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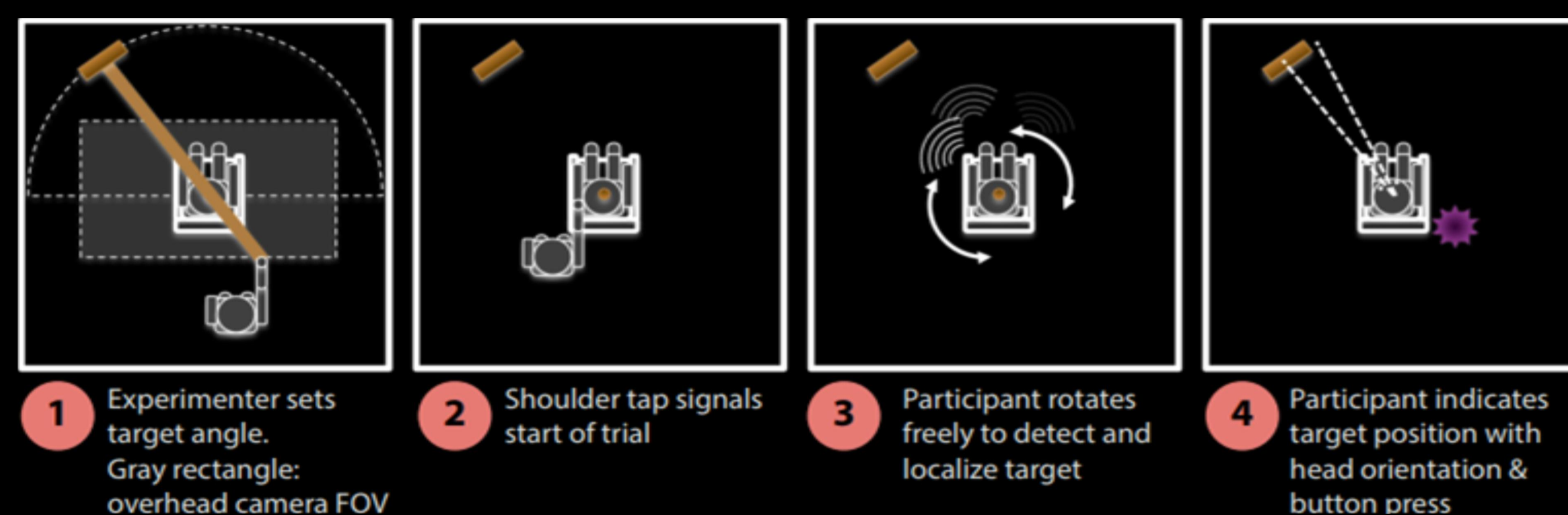
MODELING TARGET SEARCH IN BLIND ECHOLOCATORS USING A KALMAN FILTER WITH REALISTIC EXPLORATORY BEHAVIOR SIMULATIONS

