Measurement of Executive Functions with Conflict Tasks: Implications for Alcohol Research

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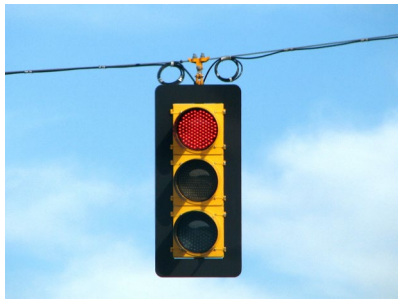
It Is Widely Thought that Substance Use Disorders Involve Reduced "Top-Down Control"

"Top-down control" is the ability to suppress an automatic response tendency and it goes by many names

inhibition
cognitive control
executive control
inhibitory control
impulse control/self-control



Top-down control is an "executive function"

Classic "triad" view → Top-down control/Inhibition
Task Switching
Working Memory Updating

It is often measured with "conflict tasks"

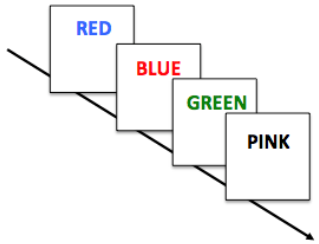
Miller, E. K., & Cohen, J. D. (2001)
Nigg, J. T. (2000)

Miyake, A., et al.: A Latent Variable Analysis. *Cognitive Psychology*, *41*, 49–100.

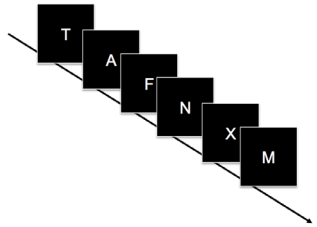
Conflict Tasks Pit Spontaneous, Automatic Response Tendencies Against Contextually-Appropriate Responses

