A dynamic normalization model with temporal receptive fields captures perceptual and attentional trade-offs across time

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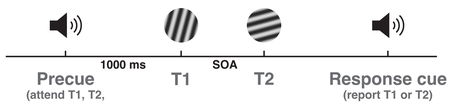
Background

- Temporal context preceding or following stimuli (e.g., stimulus onset asynchronies[1] or contrast[2]) and attention[3] can lead to trade-offs in processing sequential stimuli
- Temporal normalization, the idea that neural responses are divisively suppressed by activity at other times[4,5], offers a potential mechanism that could unify these findings
- Attention is known to interact with spatial normalization[6], but it is currently unknown how it might interact with temporal normalization

Question

Does temporal normalization capture trade-offs in perception across time due to stimulus contrast and attention?

Methods

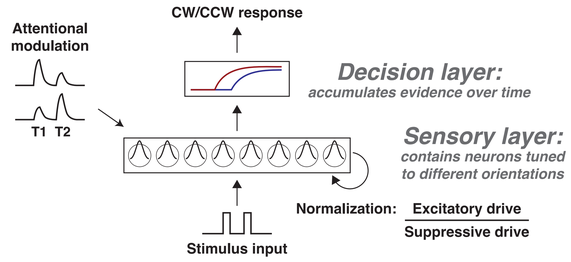


We simulated behavior in a two-target cueing paradigm[3], where the task was to report the clockwise or counterclockwise tilt of a target stimulus

Simulation 1: Precues were always neutral, SOA was fixed at 250 ms, contrast of each stimulus varied independently (high = 64%, low = 32%)

Simulation 2: Precues and SOAs varied, contrast was fixed

Normalization model of dynamic attention[1]



References

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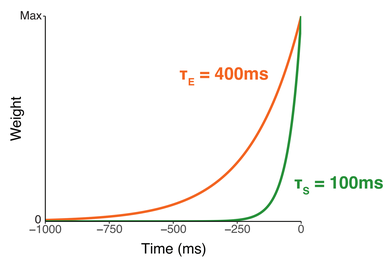
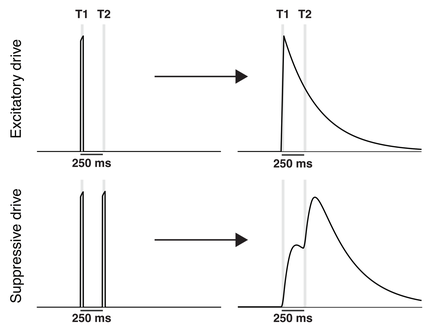
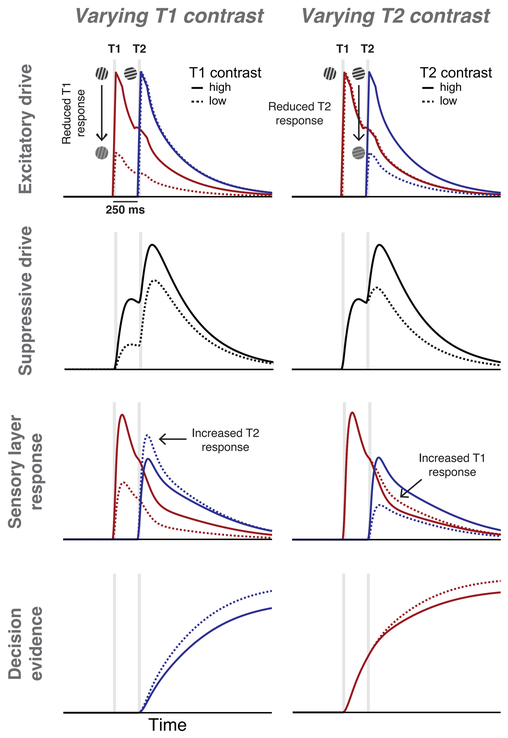
Simulation 1: Temporal normalization reproduces perceptual suppression of past and future stimuli

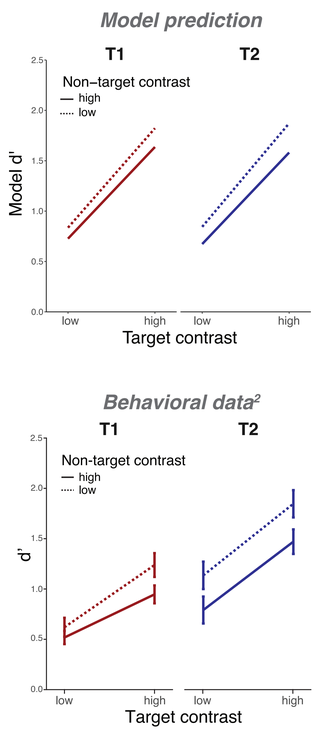
Temporal receptive fields extend excitatory and suppressive drives





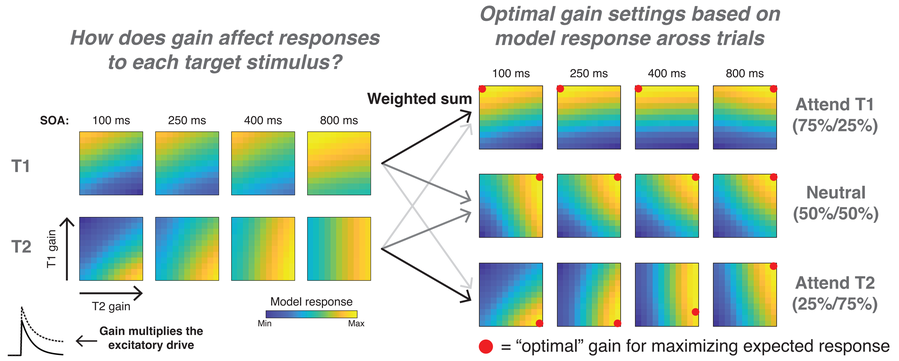
Temporal normalization affects the response to stimuli both forward and backward in time



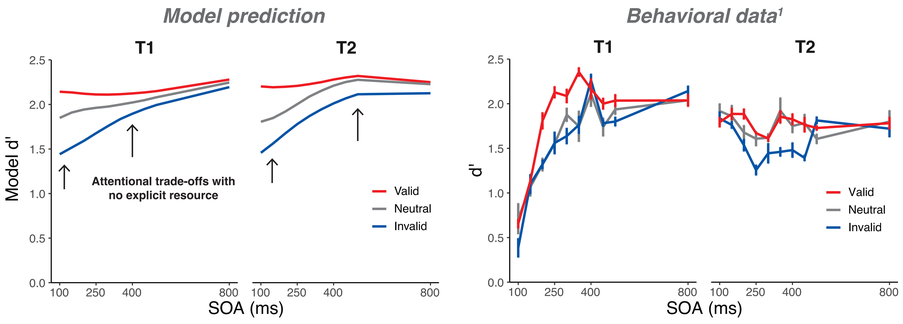


Simulation 2: Temporal normalization predicts attentional trade-offs without an explicit resource parameter

Temporal normalization induces trade-offs between stimuli at short-to-medium SOAs



Optimal gain under temporal normalization predicts attentional enhancement at early but not late SOAs



Conclusions

- Adding temporal windows to the Normalization Model of Dynamic Attention[1] allowed for interactions between responses to sequential stimuli
- Varying the contrast of stimuli in the model resulted in suppression of target stimuli when non-target contrast was high, replicating previous behavioral findings[2]
- Temporal normalization incentivizes trade-offs between stimuli across time without requiring an explicit attentional resource parameter
- **Dynamic normalization models can capture a range of perceptual and attentional phenomena**