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BACKGROUND

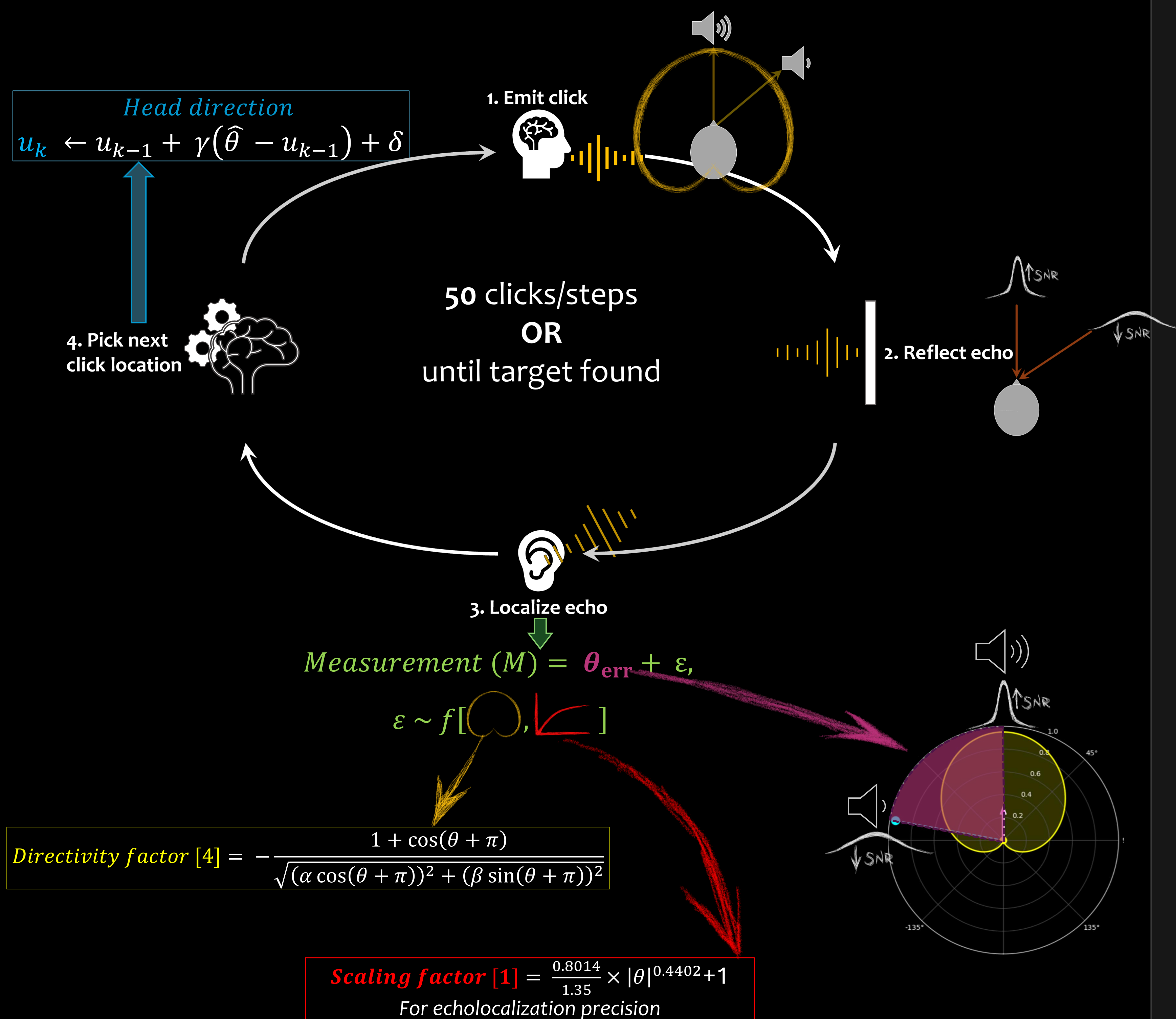
How do humans learn to localize objects using echolocation alone?



- Some blind individuals use series of clicks and echoes to guide perception and action
- We simulate this using a predictive model that learns to orient based on echo feedback

