

## Introduction

Prior research has found that visual cues presented before (pre) or after (retro) an object improve object properties recognition, like identity (what it is) and spatial location (where it is), in humans (Griffin & Nobre, 2003) and monkeys (Brady & Hampton, 2018). However, this has not yet been tested in other species or using other cue modalities (e.g., auditory). Secondary tasks and time delays have been found to impact performance in identity change detection in human subjects (Washburn & Astur, 1998), and the time delays also impacted spatial change identification in pigeons and monkeys (Leising et al., 2013).

Pigeons have served as a good model for studying Visual Working Memory. Previous evidence found that increasing the delay between the stimuli being studied (target) and the stimuli being tested (probe) reduces their performance, showing a similar behavioral pattern as humans when exposed to similar conditions (Leising et al., 2013). Similarly, other properties have been studied in Visual Working Memory, such as processing of multiple items. For instance, Leising et al. (2019) reported comparative results where humans and pigeons exhibited a similar behavioral pattern of decreasing performance in a Visual Working Memory task as function of increasing the number of stimuli to be remembered in a change detection task.

Despite the multiple instances of pigeons performing Visual Working Memory tasks, it has not been studied with the effect of pre and retro cue, or with the effect of using cues from different modalities. Therefore, the current experiment will analyze the effect of visual and auditory cues on object recognition in 6 pigeons, explicitly examining how these cues influence identity and spatial location processing in a visual working memory task.

## Funding



## Method

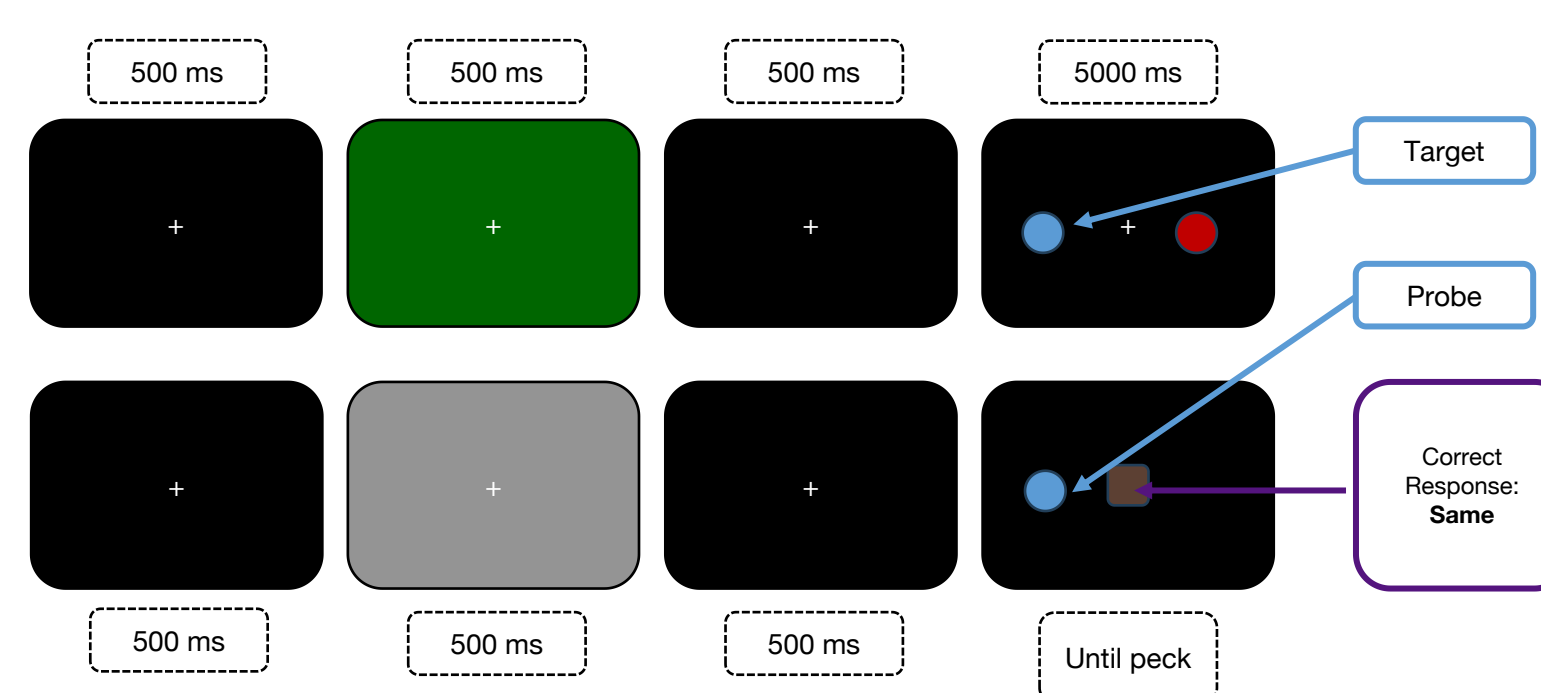
### Participants

Six adult pigeons (*Columba livia*) housed individually were given a 12-hour light and dark cycle, free access to water and gird, and were kept at 83-85% of their free-feeding weight.

