Interval Timing Under Microgravitational Stressors

COLLEGE of CHARLESTON
DEPARTMENT OF PHYSICS AND ASTRONOMY

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Introduction

Interval timing refers to the capability of having perceptual and behavioral control of time in the seconds-to-minutes range. Under the influence of microgravity, interval timing becomes impaired, which can lead to significant cognitive and motor dysfunctions. Studies suggest that certain regions of the brain, such as the thalamus and its sub-regions, display decreased neuronal connectivity after being exposed to microgravity. These regions play important cognitive roles in both working memory and decision making. This could lead to an increase in noise/variance throughout the cerebrum, resulting in a delay or impairment in one's ability to produce accurate timing intervals. This noise varied in the SBF model to accurately portray the effects of microgravity.

Behavioral Experiments

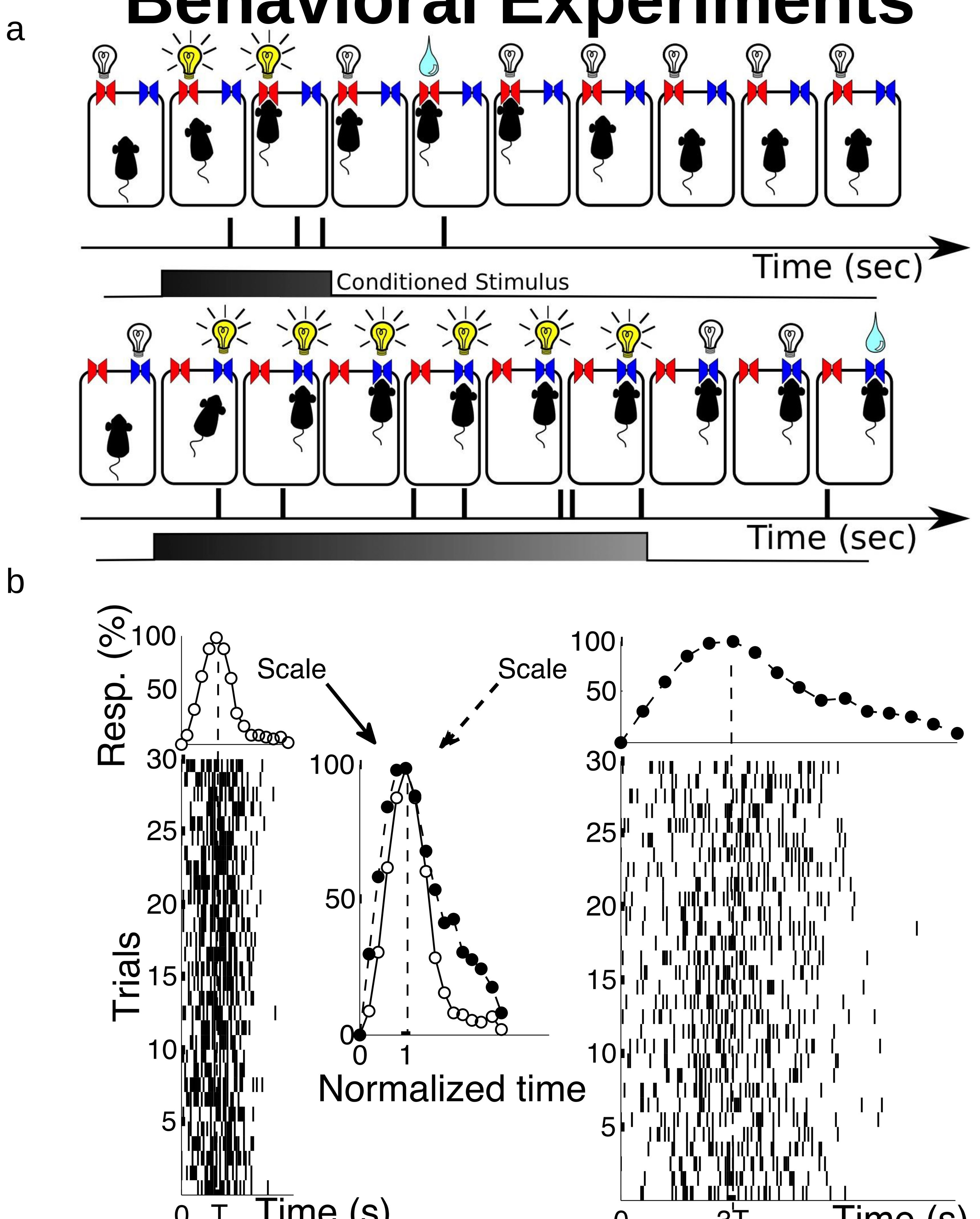
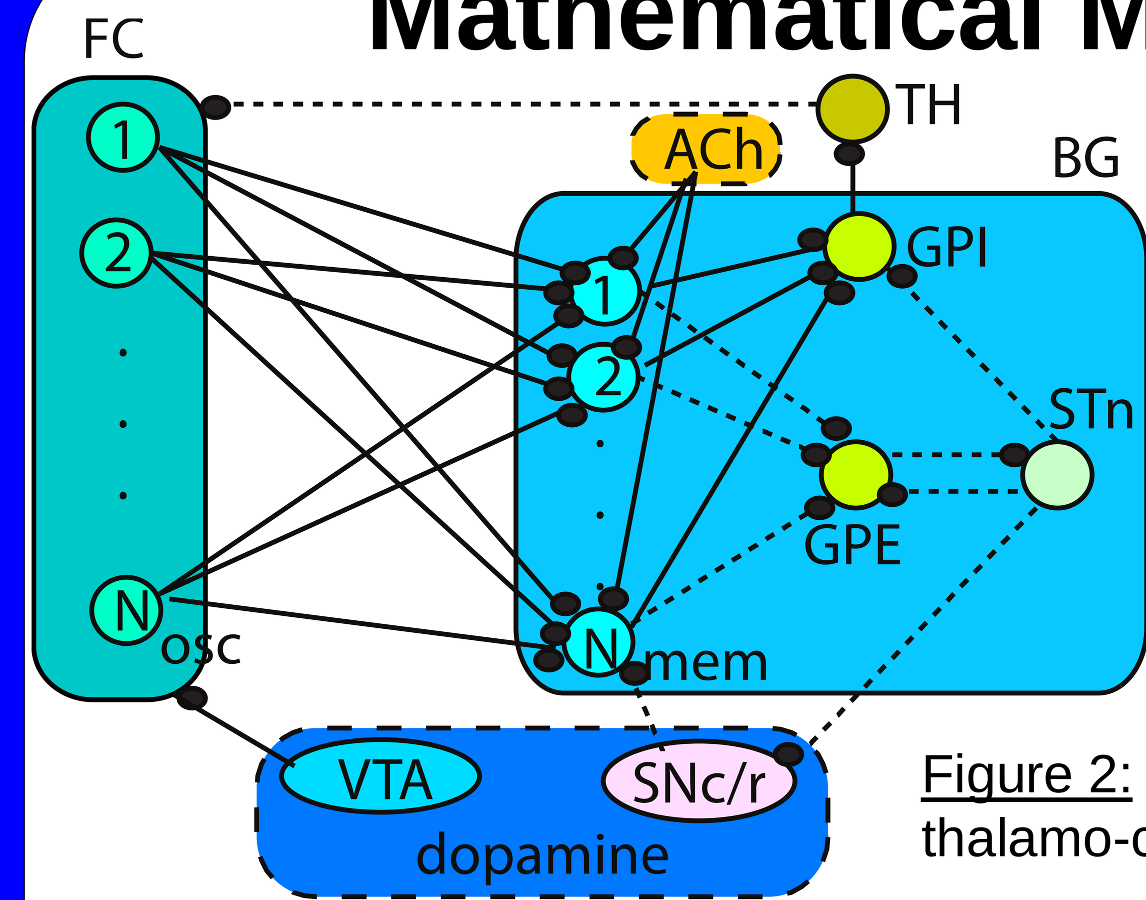