Conflict Tasks

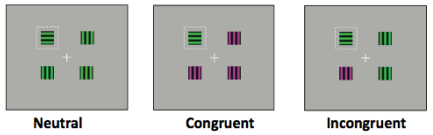
Stroop Task



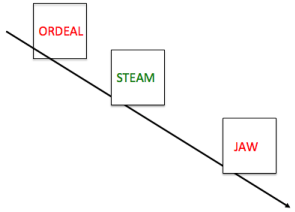
Go/NoGo Task



Distractor Task

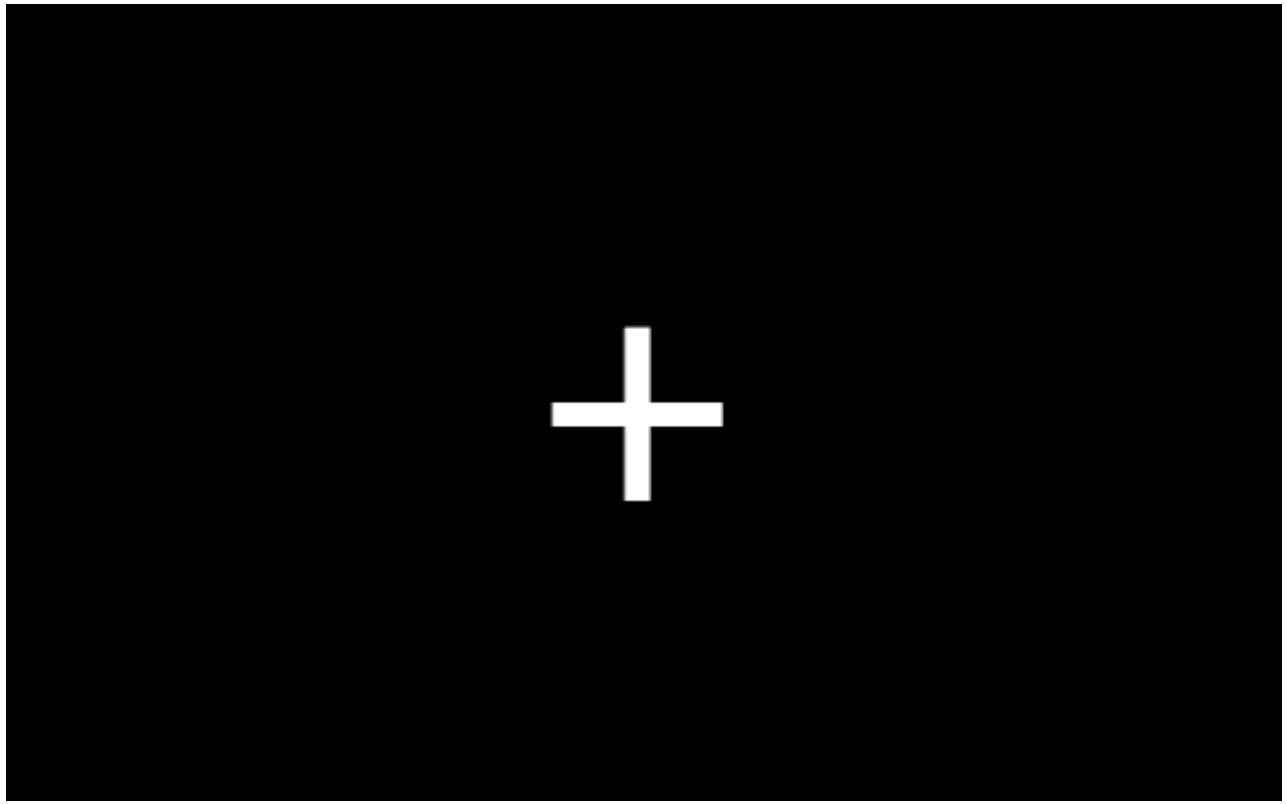


Think/NoThink Task



Stroop Task

"Say the ink color of each word"



Stroop, J. R. (1935b). Studies of interference in serial verbal reactions. JournalofExperimental Psychology,18,643-662.
MacLeod, C. M. (1991) 'Half a century of research on the Stroop effect: an integrative review', *Psychological Bulletin*, 109(2), pp. 163–203.

Conflict Tasks Are Standardly Analyzed With “Difference Metrics”

Stroop “name the ink color of the word”:

INCONGRUENT

Red

incongruent reaction time

1 automatic word reading response 

2 executive process to suppress automatic word reading response 

CONGRUENT

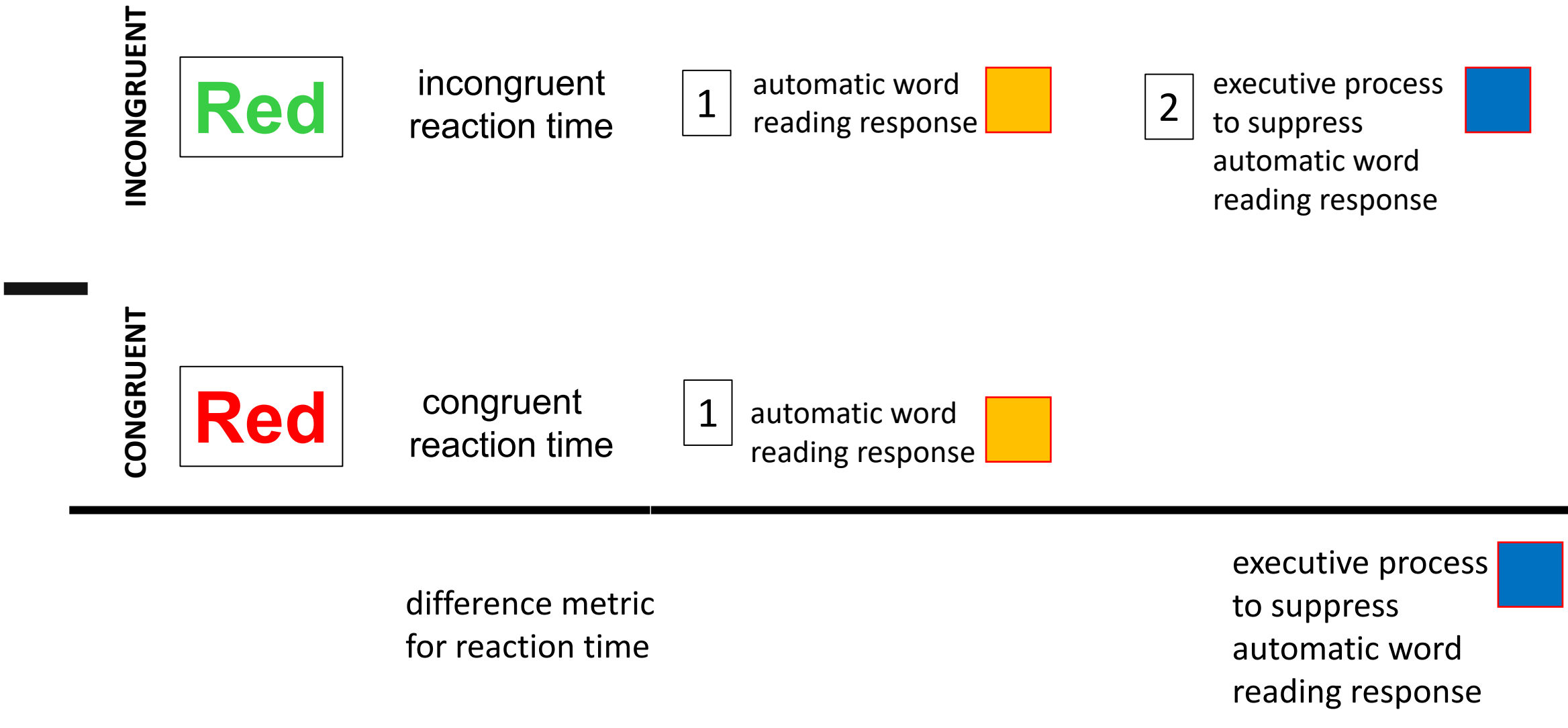
Red

congruent reaction time

1 automatic word reading response 

Conflict Tasks Are Standardly Analyzed With “Difference Metrics”

Stroop “name the ink color of the word”:



There Are Numerous Studies Attempting to Examine Individual Differences in Conflict Task Performance and Link These Differences to Substance Use Disorders Including Alcohol Use Disorders

Deficits in behavioural inhibition in substance abuse and addiction: A meta-analysis

Janette L. Smith [a], Richard P. Mattick [a], Sharna D. Jamadar [b], Jaimi M. Iredale [a]

Is (poly-) substance use associated with impaired inhibitory control? A mega-analysis controlling for confounders

Yang Liu [a b], Wery P.M. van den Wildenberg [a c], Ysanne de Graaf [d], Susan L. Ames [e], Alexander Baldacchino [f], Ragnhild Bø [g], Fernando Cadaveira [h], Salvatore Campanella [i], Paul Christiansen [j], Eric D. Claus [k], Lorenza S. Colzato [l], Francesca M. Filbey [m], John J. Foxe [n], Hugh Garavan [o], Christian S. Hendershot [p], Robert Hester [q], Jennifer M. Jester [r], Hollis C. Karoly [s], Anja Kräplin [t], Fanny Kreusch [u]… Reinout W. Wiers [a b 1]

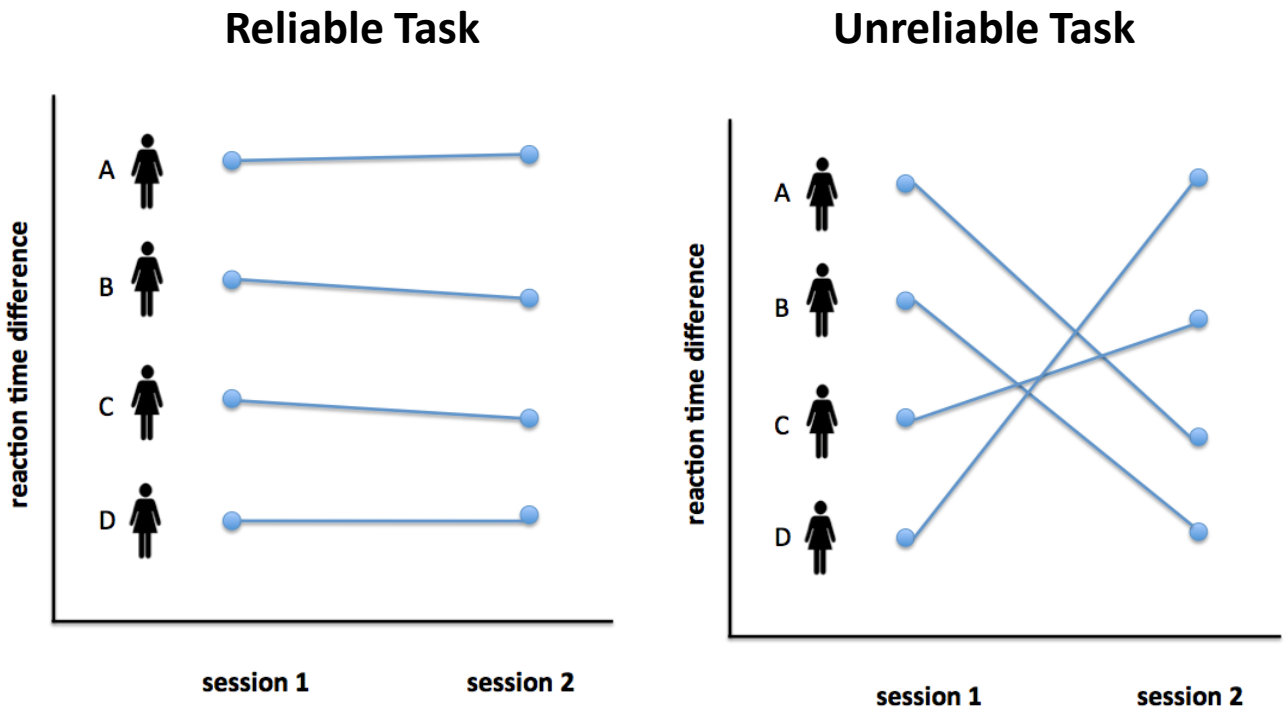
Inhibitory Control Deficits in Childhood and Risk for Substance Use Disorders: A Review