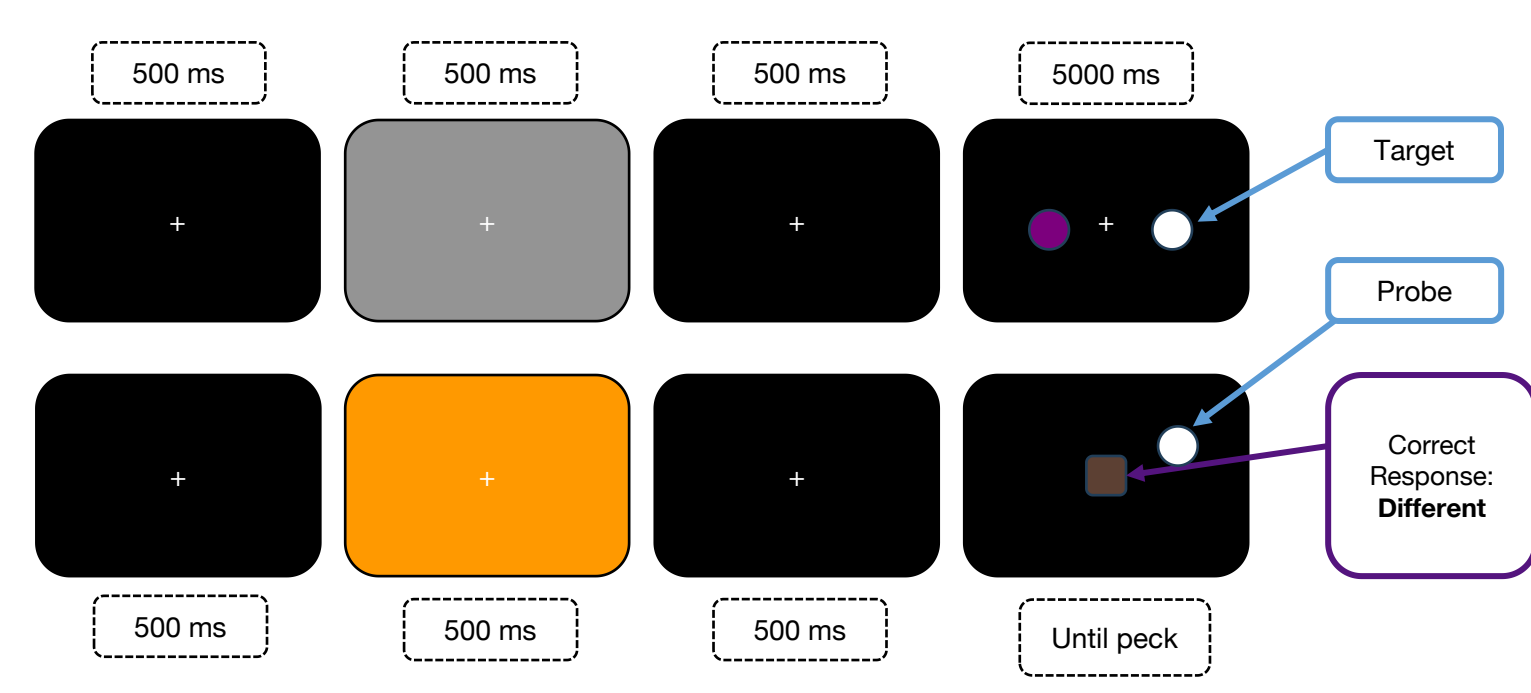
**Figure 1: Baseline / Control-Spatial**



