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The Psychology and Neuroscience of Confidence in Memory and Perception

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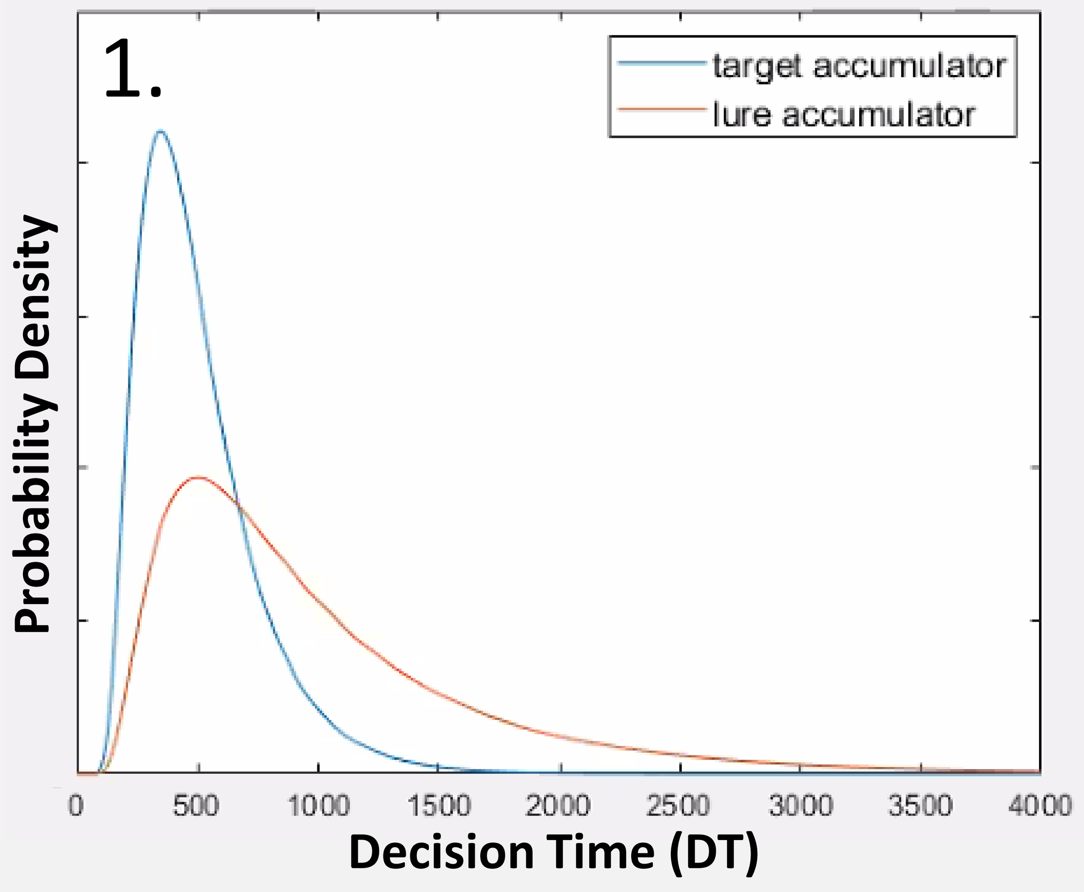
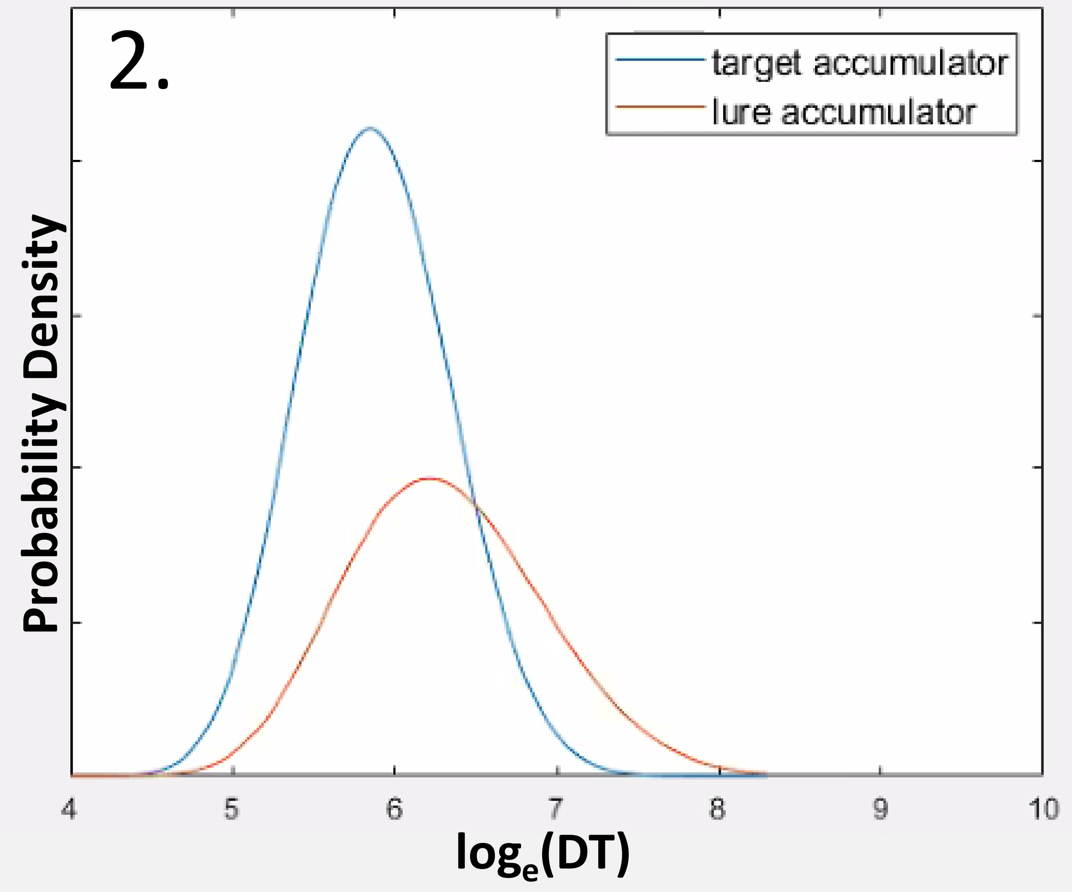
INTRODUCTION. Signal detection theory (SDT) provides a natural explanation of confidence, but it does not explain reaction time (RT). Meanwhile, sequential sampling models (SSMs) naturally explain RT but struggle to explain confidence. Recent efforts to combine SDT with SSMs involve a somewhat artificial marriage. We therefore investigated how SDT and SSMs might be inherently reconcilable, as it seems they should be given that both modeling traditions have stood the test of time and are applied to the same kinds of tasks.