Iliyan Ivanov , M.D., Kurt P. Schulz , Ph.D., Edythe D. London , Ph.D. & Jeffrey H. Newcorn , M.D.

However, recent work shows conflict tasks lack basic psychometric properties needed to serve as effective individual difference metrics! They lack:

Test-Retest Reliability
Cohesiveness Across Tasks (Convergent Validity)
Predictive Validity

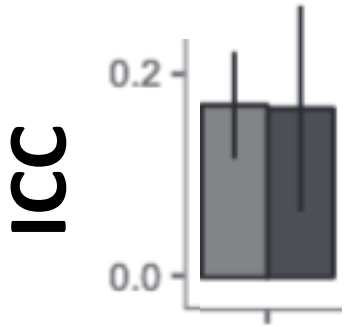
Conflict Task Difference Metrics Have Poor Test-Retest Reliability



PNAS

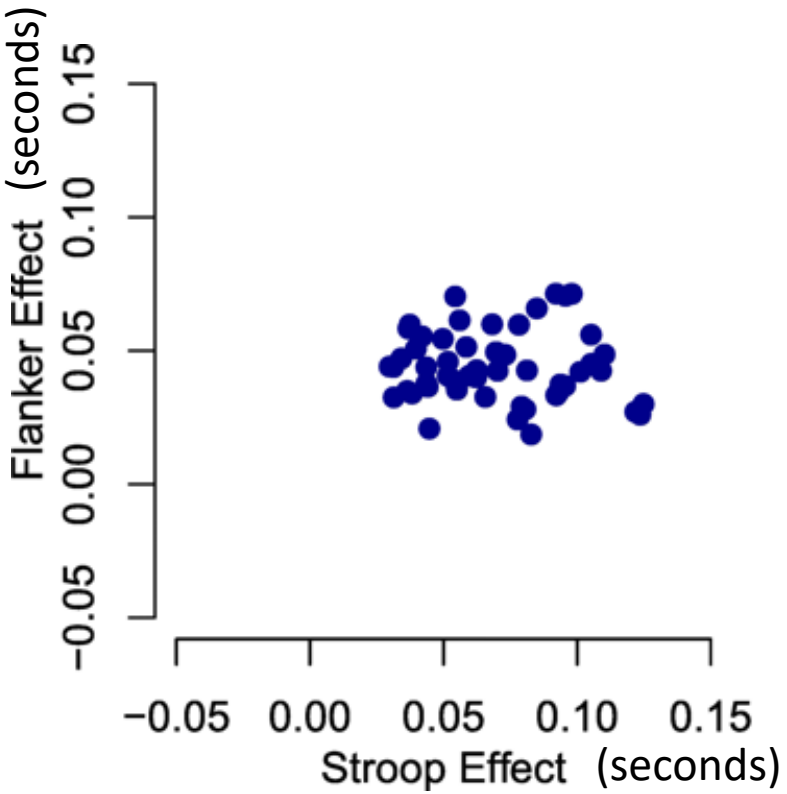
Large-scale analysis of test–retest reliabilities of self-regulation measures