Figure 1: **(a)** Fixed Interval Trials: The first response after the stimulus cutoff is reinforced. **(b)** Peak interval responses scale with the to-be-timed interval *T*.

Mathematical Model



$$w_i(T) = \frac{1}{S}\sum_{j=1}^{N_{mem}} v_i(T_j)$$

$$out(t) = \sum_{i=1}^{N_{osc}} w_i(T)\, w_i(t)$$

Figure 2: Diagram mapping the thalamo-cortical loops.

The Striatal Beat Frequency (SBF) model is based on neurobiological data: striatal spiny neurons (BG) integrate the activity of frontal cortical (FC) oscillators to produce coincidental beats. Altering the frequency and memory variances of the neural oscillators within this system is what represents biological noise.

Results

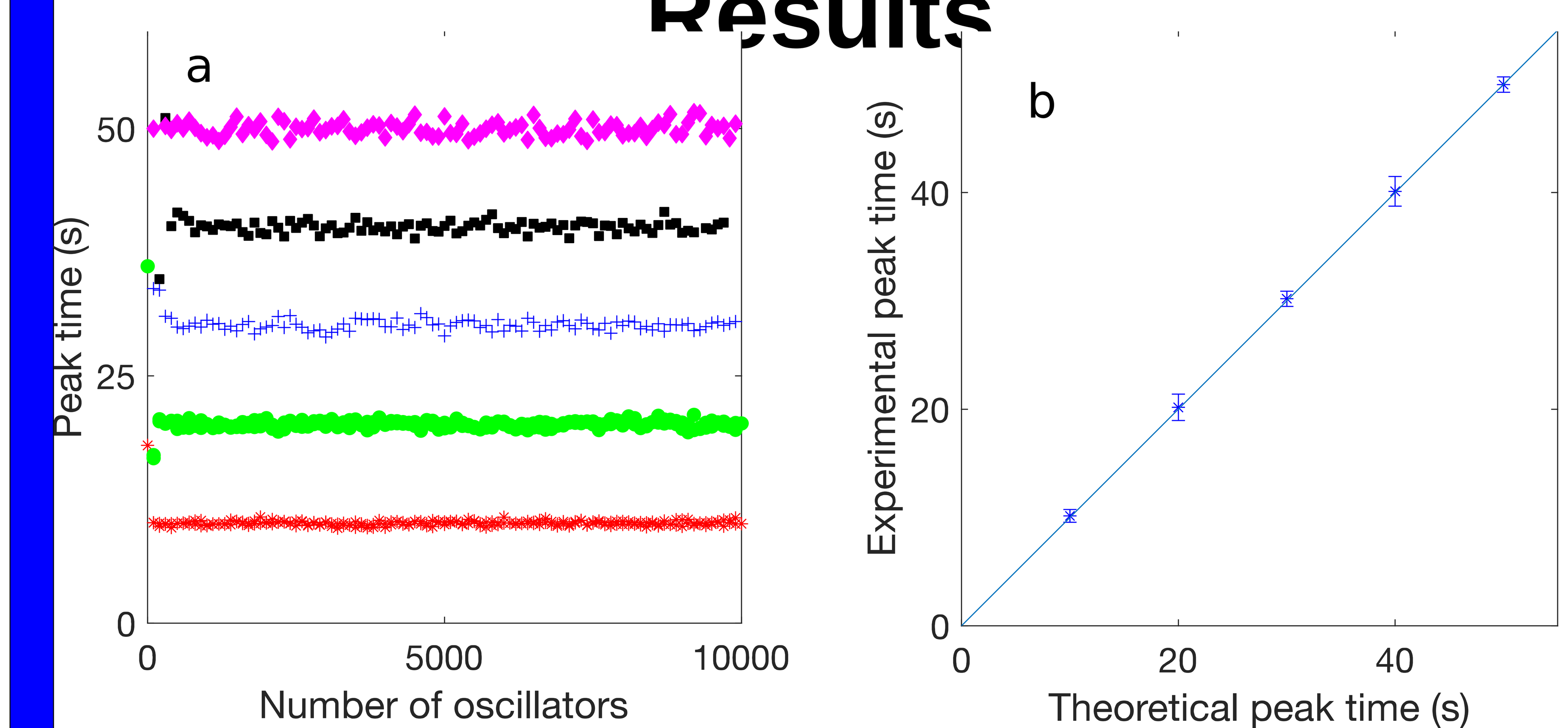


Figure 3: (a) Peak experimental timing is accurate even with fewer FC oscillators. (b) Interval timing is accurate.