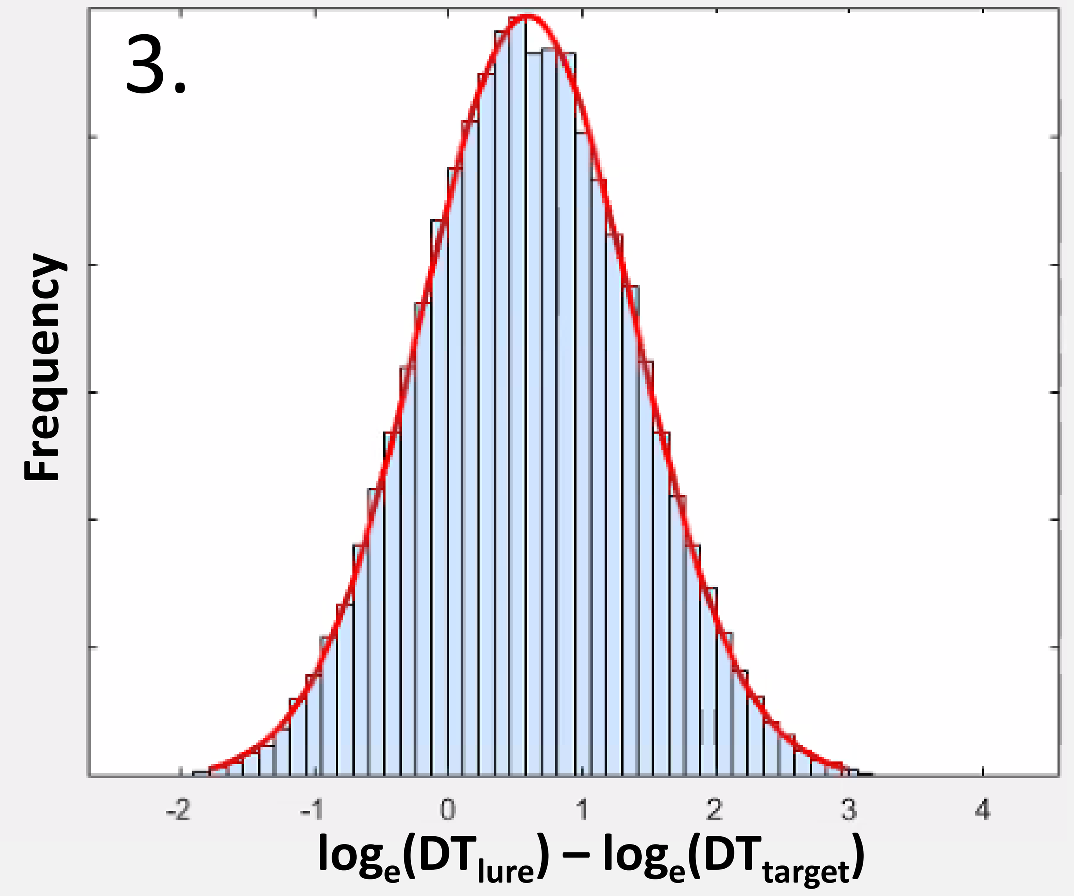
TYPES of SPEEDED DECISIONS. Two basic methods are used to investigate speeded decision-making: **interrogation** and **free response**. In the interrogation method, a signal is presented at a predetermined time interval, demanding the binary decision (e.g. "target" vs. "lure"). In the free response method, the participant makes a decision when enough information has accrued, which occurs when an accumulator hits a decision boundary.

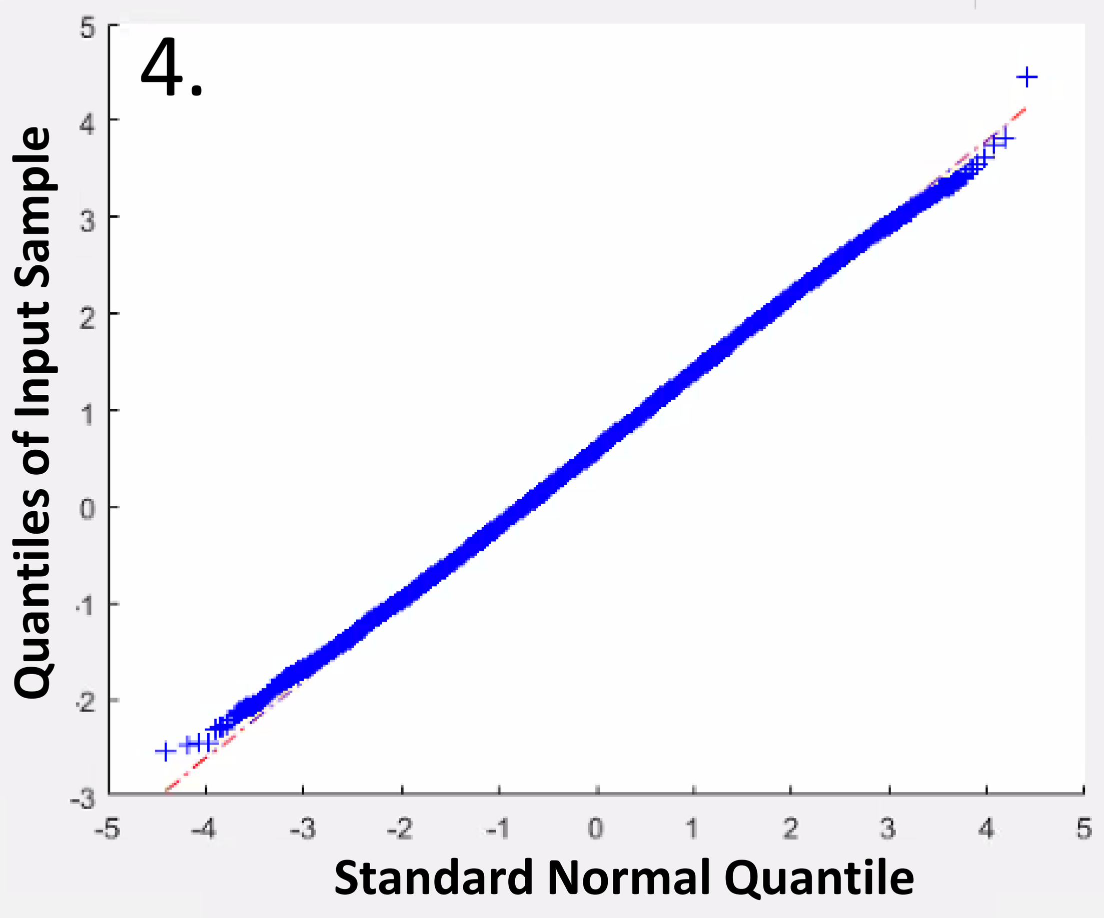
BALANCE OF EVIDENCE (BOE). Neurologically plausible SSMs have explained confidence using a BOE approach.[1,2] A BOE model involves two accumulators, one for each possible decision. Confidence is based on the vertical distance (e.g., the quantity of evidence accumulated) between the two accumulators. The greater the difference between accumulators, the greater the confidence in the decision. SDT would inherently fall from a BOE model if the distribution of difference scores were Gaussian. **Interrogation:** Using the vertical difference score as the decision variable, BOE models inherently generate a Gaussian SDT model in this type of task.[3] **Free response:** In the free response method, vertical difference scores between the winning and losing accumulators yield a non-Gaussian bimodal distribution. We've found two ways to yield Gaussian distributions in this task: 1) allowing for post-decisional evidence accumulation or 