations, it was more likely due to some rats in the sample taking longer to run Trial 1 causing skewed data.
  - For novel rat Day 1 in Figure 16, there was no main effect of session but there was a main effect of trials with a trend towards an interaction

indicating an upward trend in latency. This gradual increase in latency seen across all sessions indicates that because the rats were not greatly affected by the addition of the social manipulation, they were getting slower within their sessions due to fatigue or lack of interest in the food reward over time.

- Since the social manipulations did not show the results that were expected, further testing via Paired T-Tests were done in order to further understand the deviation from the hypothesis.
- It was expected that during the comparison of latency familiar to novel sessions with the same “novel” manipulation the following day, rats would have a similar latency in both types of sessions. This is due to the fact that as the “remapping” their environment becomes less novel and the novel manipulations are further incorporated into the rats’ cognitive map, the rats would need less and less time to run the maze with each subsequent exposure (O’Keefe & Nadel, 1978).
  - This hypothesis was supported, as was seen in Figures 7 and 9, in regard to the novel spatial manipulations. Day 2 for both left and right turn showed that Session 1 and 2 showed no significant difference in latency and that both Sessions 1 and 2 had a higher latency than Session 3. This created a gradual decrease in latency across sessions. This indicates that the addition of the novel spatial manipulation on Day 2 no longer caused a significant increase in latency. The gradual decrease in latency across sessions also suggests that due to the fact that the novel scenario was no longer considered novel to the rats, the rats were getting better at running the maze because they were getting more practice.



- In terms of the novel social manipulations in Figures 11, 13 and 15, there was no significant difference between any of the sessions on Day 2.
  - For female bedding as (seen in Figure 11), Session 1 and 3 were trending towards significance of Session 1 having a higher latency than Session 3 but this may be due to the relatively larger SEM of Session 1.
  - For coyote urine (as seen in Figure 13), there was no significance between any of the sessions on Day 2.
  - For novel rat (as seen in Figure 15), there was no significance between any of the sessions on Day 2.
  - This lack of significance may be explained by a trend seen in Figures 8, 10, 12, 14 and 16. If one were to line up all five of these Day 2 graphs, the familiar trials rats started off with an average latency of about 15 seconds. But by the time we get to the social odor trials in figure 12, before which the rats had run the maze numerous times, they seem to have reached an asymptote of performance of about 10 seconds. Then all social odor trials show that across sessions there was a gradual increase in latency as the rats became more fatigued. Because the rats had reached this asymptotic stage by the time they started the social trials, they were no longer improving as they ran Session 1 to Session 3 each day.
- It was expected that when comparing the latency of rats before they detected the novel social manipulation to the latency of rats after they detected the novel social manipulation that the latency of the post-detection would be higher than that of the pre-detection for the first novel session and would be more similar the following day. This was because

after the rats detect the social manipulation, they will have to undergo the remapping process to incorporate the new information about their environment (Markus et al., 1995) but would acclimate to the novelty by the second day

- Our hypothesis was not supported by the data. Figure 17 and 18 revealed that there was no significant difference between the pre-detection and post-detection latencies during Session 2 of Day 1 for both female bedding and coyote urine. But However for Day 2, the post-detection latency was significantly higher than the pre-detection latency in female bedding and was trending towards significance in coyote urine. So despite the original hypothesis, rats were more distracted by the novel odor on the second exposure. This discrepancy may be due to the small sample size, as only rats who ran more than 11 trials were able to be included in the data. This could once again be addressed by increasing the sample size in forthcoming experiments.
- Figure 19 showed that the post-detection latency of the novel rat experiment was higher than the pre-detection latency for both Day 1 and Day 2. Again, this was not consistent with the original expectation and contradicts the findings from Figure 15 and 16 which made it seem like the presence of the novel rat made no effect on latency. This indicates that although there isn't as much of a stark difference in latency between sessions for the novel rat as was seen in the spatial manipulations, there was a subtle effect on latency in the presence of the novel rat.

## CONCLUSION

All in all, the data concluded that rats showed a higher latency during the novel spatial scenarios than in the familiar scenarios and this increase was not seen on Day 2 when the scenario was no longer novel. However in the case of the case of the novel social scenarios, rats showed no change in their latency across sessions. The only case in which a subtle change in latency was found was in the novel social scenarios was when comparing the pre-detection and post-detection latencies of rats in the novel rat scenario. Furthermore, when examining latency on familiar trials rats showed that they took approximately 15 seconds to complete a trial but as the experiment progressed the rats showed lower latencies at the start of the session (about 10 seconds) with a slowing (to about 15 seconds) as the session continued. This indicates that rats improved their running times as they were further exposed to the maze, eventually reaching a performance asymptote. If we were to conduct this experiment again, it may be more effective to have a larger sample size as well as change the odors involved in the social manipulations. As these rats were domesticated and have not had the opportunity to encounter either reproductive or predatory situations before, it has been theorized that the reason why the social manipulations seem to have not had an effect on the latency of the rats may be due to the fact that food was a better motivator than that of reproduction or threat of a predator to these rats. Overall, although certain novel manipulations clearly have an effect on rat behavior, further investigation could provide more concrete insight into the true effects of novelty on rat behavior. For example, looking into other social motivators which may elicit a different response in rat behavior than the ones used in this experiment or conducting further analysis on the difference between ventral and dorsal hippocampal responses in spatial versus social scenarios.

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