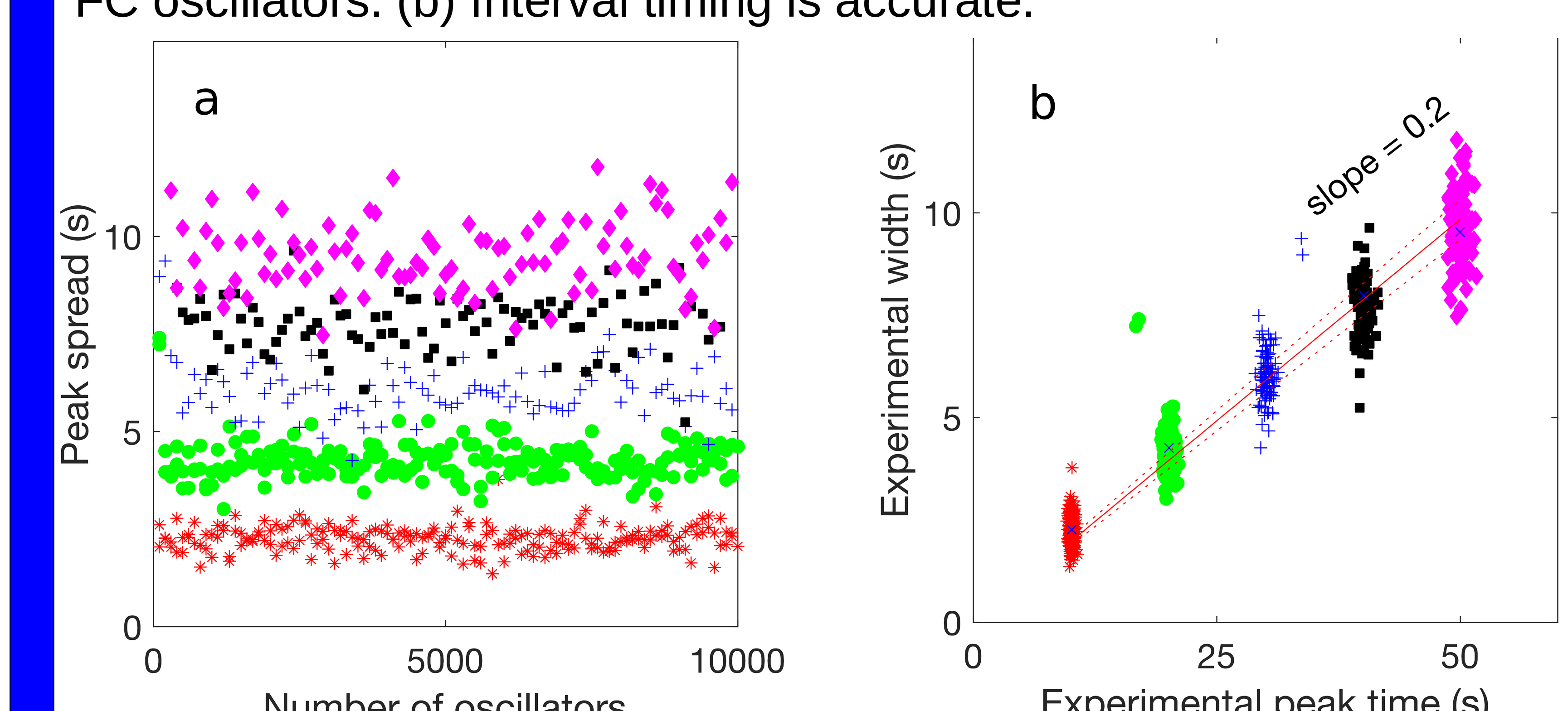


Figure 3: (a) Gaussian width is consistent even at low FC oscillator #. (b) Scalar property: Gaussian width is proportional to peak time.

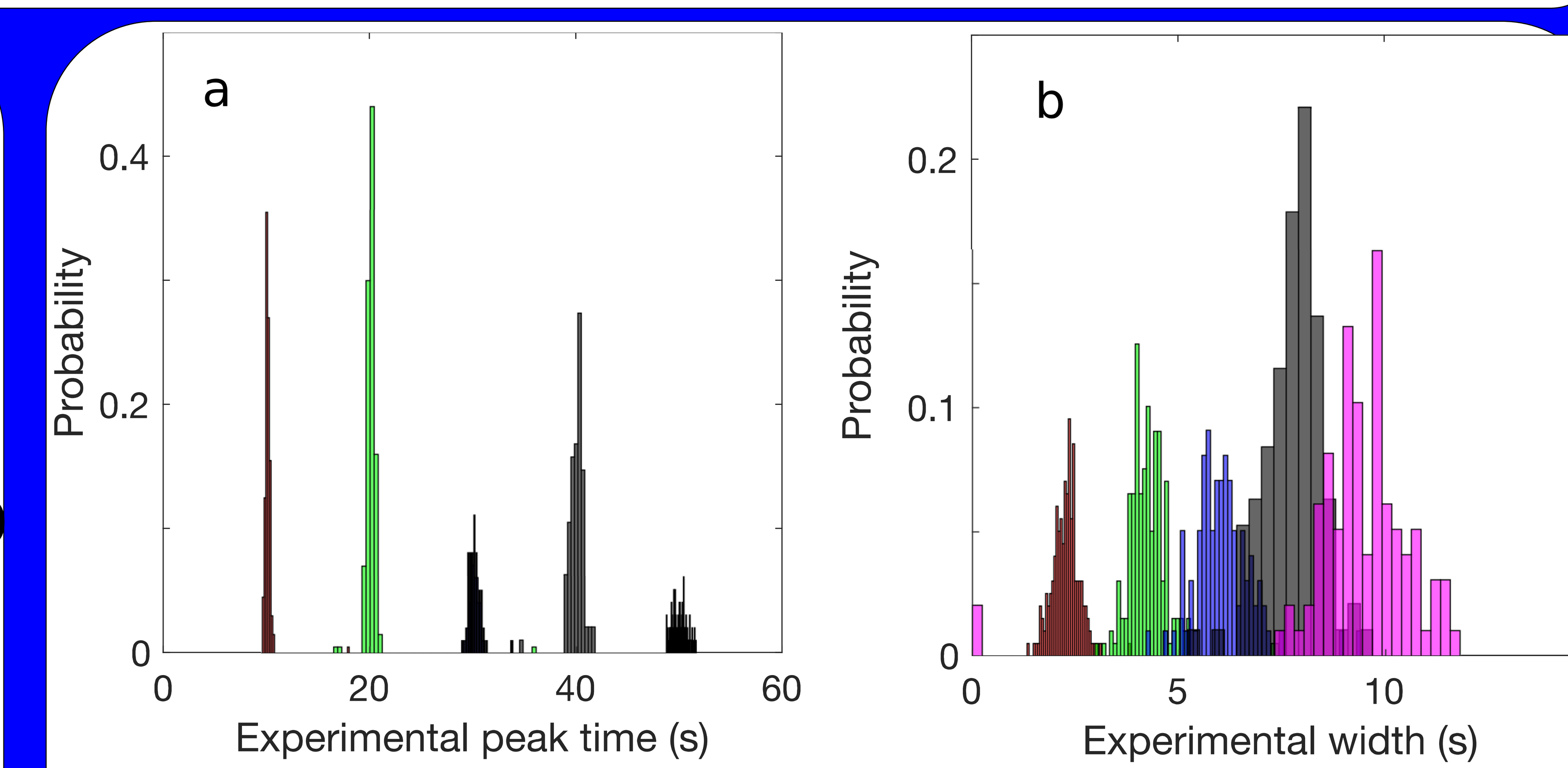


Figure 4: (a) Gaussian spread of peak time. (b) Gaussian spread of output width has a larger standard deviation than peak time spread.