2) switching to the *horizontal* distance[4] (e.g., the difference in DTs; see "Simulation") as the difference score for the two accumulators. This poster focuses on the latter since we believe that it more-naturally yields a Gaussian SDT model, but further investigation is still needed.

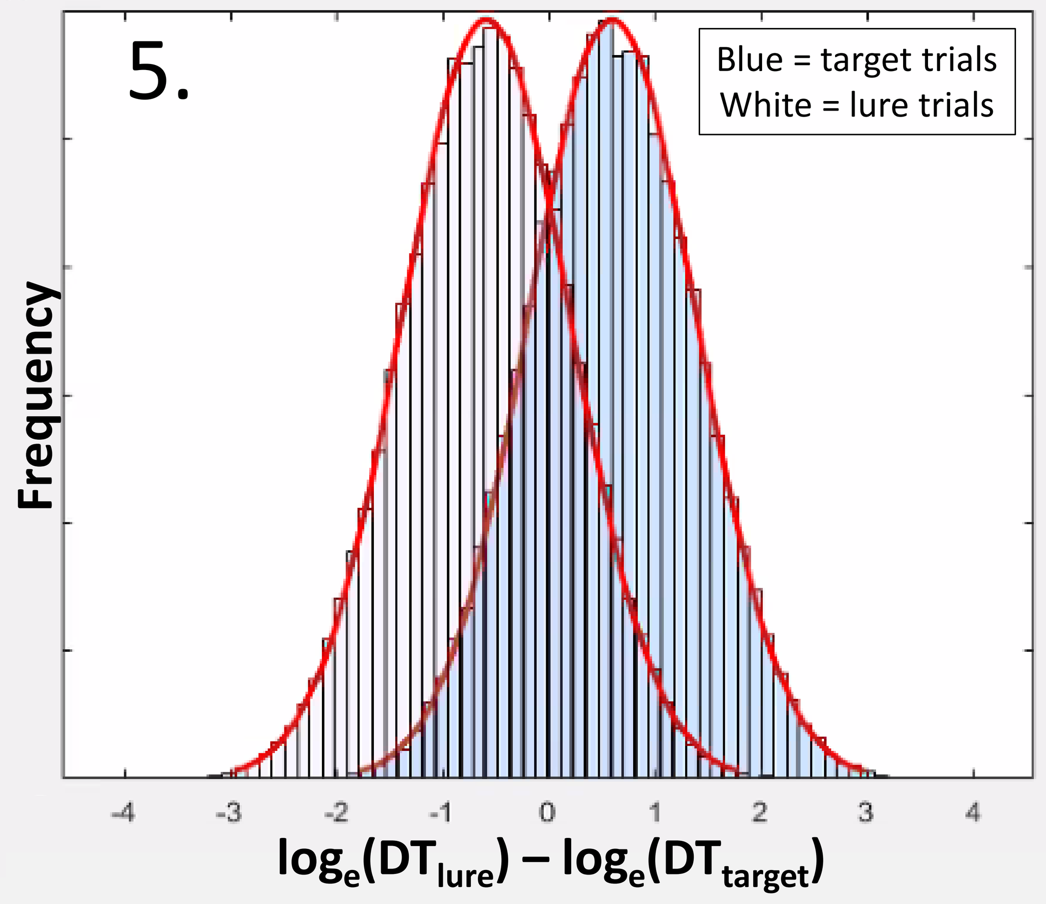
SIMULATION. *An illustration of a free-response target trial.* When the winning accumulator reaches the decision boundary, the participant continues to monitor the boundary until the second accumulator reaches the boundary as well. When the second accumulator reaches the boundary, the difference between the decision times (DT) of the winning and losing accumulators is decision variable upon which confidence is based. A larger difference between the two DTs corresponds to greater confidence in the decision.











Figures. ***1.*** Inverse-Gaussian distributions of DT for each accumulator hitting a boundary. ***2.*** The log of those DTs are taken, consistent with evidence that humans' perception of time is a log-transform of real time.[5] ***3.*** Simulated log(DT) difference scores for target trials yield a near-Gaussian distribution. ***4.*** A QQ plot of the simulated data in Fig. 3 vs. the standard normal. The red line indicates expected scores for a true Gaussian distribution. The simulated data closely hug that line. ***5.*** A representation of Fig. 3 along with the corresponding distribution of log(DT) difference scores for lure trials.

CONCLUSIONS. Within the BOE framework – which has the benefit of being neurologically plausible – SDT and SSMs are inherently compatible. We find this compatibility within both interrogation and free-response tasks. In an ***interrogation*** task, the participant monitors a sensory channel. When the cue is presented, confidence is based on the difference in accumulated evidence. This was already known to yield a Gaussian SDT model using the standard Weiner diffusion process. In a ***free response*** task, we propose one way of reaching standard SDT. In this method, the participant monitors a decision boundary. When one accumulator reaches the boundary, the binary decision is determined. However, confidence is not determined until the *second* accumulator also reaches the boundary. The difference between the log(DT) for each accumulator is what determines confidence (and is normally distributed, naturally connecting itself to SDT). There are many SSMs that account for the basic data with similar degrees of goodness-of-fit. Thus, goodness-of-fit may not be the ultimate arbiter. Other important dimensions of model evaluation include neurological plausibility as well as the ability to simply and elegantly tie to SDT. Here, we considered one way to reconcile these two modeling frameworks.

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FURTHER INFORMATION: For questions, contact Anne Yilmaz at a1yilmaz@ucsd.edu