## **Challenges of Graph Judgment: Top-Down and Bottom-Up Influences** By Ethan C. Guthrie & Anthony J. Bishara **College of Charleston ROC Results** Stimuli Examples Abstract Bias to decide that while taking Ziaxin Medium proportion cholesterol 0.9 Low proportion increased 8.0 0.7 S Positive Belief perseverance primarily impacted a signal detection measure of bias, $\eta^2_{G} = 0.22^{***}$ . elation True Introduction Belief perseverance had a smaller 0.3 influence on discriminability, $\eta^2_{G} = 0.02^{***}$ . There was also a small 0.2 interaction, $\eta^2_{G} = 0.01^{***}$ . while taking Ziaxin in 0.1 • People may interpret ambiguous or missing feedback as confirming previous beliefs<sup>1</sup> 0.002 03 04 05 06 07 08 09 0 1 Zero Autocorr 1.0 • A major source of such features is autocorrelation (error in earlier time points affects Higher (better) discriminability 0.9 **Positive Autocorr** 0.8 elation 0.7 S sitiv In contrast, autocorrelation primarily while taking Ziaxin rin impacted discriminability, Po 0.4 $\eta^2_{G} = 0.13^{***}.$ Autocorrelation had a smaller influence 0.2 on bias, $\eta^2_{G} = 0.03^{***}$ . 0.1 Method 0.0 0.9 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.1 lation False Positives (incorrectly deciding cholesterol increased) • Graphs showed cholesterol level before and after made-up drug (e.g., Ziaxin) was started • Participants judged whether cholesterol increased after drug-start using a 6-point scale Probably Definitely • For each drug, the first 18 trials (practice trials) had feedback and were manipulated to Guess An Guess No Additional Experiments Increase Increase Increase Increase (Wager 1) (Wager 1 (Wager 2) (Wager 3) autocorrelation effects were due to Lens Model Results variance and extended effects to Human decisions were also two-tailed decisions Unsurprisingly, actual Cohen's D associated with practice (Standardized cholesterol increase was difference between proportions and postpredicted by the standardized pre- and post-Discussion *intervention slope*<sup>4,5</sup> difference •Half of trials had a cholesterol increase (population intercept higher during drug phase) intervention Common characteristics of informal means) .57\*\*\* .71\*\*\* time-series graph judgments





Informal judgment of graphs can be swayed by both top-down expectations and bottomup perceptual factors. Participants judged whether an event in the middle of a time-series graph affected later data points. Participants' beliefs about the proportion of graphs with such an effect had large impact on a signal detection measure of bias. In contrast, the autocorrelation of the time-series – which controlled perceptual features – primarily affected discriminability. These results highlight the importance of formal statistical algorithms to corroborate informal graph judgment.

Interrupted time series graphs are common in A-B designs, and more generally in any situation where something new (an interruption) is thought to cause a change • Top-down influences could include **belief perseverance** 

- Bottom-up influences include perceptual features of the graph
  - later time points)
  - Positive autocorrelation
    - E.g., hot days followed by hot days, and cold by cold
    - Leads to smoother line patterns
    - Previous evidence of impaired graph judgment<sup>2,3</sup>
  - Negative autocorrelation
    - E.g., low sleep nights followed by long sleep nights, & vice-versa
    - Leads to jagged, reversing patterns

Could belief perseverance and autocorrelation affect informal graph judgment in distinct wavs?

• Subjects (n=91) judged 378 interrupted time-series graphs

- influence **belief perseverance**. Three conditions:
  - **High proportion** (89% had cholesterol increase)
  - Medium proportion (50%)
  - Low proportion (11%)
- •In critical trials, no feedback was given, and all proportions were 50% • Population autocorrelation was manipulated through an AR1 generating model:
- positive (+.75), zero (0), or negative (-.75).

# References

<sup>1</sup>Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology*, 2(2), 175–220. <sup>2</sup>Matyas, T. A., & Greenwood, K. M. (1990). Visual analysis of single-case time series: Effects of variability, serial dependence, and magnitude of intervention effects. Journal of Applied Behavior Analysis, 23(3), 341–351.

<sup>3</sup>Bishara, A. J., Peller, J., & Galuska, C. M. (2021). Misjudgment of interrupted time-series graphs due to serial dependence: Replication of Matyas and Greenwood (1990). Judgment and *Decision Making, 16*(3), 22.

<sup>4</sup>White, P. A. (2015). Causal judgements about temporal sequences of events in single individuals. *Quarterly Journal of Experimental Psychology, 68*(11), 2149–2174. <sup>5</sup>Zhang, Y., & Rottman, B. (2021). Causal learning with Interrupted time series. *Proceedings of the Annual Meeting of the Cognitive Science Society* (Vol. 43, No. 43). <sup>6</sup>Bishara, A. J., Li, J., & Conley, C. (2021). Informal versus formal judgment of statistical models: The case of normality assumptions. *Psychonomic Bulletin & Review, 28*(4), 1164–1182. <sup>7</sup>Borckardt, J. J., & Nash, M. R. (2014). Simulation modelling analysis for small sets of single-subject data collected over time. *Neuropsychological Rehabilitation*, 24(3–4), 492–506. <sup>8</sup>McKnight, S. D., McKean, J. W., & Huitema, B. E. (2000). A double bootstrap method to analyze linear models with autoregressive error terms. *Psychological Methods*, 5(1), 87–101.

		S
	250 I	Patient #9871 before taking Ziax
Total Objects Street Constants	1 otal Unoresterol (mg/aL) 200 1	
	150 1	Autocorre
	250 I	1 2 3 4 5 Patient #8060 before taking Ziax
Total Chalastant (mailed)	150 101al Crioresterol (mg/aL) 200 1 1	V Zero Autocorre
	250 I	1 2 3 4 5 Patient #9003 before taking Ziax
Tatal Chalastanai (mai/d) V	150 101al Criolesterol (mg/al.) 200 1 1	Autocorre
		1 2 3 4 5
		Definitely No Increase Wager 3) (Wager 2

Actual Cholesterol Increase (in parameter)

Proportion of Human Decision practice trials that Cholesterol .17\*\*\* .00 – showing actual cholesterol Increased increase .14\*\*\* .00

Post-intervention

slope



- Ruled out the simple explanation that
- impacted decisions in different ways • We recommend corroborating informal graph judgments with formal statistical models<sup>6</sup>, particularly
- those designed for short timeseries<sup>7,8</sup>