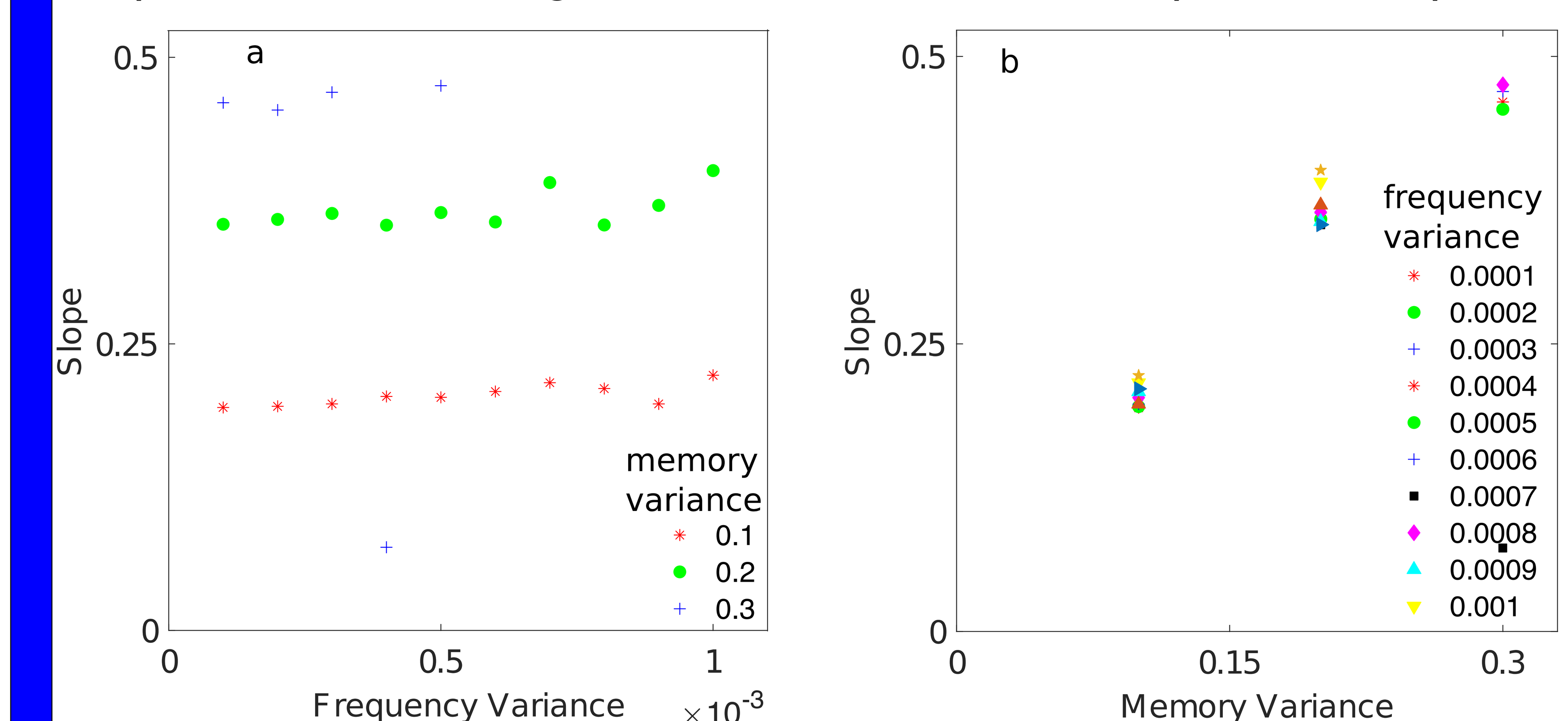


Figure 5: The slope of the scalar property (Fig. 3b) changes with noise levels that mimic microgravity. (a) Frequency variance does not show a consistent effect on scalar property slope. (b) The scalar property slope increases proportionally with memory variance noise intensity.

Conclusion

- Timing is precise over a wide range of FC oscillators # (Fig.3).
- Timing is scalar (Fig.4)
- The error in time estimation and its Gaussian width increase with criterion time (Fig.4)
- The frequency variance does not seem to create a consistent linear trend for scalar property slope (Fig.5a)
- The memory variance produces a proportional increase in the slope of the scalar timing (Fig.5b).
- Further work is needed to elucidate why FC noise has a different effect than memory noise on timing.

