Developing a Response Time Modeling Approach to Assess Cancer Cognition

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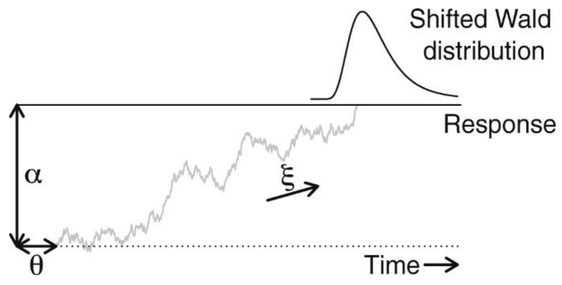
CRCD Measurement

Cancer-related cognitive decline (CRCD) can be debilitating, which can lead to deeper ramifications, including loss of social relationships, nonadherence to medication, and lower survival rates. To combat this detriment to survivor and patient quality-of-life, there has been a surge to understand what is causing CRCD, so we can create treatments (or even prevent) this dysfunction. However, there have been some notable concerns with the measurement of CRCD:

- Rate of CRCD incidence ranges from 15% - 75%, depending on the study
- Qualitative and quantitative measures frequently lack correlation
- The immense variability of assessments
- The reverse-inference problem

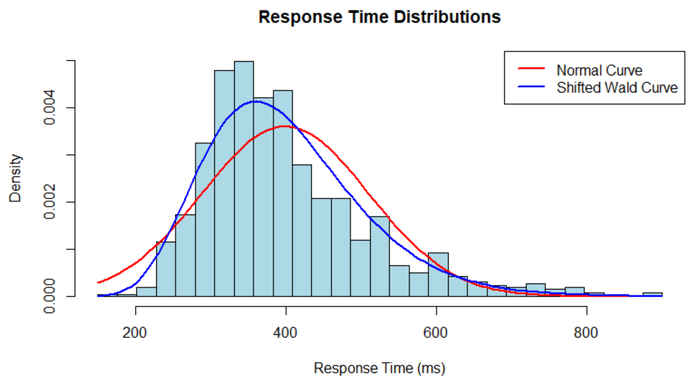
Response Time Modeling

Response time modeling is a technique that allows us to evaluate response times through the lens of the entire decision process. As Schwarz (2001) explained, "the decision to initiate and execute a specific overt response does not arise holistically, in an all-or-none fashion, but is rather preceded by a stage during which response-related information gradually accumulates over time."



Response time modeling offers many benefits, including:

1. Increased sensitivity (White et al., 2010)
2. Connect theory to data (Ratcliff et al., 2006)
3. Account for all behavioral data (better fitting models), including accuracy and error rates.



Could response time modeling help us capture minute changes in CRCD, such as those caused by inflammation and stress?

The Collaboration Project

In a collaboration with the HEAL team at UT-Health San Antonio, we plan to evaluate CRCI throughout a 6-month holistic, therapeutic yoga intervention. Throughout this study, cancer survivors will also receive dietary counseling and daily psychosocial support. At intervals throughout the 6-months, CRCD will be assessed with the following measures:

- Attention Network Test (ANT)
- Dual-N-Back (DNB) Task
- Open-Source Anticipated Response Inhibition (OSARI) Task
- PROMIS Functional Assessment of Cancer Therapy- Cognitive Function (FACT-Cog) Short Form

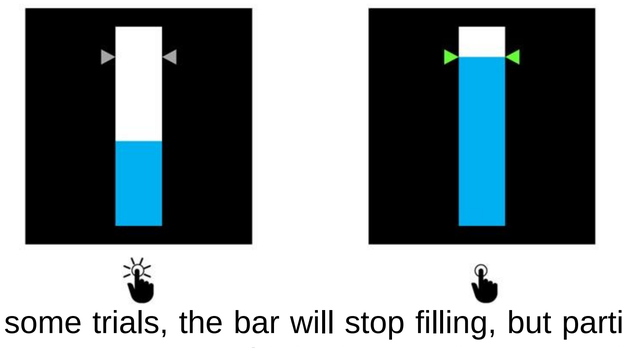
We will utilize response time modeling to longitudinally assess changes on the three response time tasks for each participant. In addition to evaluating the effectiveness of the intervention, we will assess the ability of response time modeling to capture changes in cognition driven by inflammation and stress.

The Current Study

To pilot our cognitive assessments and models, we evaluated changes in student cognition due to academic stress. At three time points (before, during, and after finals week), 15 students completed a cognitive task, a salivary cortisol kit, the Perceived Stress Scale-10 (PSS), and the RAND 36-Item Short Form (SF-36). The OSARI task was fit with an ex-Gaussian Stop-Signal model, and changes in parameters were assessed over the three time points.

The OSARI Task

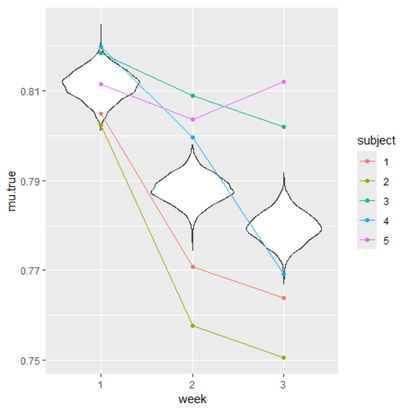
The OSARI is a computerized task designed to measure executive control. In this assessment, participants press a button to fill a bar until the point of threshold.