A. Zeynep Enkavi[a,1], Ian W. Eisenberg[a], Patrick G. Bissett[a], Gina L. Mazza[b], David P. MacKinnon[c], Lisa A. Marsch[d], and Russell A. Poldrack[a]

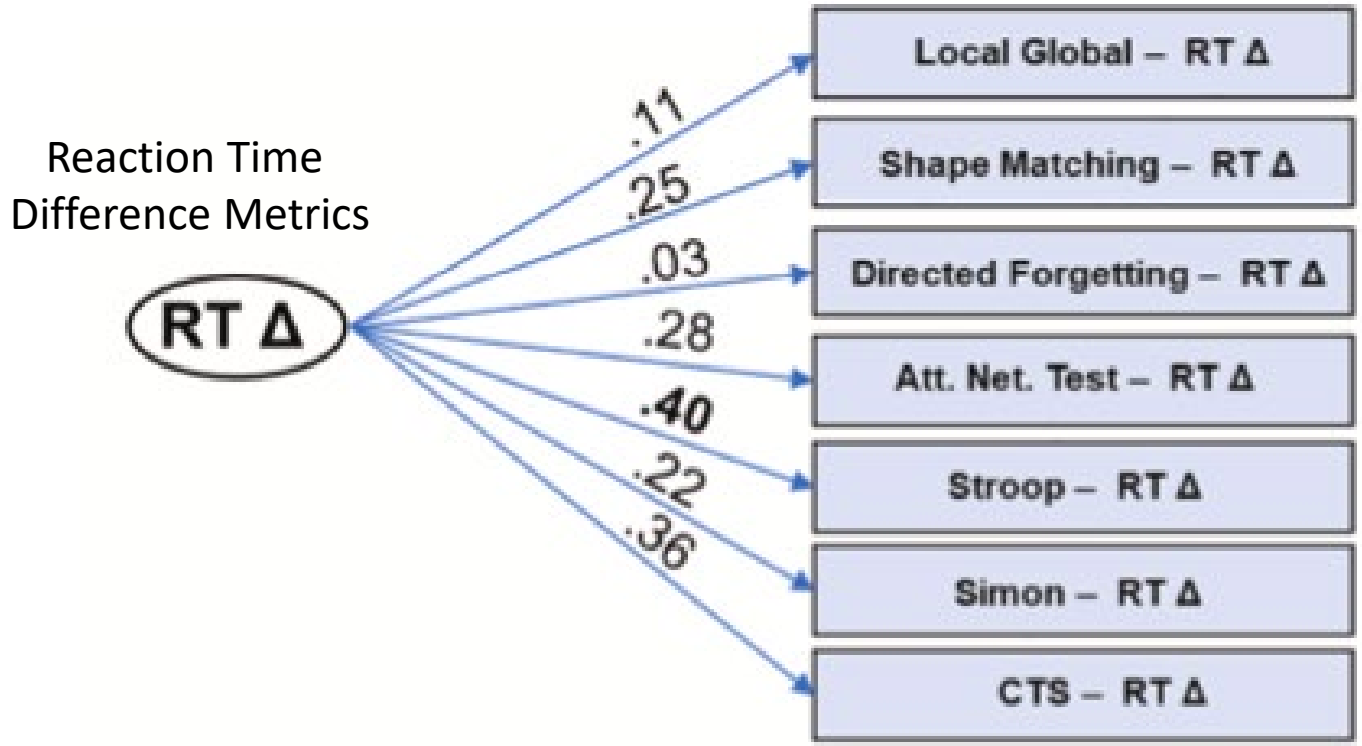


Enkavi et al., 2019; Hedge et al., 2018, Weigard, Clark, and Sripada (2021)

Conflict Tasks Difference Metrics Are Not Cohesive Across Theoretically Similar Tasks



Rouder, J. N., & Haaf, J. M. (2019)

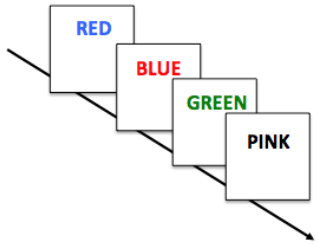


Weigard, Clark, and Sripada (2021)

See also Rey-Mermet et al., 2019; Hedge et al., 2018a & 2018b

Conflict Tasks Difference Metrics Have Poor Predictive Validity. They Fail to Predict the Things They Are Supposed to Predict