Acknowledgments

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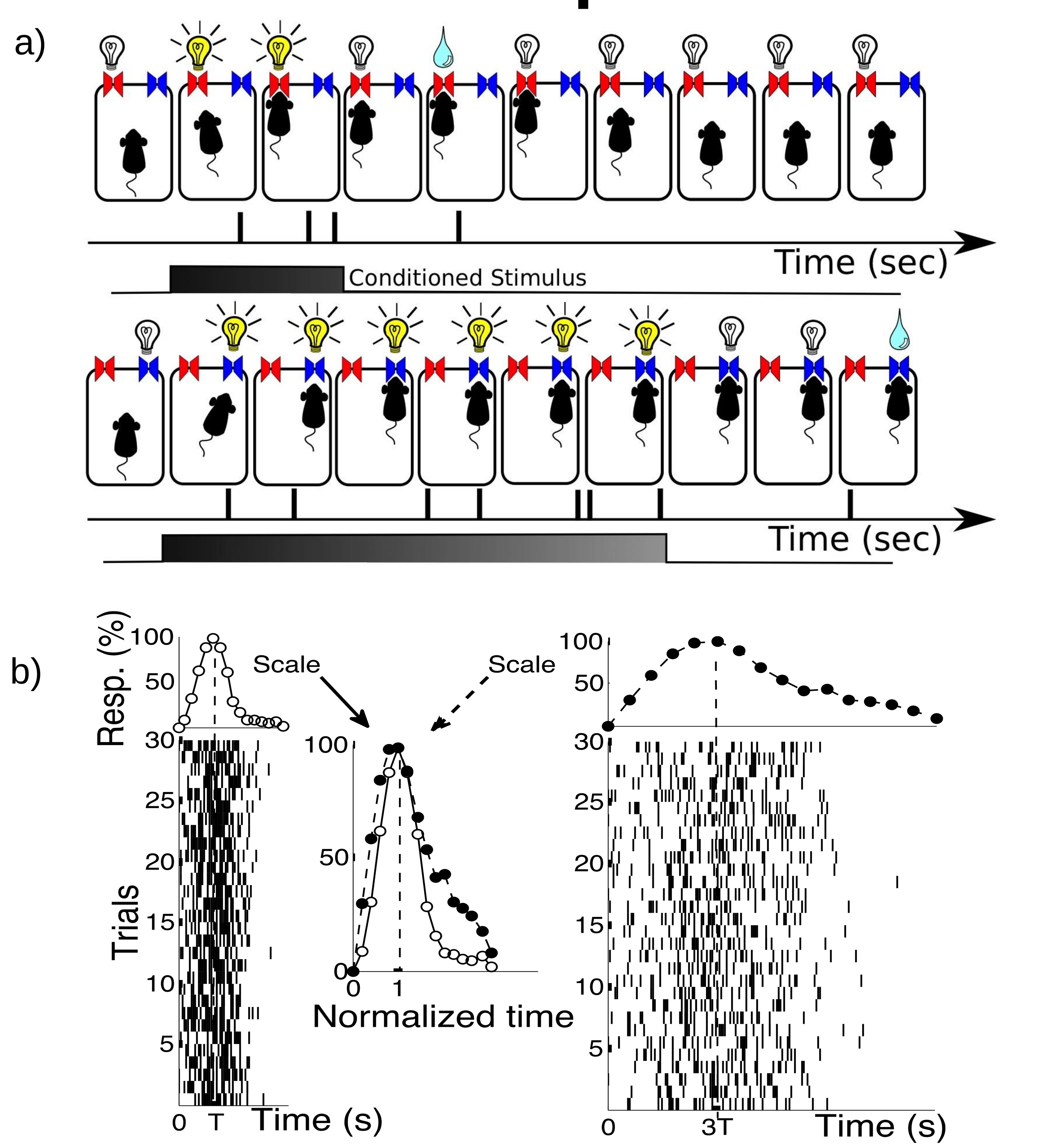
Behavioral Experiments



