Temporal normalization incentivizes attentional tradeoffs across time

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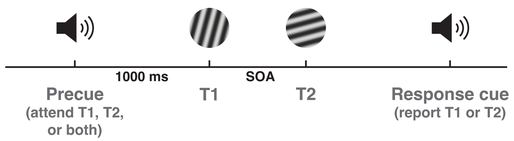
Background

- The ability to process sequential stimuli is limited by factors such as their timing[1] and contrast[2], as well as attention[3]
- Temporal normalization, the idea that neural responses are divisively suppressed by activity at other times[4,5], offers a potential mechanism that could explain the the interaction between stimuli and unify these findings
- Attention is known to interact with spatial normalization[6], but it is currently unknown how this extends to temporal normalization

Question

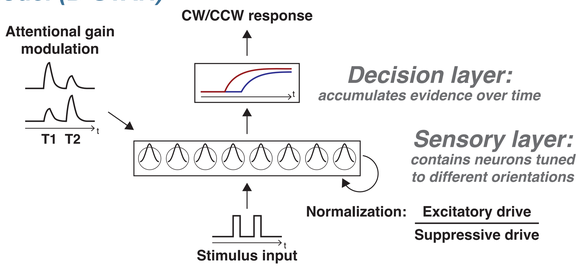
How does temporal attention interact with temporal normalization?

Methods



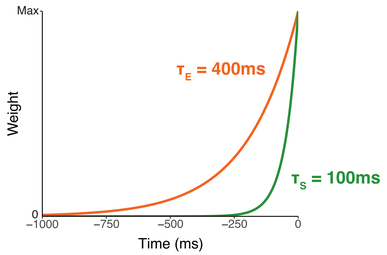
We simulated behavior in a two-target cueing paradigm[3], where the task was to report the clockwise or counterclockwise tilt of a target stimulus. We measured model responses to the cued and uncued stimulus across a range of stimulus onset asynchronies (SOAs, 100-800 ms)

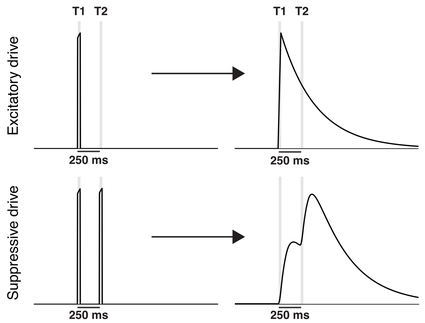
Dynamic spatiotemporal attention and normalization model (D-STAN)



D-STAN model implements temporal normalization through temporal receptive fields

Stimulus history affects current neural response

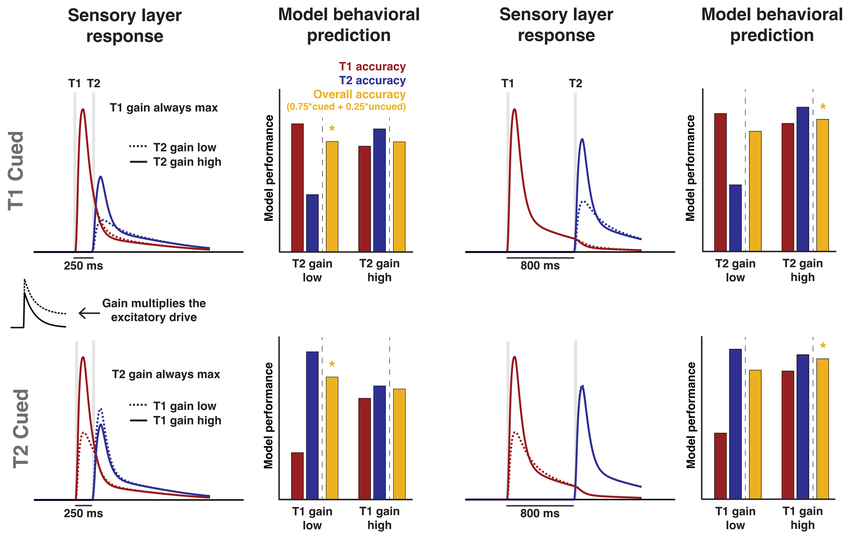




Attentional gain interacts with temporal normalization to bias temporal competition between sequential stimuli

At short SOAs, attending the cued stimulus maximizes overall accuracy

At longer SOAs, attention across both stimuli maximizes overall accuracy

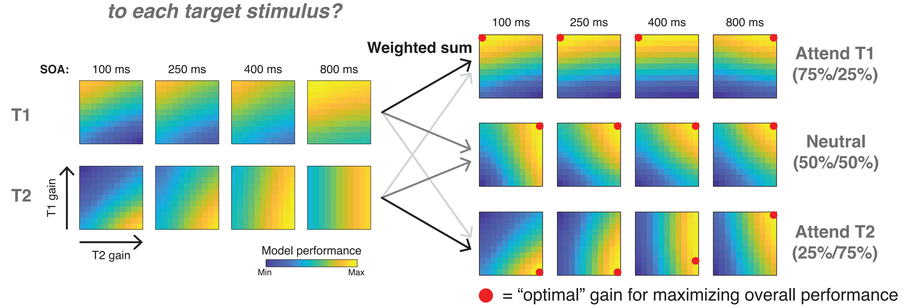


Temporal normalization incentivizes attentional tradeoffs without an explicit resource parameter

D-STAN predicts tradeoffs between stimuli at short-to-medium SOAs due to temporal normalization

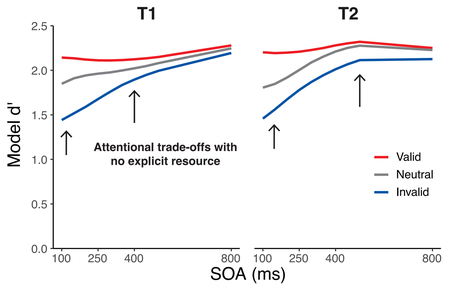
How does gain affect responses to each target stimulus?

Optimal gain settings based on model response across trials

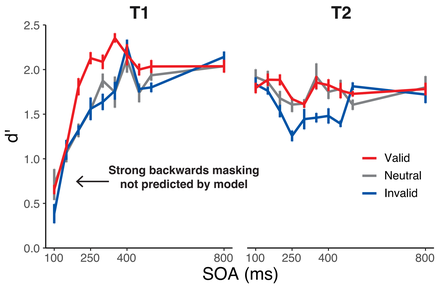


Optimal gain under temporal normalization predicts attentional enhancement at short but not long SOAs

Model prediction



Behavioral data[1]



Conclusions

- Our new model, D-STAN, incorporates temporal attention and temporal normalization to predict neural responses and behavior over time
- Varying the attentional gain in the model changed the predicted behavioral performance for cued and uncued stimuli, which depended on the SOA between targets
- Temporal normalization incentivizes selective attentional selection between stimuli across time without requiring an explicit attentional resource parameter

References

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