Stroop Task



Self-Report Scales

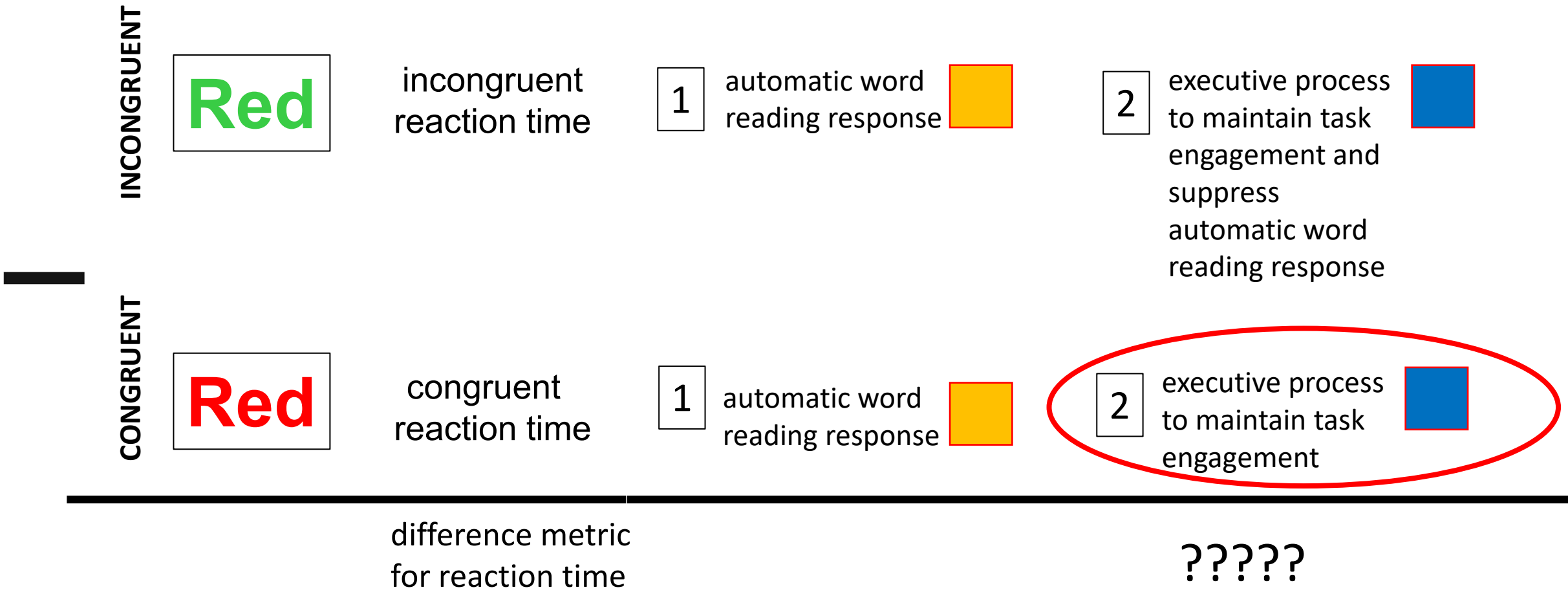
	Strongly Disagree	Somewhat Disagree	No Opinion	Somewhat Agree	Strongly Agree
I am easygoing.	O	O	O	O	O
I have high standards.	O	O	O	O	O
I enjoy time alone.	O	O	O	O	O
I work well with others.	O	O	O	O	O
I dislike confrontation.	O	O	O	O	O
I prefer crowds over intimacy.	O	O	O	O	O