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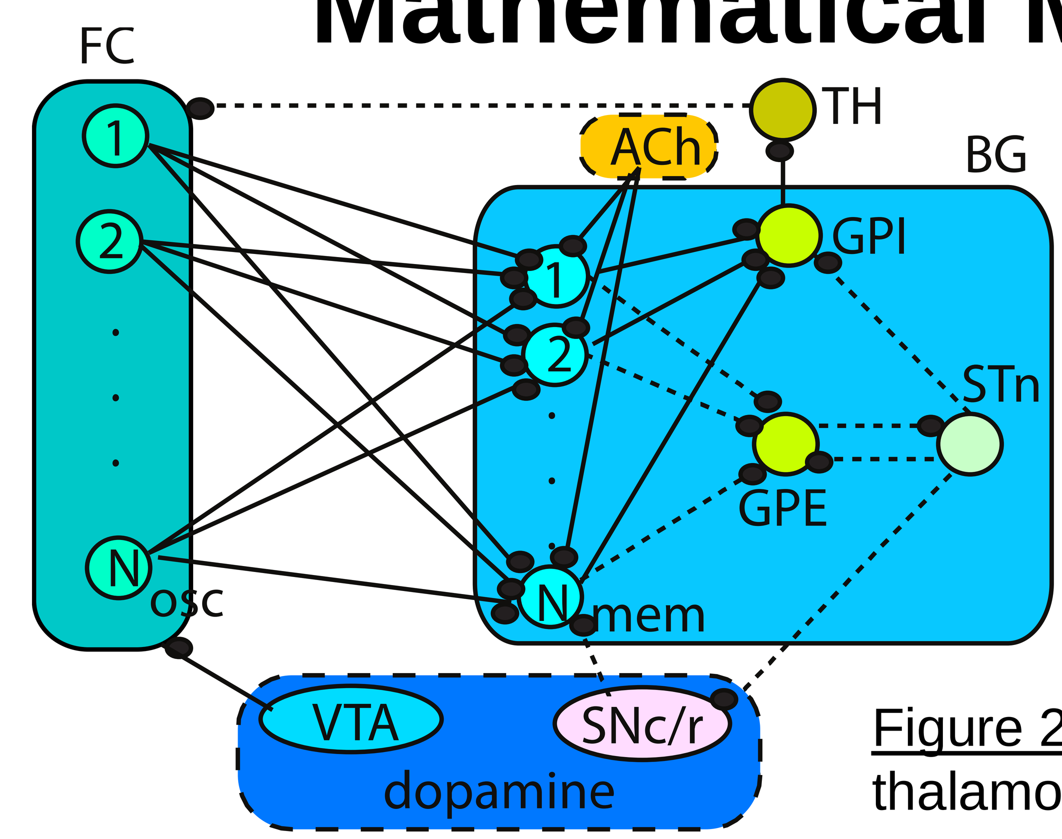

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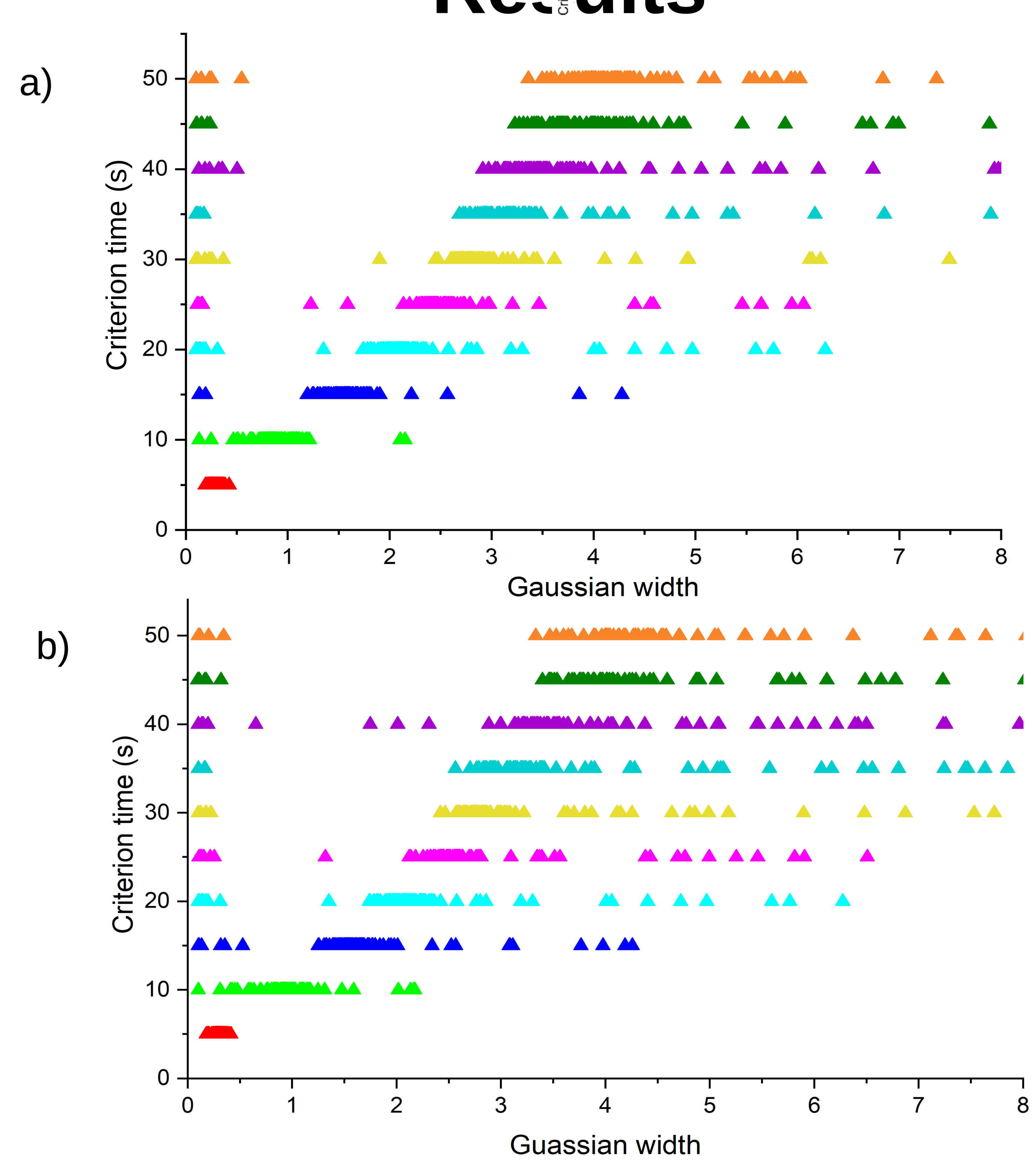