**Figure 2: Pre-cue Visual-Identity**



**Figure 3: Retro-cue Visual-Spatial**



**Table 1: Cueing Arrangement**

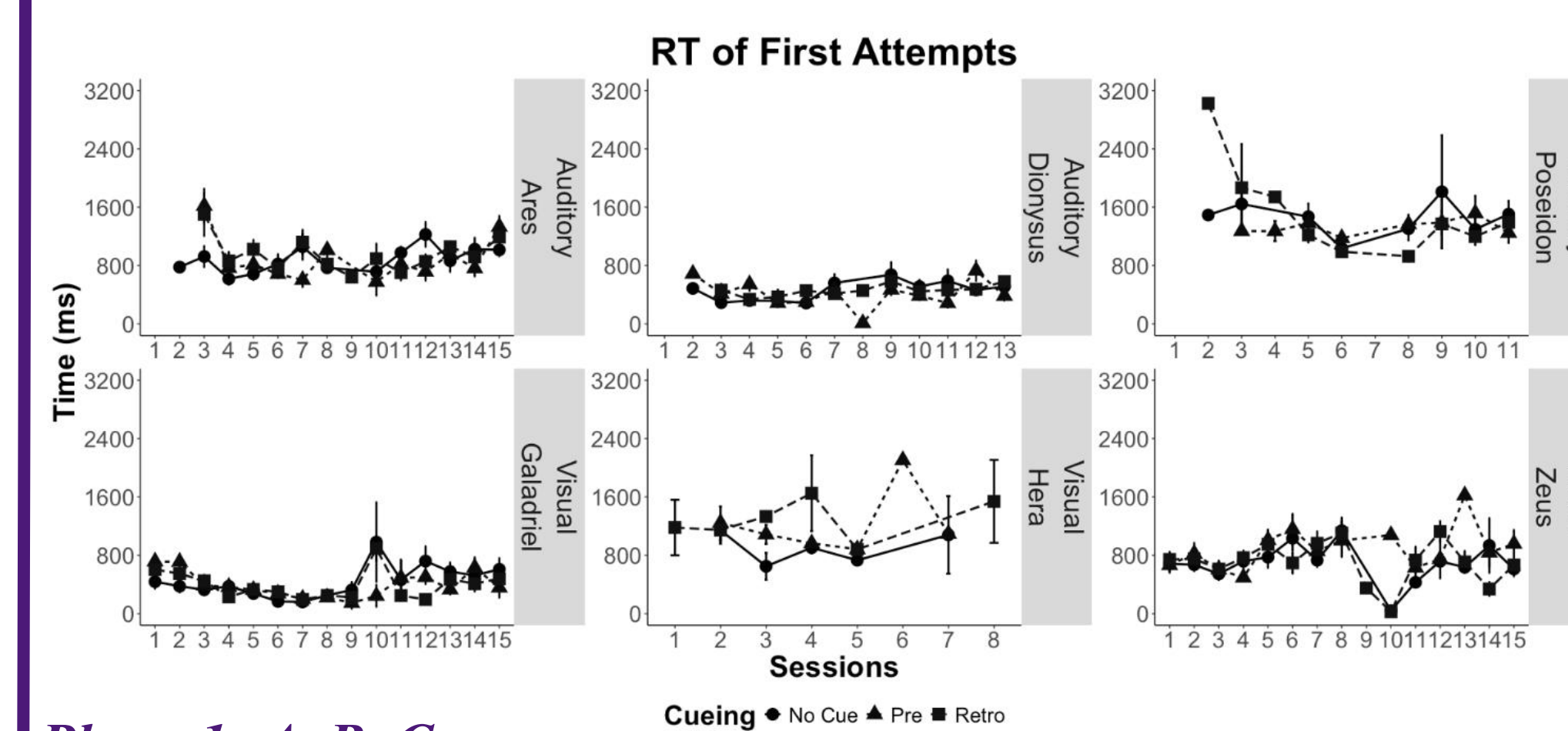
	Left (Identity)		Right (Spatial)	
	Before	After	Before	After
Baseline	No cue	No cue	No cue	No cue
Pre cues	Pre	Neutral	Pre	Neutral
Retro cues	Neutral	Retro	Neutral	Retro

**Table 2: Sample and Probe Location for Experiments**

Phase	Sub-Phase	Sample Location	Probe Location	Sessions
1	A	Left	Left	4
	B	Right	Right	4
	C	Intermixe		8
	d			
2	A	Both	Left	1
	B	Both	Right	1
	C	Both	Both	8
3	A	Both	Both	Stability Criteria