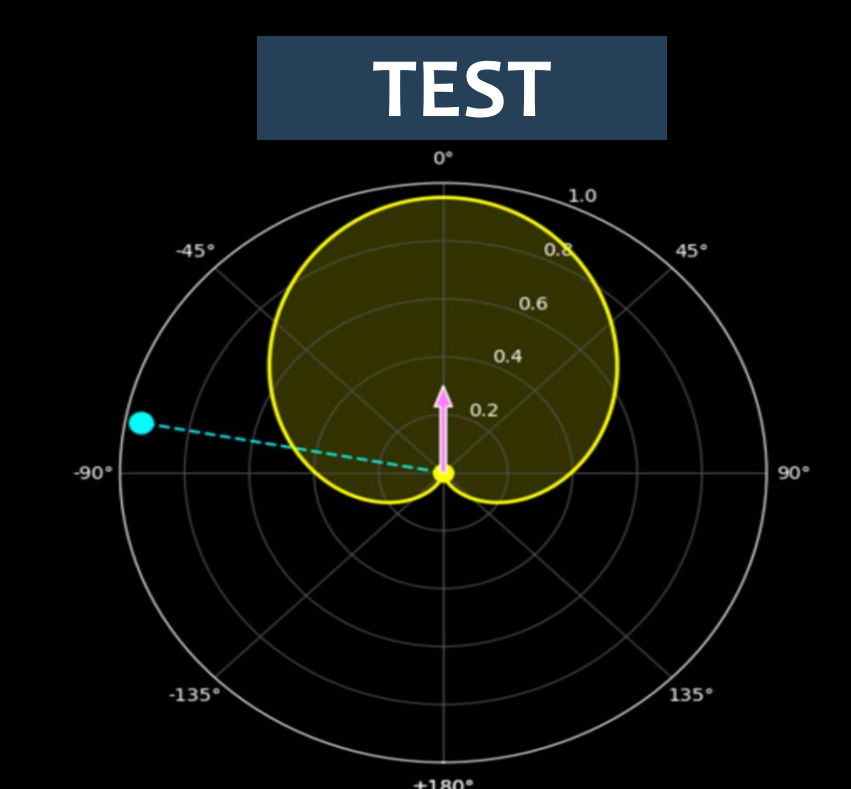
MODEL CONCEPT

Model estimates azimuth and updates head position based on simulated echo cues

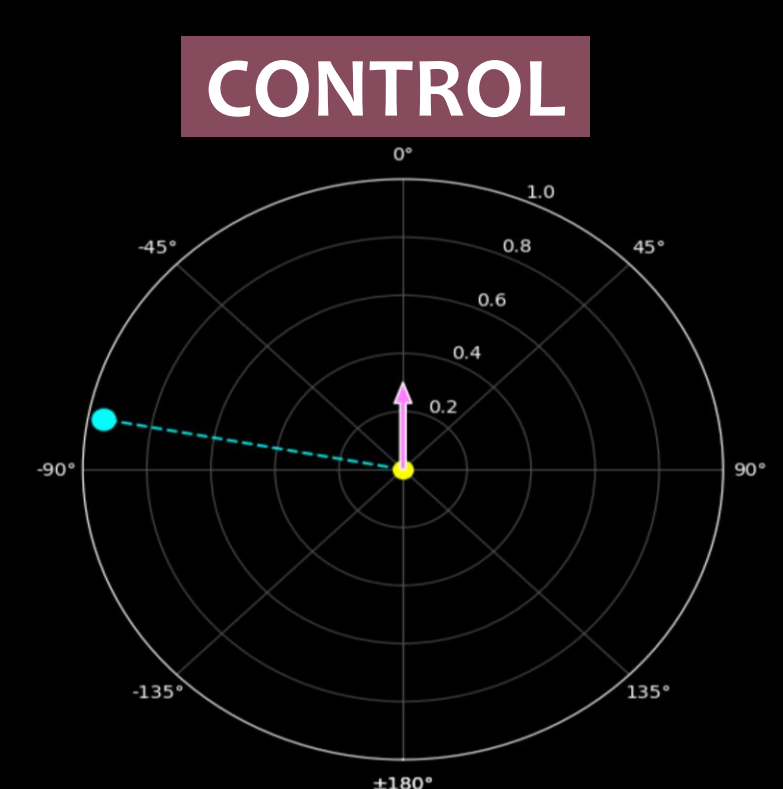