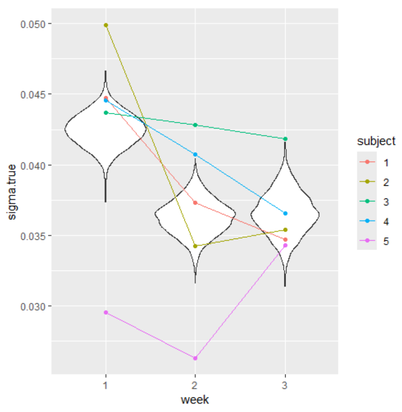
In some trials, the bar will stop filling, but participants must continue to hold the button, despite the impulse to release the bar. The accuracy and response times are recorded for all trials, and the data is fit with the EGSS model.

Results: Parameters

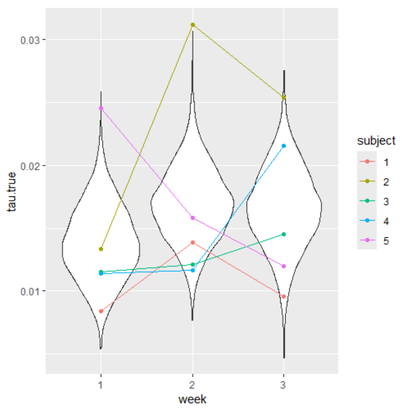
Mu (Go Trials)



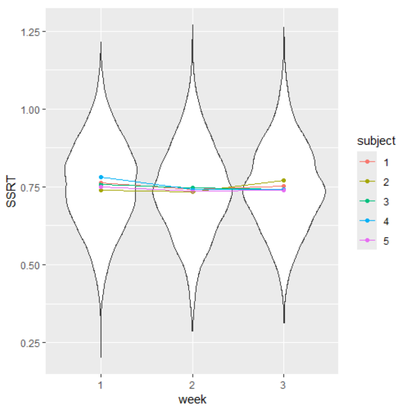
Sigma (Go Trials)



Tau (Go Trials)



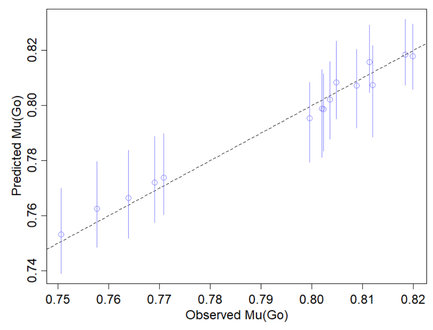
SSRT



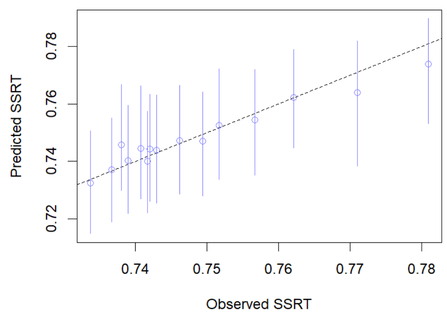
Results: Stress

The participants self-report measures were assessed with Bayesian mixed-effect models to evaluate how stress mediated changes in the cognitive parameters. The PSS and the SF-36 Emotional Wellbeing were used to represent stress in both mediation models. The posterior predictive distributions for both partial mediation models (the hypothesized models) are included below.

SSRT Posterior Predictive Distribution



Mu (Go Trials) Posterior Predictive Distribution



SSRT Models

Model	WAIC	SE	dWaic	dSE	pWAIC	weight
Time Only	**-87.6**	**2.08**	**0.00**	**NA**	**15.6**	**0.82**
Partial Mediation	-84.6	1.52	3.00	1.13	13.8	0.18
Full Mediation	-74.4	3.20	13.20	2.05	5.4	0.00

Mu (Go Trials) Models

Model	WAIC	SE	dWaic	dSE	pWAIC	weight
Time Only	**-102.6**	**1.26**	**0.00**	**NA**	**24.3**	**0.99**
Partial Mediation	-92.4	1.25	10.20	0.86	30.5	0.01
Full Mediation	-68.2	2.87	34.40	3.22	3.9	0.00

Discussion

These results illustrate that a modeling approach can successfully capture and predict changes in cognition. Surprisingly, stress did not seem to drive these changes, though there are many questions to be answered. Will the impact of stress change once cortisol is included? Did we capture a full range of stress within this timeframe?

Future Directions

As this project is ongoing, there is still much to do and learn about response time modeling for CRCD.

- Fitting ANT data with a shrinking spotlight model
- Evaluating changes in workload capacity after fitting the DNB with a linear ballistic accumulator model
- Assessing how cortisol relates to changes in the cognition parameters
- Implementing response time modeling with cancer survivors
- Determining how inflammatory biomarkers drive changes in cognition parameters
- Implementing response time modeling with other CRCD assessments
- Comparing traditional techniques to response time modeling

For references, contact information, and code, please see QR code. Questions, collaborations, and ideas are always welcome.