## Results

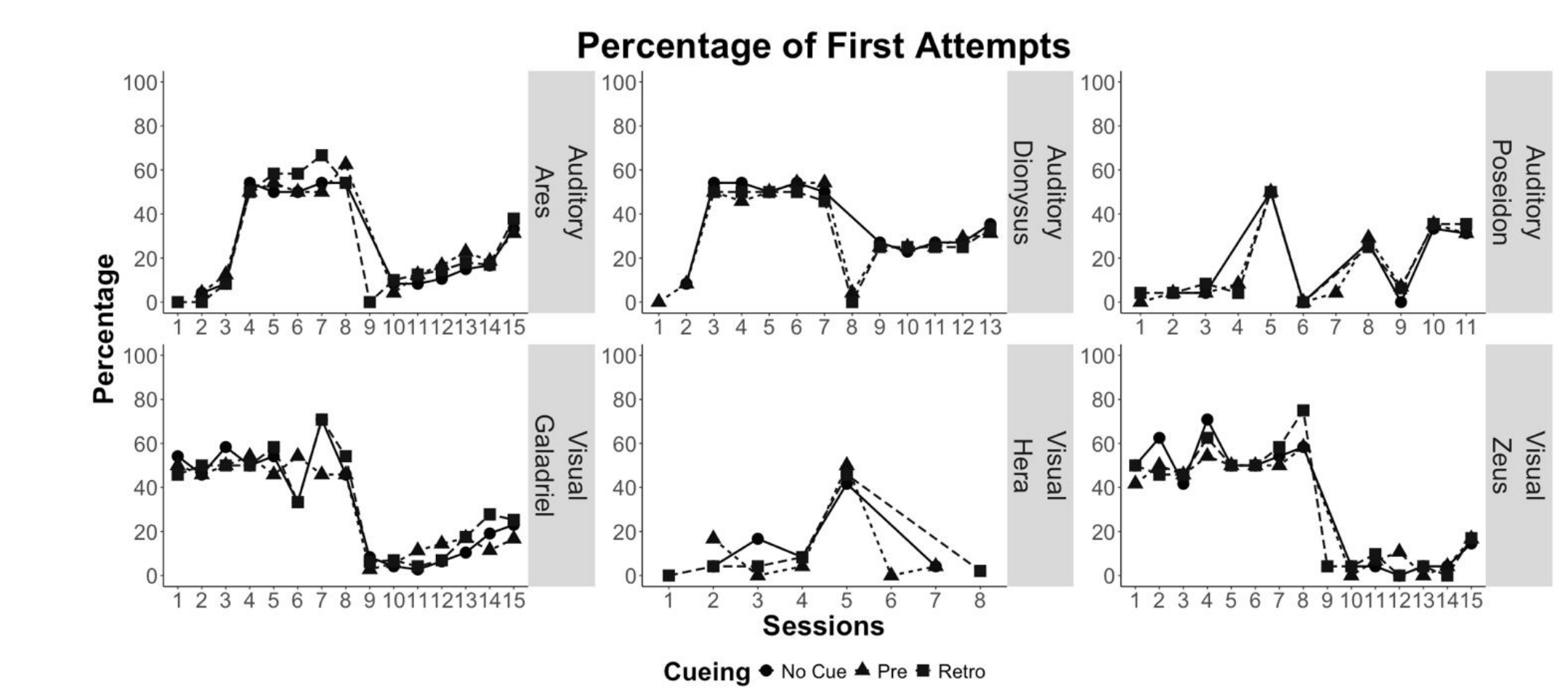
**Figure 4: Reaction Time of First Attempts (Phase 1: A, B, C)**