TL;DR: Larger $\epsilon \rightarrow$ less reliable M

2 CONDITIONS



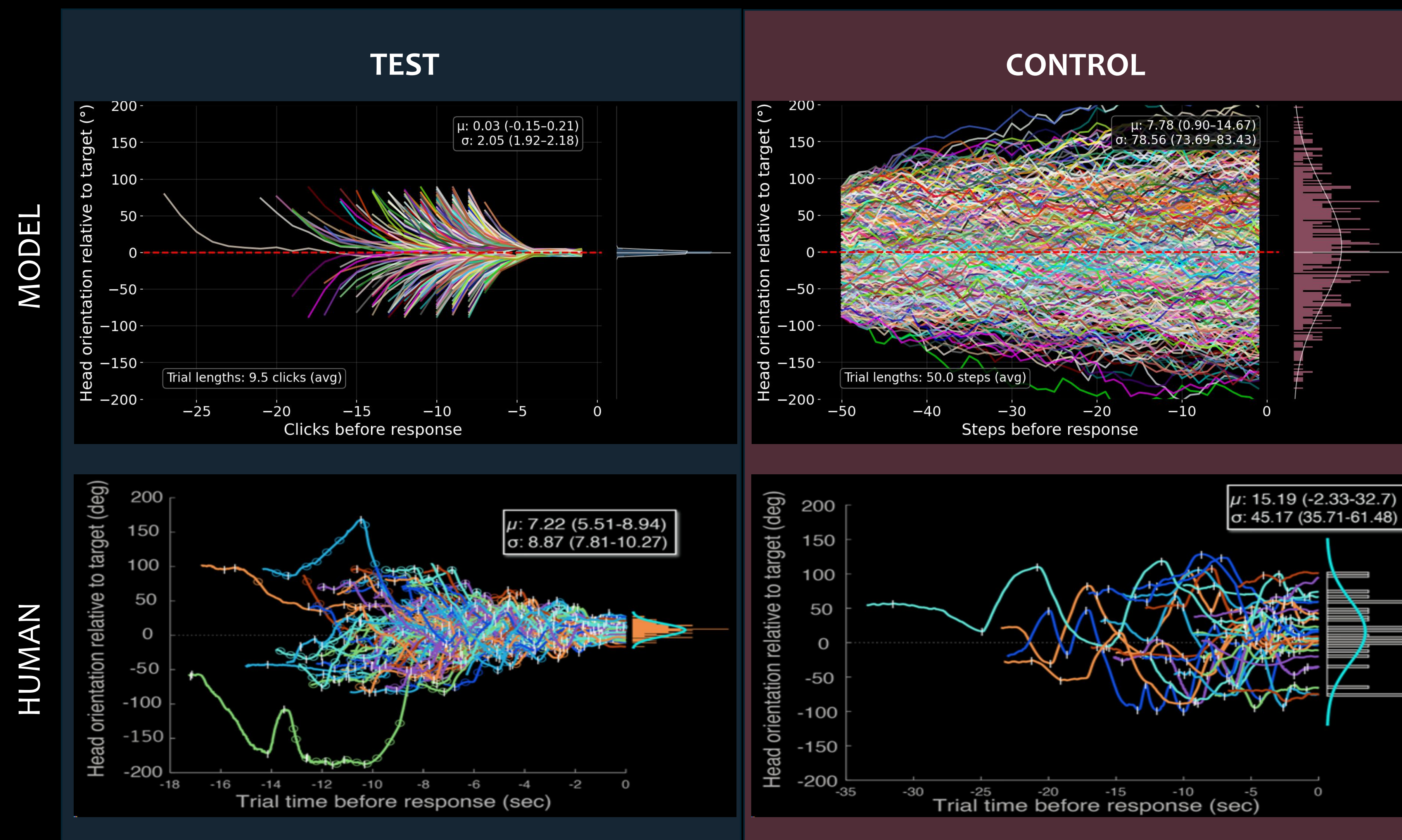
N = 5,
100 trials each



KEY RESULTS

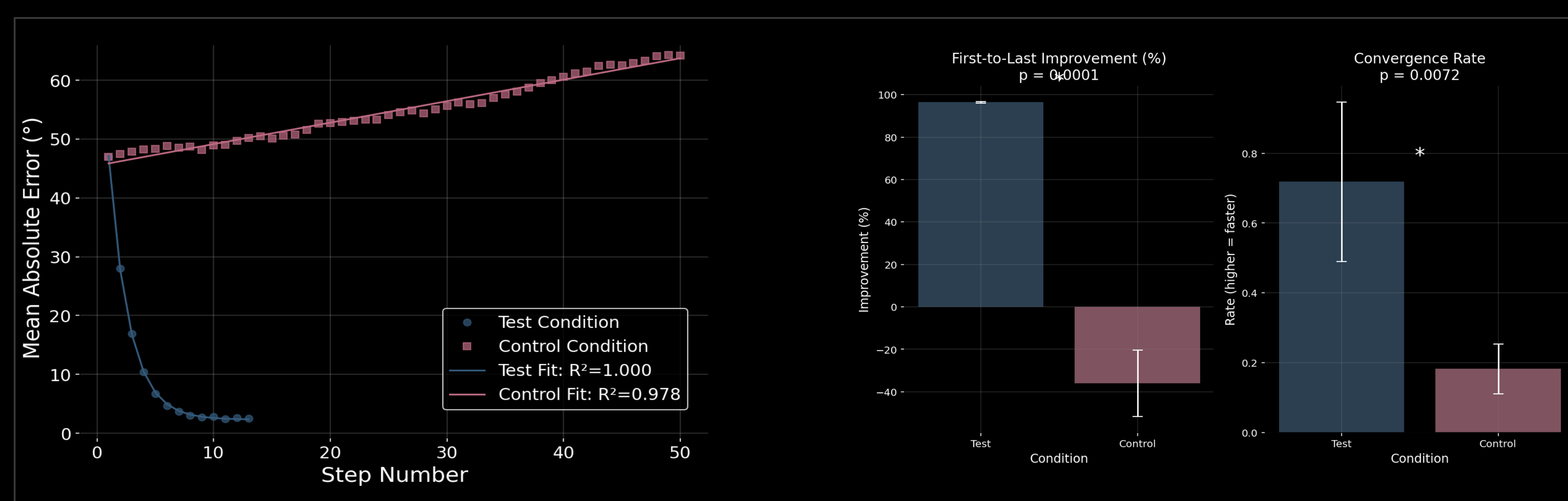
COMPARISON WITH HUMAN PERFORMANCE:

Model approximates blind expert human echolocator behavior at the same task



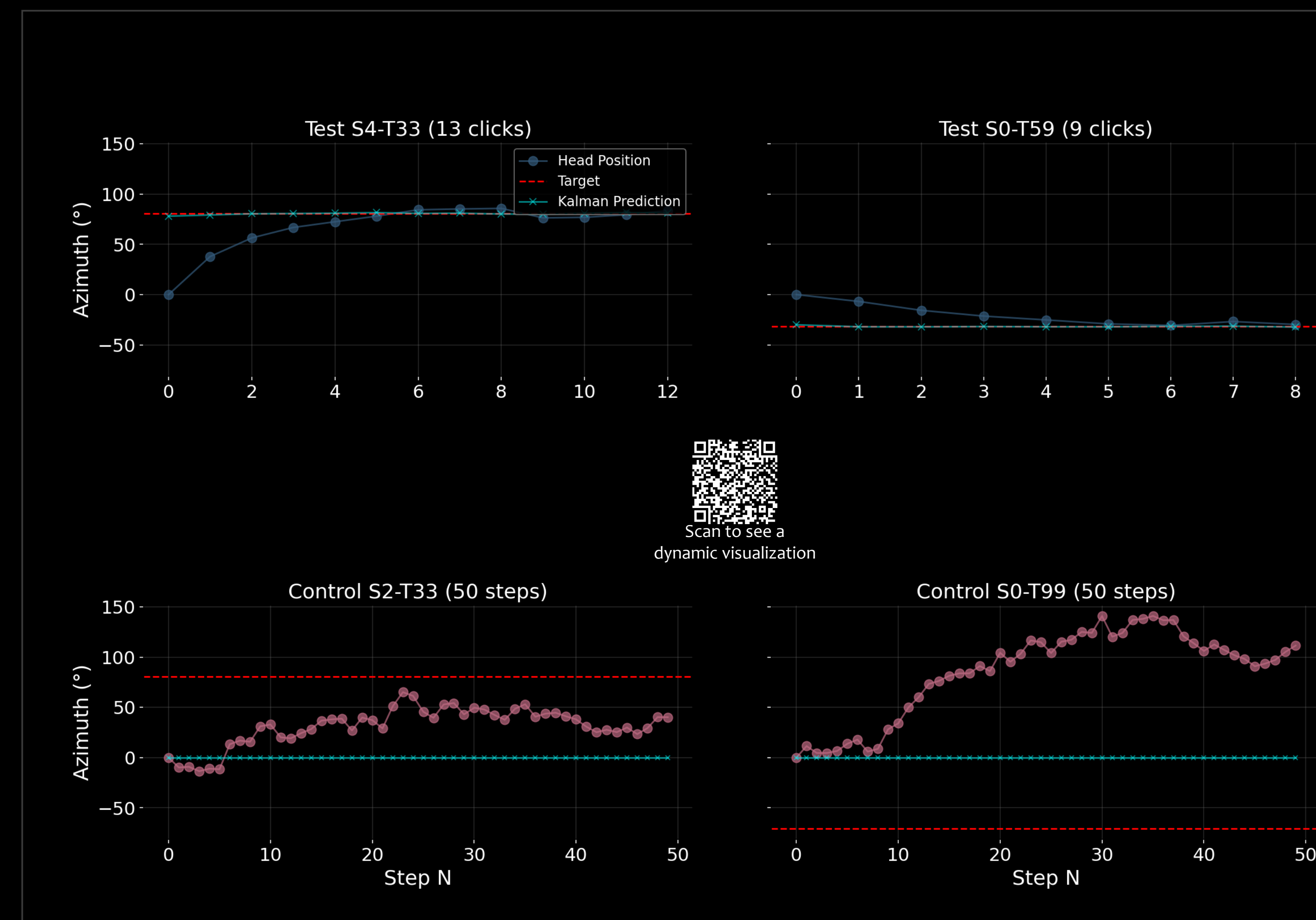
CONVERGENCE:

Error decreases with feedback. No convergence without it.