Figure 3: The width of the Gaussian curve increases with an increase in criterion time for both ranges 0.5-50.5 **(a)** and 0.5-100.5 **(b)**

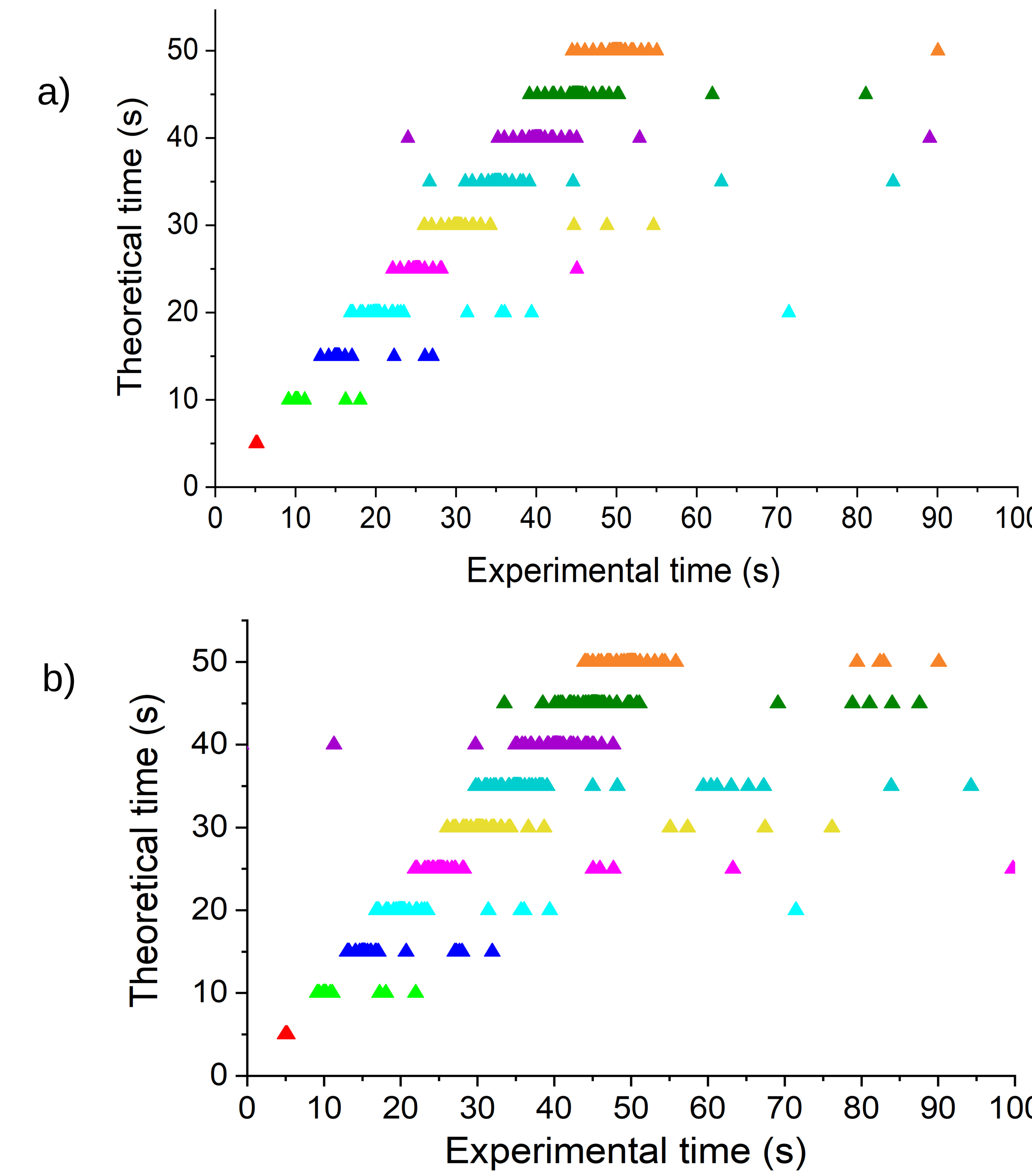

Figure 4: **(a)** As criterion time increased under the frequency range 0.5-50.5, peak intervals range more. **(b)** As criterion time increased under the frequency range 0.5-100.5, interval timing becomes less accurate.

Conclusion

- Under increased frequency ranges, even with minimal noise, (memory variance 0.05 and frequency variance .0001), criterion time directly correlated to an increased in the width of the Gaussian curve. (Fig. 3)
- Peak interval timing ranges more as criterion timing increases (Fig. 4)
- Under the frequency range 0.5-100.5, outliers are more frequent than under the range 0.5-50.5 (Fig. 3 and 4)

Acknowledgments

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