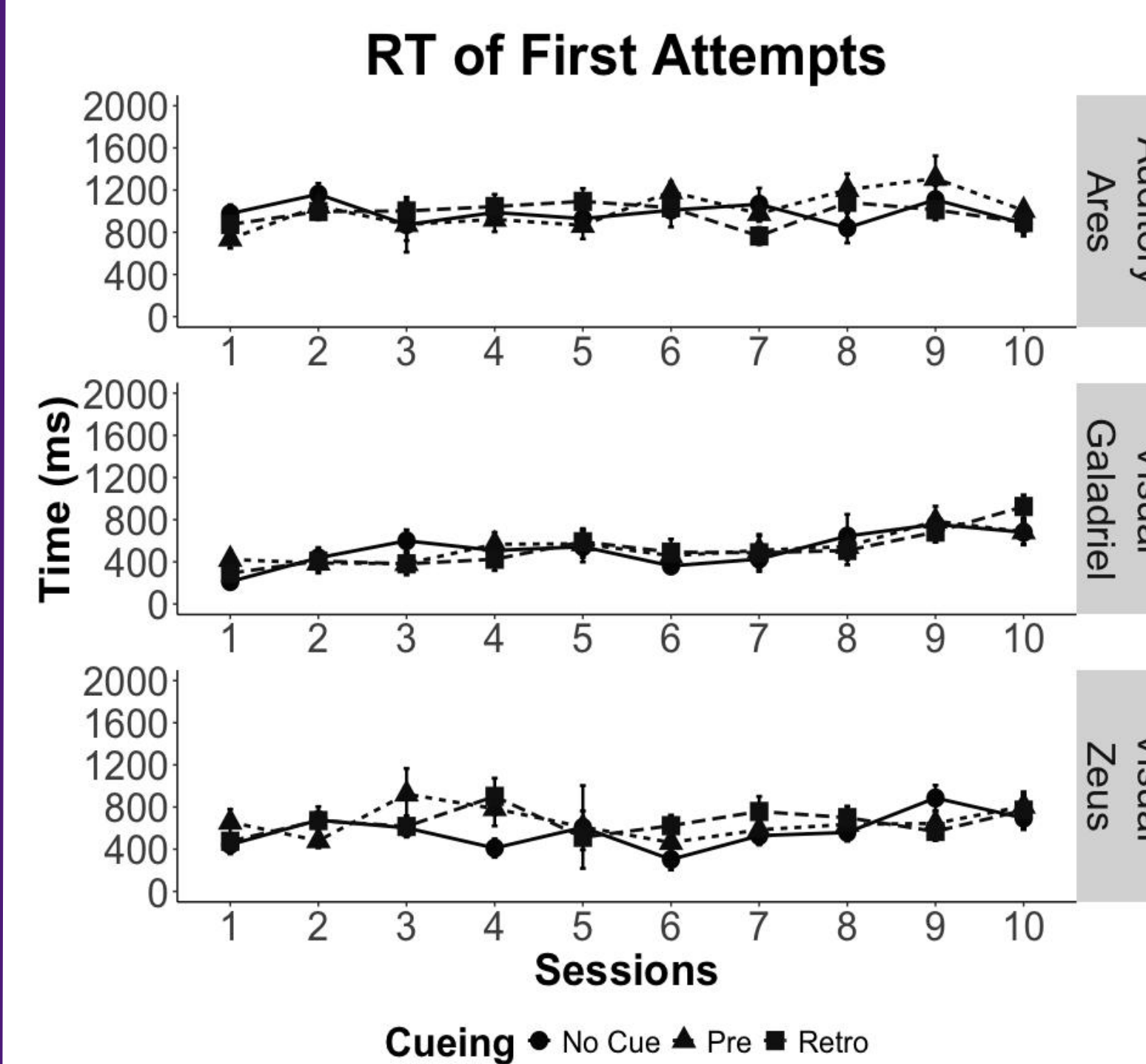
**Phase 1: A, B, C**

Figure 4 shows consistency across Ares, Galadriel and Dionysus in regards to reaction time, while the other three birds show more variation. Figure 5 displayed Ares, Galadriel, and Zeus' accelerated performance in A and B of phase 1, but less so in 1C.