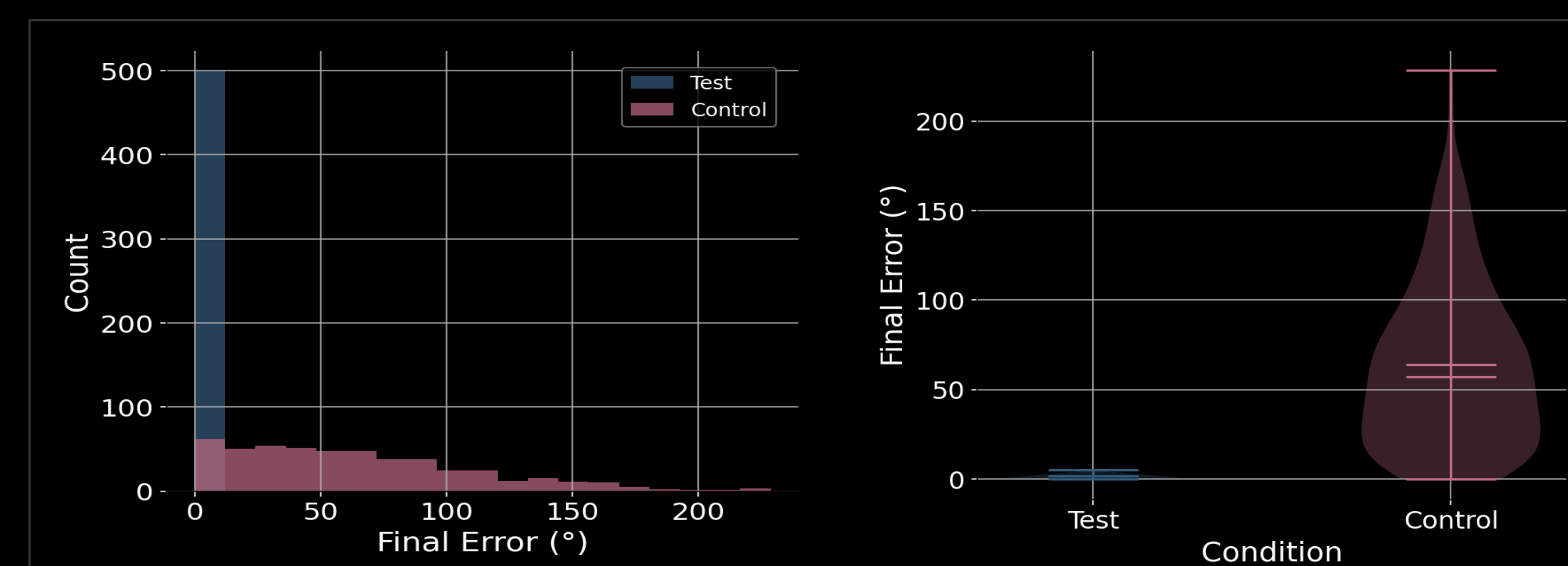
INDIVIDUAL TRIAL DYNAMICS:

KF has no updates \rightarrow model does not converge in control



FINAL ERROR DISTRIBUTION:

Echo-guided model achieves near-zero final error.



SUMMARY

- Simple predictive model \rightarrow Realistic learning behavior.
- Generated behavior patterns generally similar to human behavior patterns.
- However, human behavior is smoother and more integrated over clicks VS. click-move-click model search pattern.
- Next step: RNNs for better temporal dynamics integration.

REFERENCES

1. Makous, J. C., & Middlebrooks, J. C. (1990). Two-dimensional sound localization by human listeners. *The Journal of the Acoustical Society of America*, 87(5), 2188–2200. <https://doi.org/10.1121/1.399186>
2. Teng, S., Puri, A., & Whitney, D. (2012). Ultrafine spatial acuity of blind expert human echolocators. *Experimental Brain Research*, 216(4), 483–488. <https://doi.org/10.1007/s00221-011-2951-1>
3. Thaler, L., & Goodale, M. A. (2016). Echolocation in humans: An overview. *WIREs Cognitive Science*, 7(6), 382–393. <https://doi.org/10.1002/wcs.1408>
4. Thaler, L., Reich, G. M., Zhang, X., Wang, D., Smith, G. E., Tao, Z., Abdullah, R. S. A. B. R., Cherniakov, M., Baker, C. J., Kish, D., & Antoniou, M. (2017). Mouth-clicks used by blind expert human echolocators – signal description and model based signal synthesis. *PLOS Computational Biology*, 13(8), e1005670. <https://doi.org/10.1371/journal.pcbi.1005670>
5. Welch, G., & Bishop, G. (2002). *An Introduction to the Kalman Filter*.

ACKNOWLEDGMENTS

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