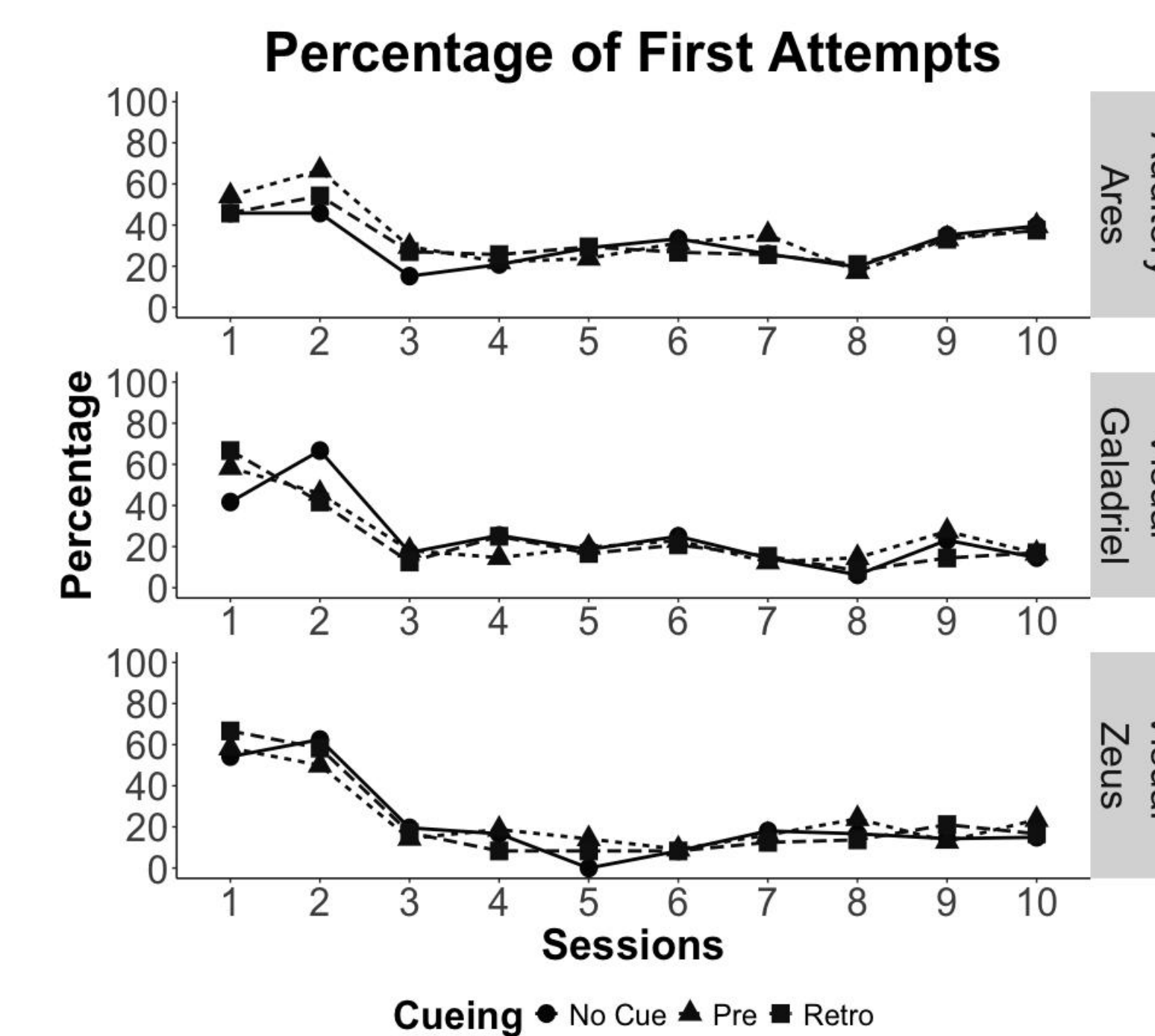
**Figure 5: Percentage of First Attempts (Phase 1: A, B, C)**



**Figure 6: Reaction Time of First Attempts (Phase 2: A, B, C)**



**Figure 7: Percentage of First Attempts (Phase 2: A, B, C)**



**Phase 2: A, B, C Figures 6 & 7**

Only Ares, Galadriel, and Zeus have made it to Phase 2, the test, so far. 2A (session 1) and B (sessions 2) are transitional to 2C (sessions 3-10), which has correction trials. Performance increased across trials, but is below 50%. The correction trials starting in session 3 contributed to performance.

## Discussion

- So far, the birds are learning the task slower than anticipated. The three birds in Phase 2 have yet to show any benefits from cueing in the metrics used. It is unclear whether the task has just not yet been fully learned by the pigeons in the testing phase, if pigeons aren't sensitive to the timing and presentation of cues used, or if this task is too complex for the pigeons to recognize the cues, causing them to focus more on the relationship between stimuli. While the learning may take longer than expected, the task will eventually be learned.
- I could not be happier or more grateful to have been a part of this experiment. Through this specific project and my time in the research lab in general, I learned so much about the processes and complexities of conducting meaningful research. Ethical research with animals is not only beneficial, but necessary, and learning about the dynamics of running a lab that prioritizes good science and results was so defining in who I am and where I see my career going. I now hope to continue to conduct research after graduating from TCU and throughout my future Masters program.

## References

Brady, R. J., & Hampton, R. R. (2018). Post-encoding control of working memory enhances processing of relevant information in rhesus monkeys (*Macaca mulatta*). *Cognition*, 175, 26-35. <https://doi.org/10.1016/j.cognition.2018.02.012>

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Washburn, D. A., & Astur, R. S. (1998). Nonverbal working memory of humans and monkeys: rehearsal in the sketchpad? *Mem Cognit*, 26(2), 277-286. <https://doi.org/10.3758/bf03201139>