Clinician-Diagnosed Psychopathology

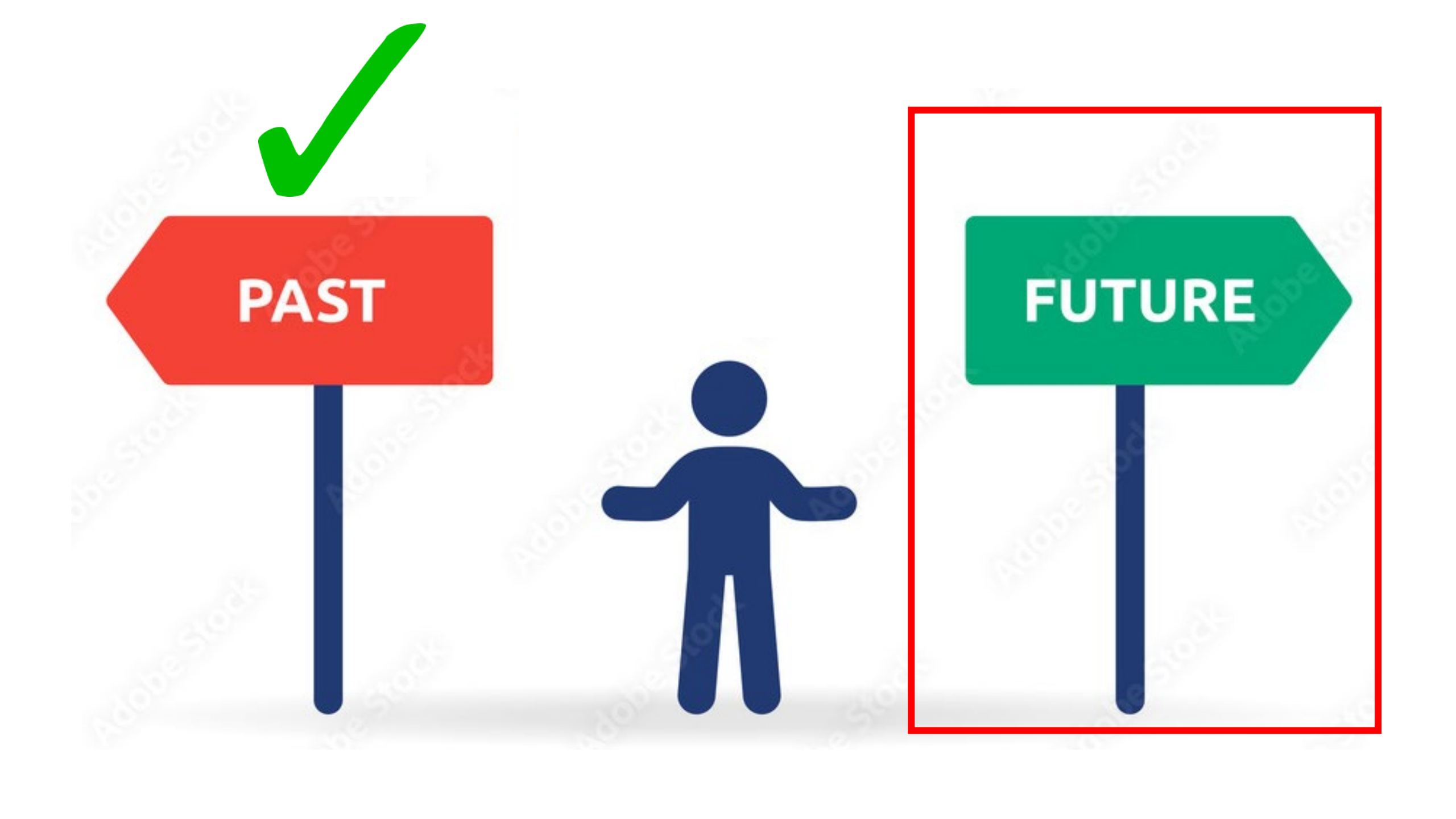
Duckworth, A. L. & Kern, M. L. (2011), Saunders et al., 2018, Eisenberg et al., 2019, Sripada & Weigard (2020)

What Explains the Failure of Difference Metrics? Our Hypothesis: The Failure of the "Assumption of Pure Insertion"

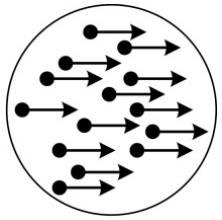
Stroop "name the ink color of the word":



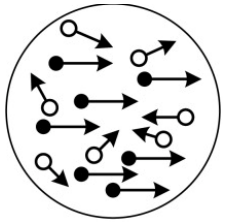
Weigard, Clark, and Sripada (2021)


PAST
FUTURE

Evidence Accumulation Models Have Emerged as a Preeminent Approach for Studying the Generative Processes Underlying Task Responses



Which direction are the dots moving?



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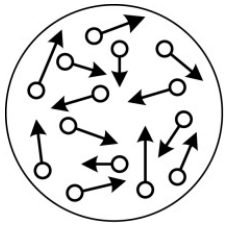

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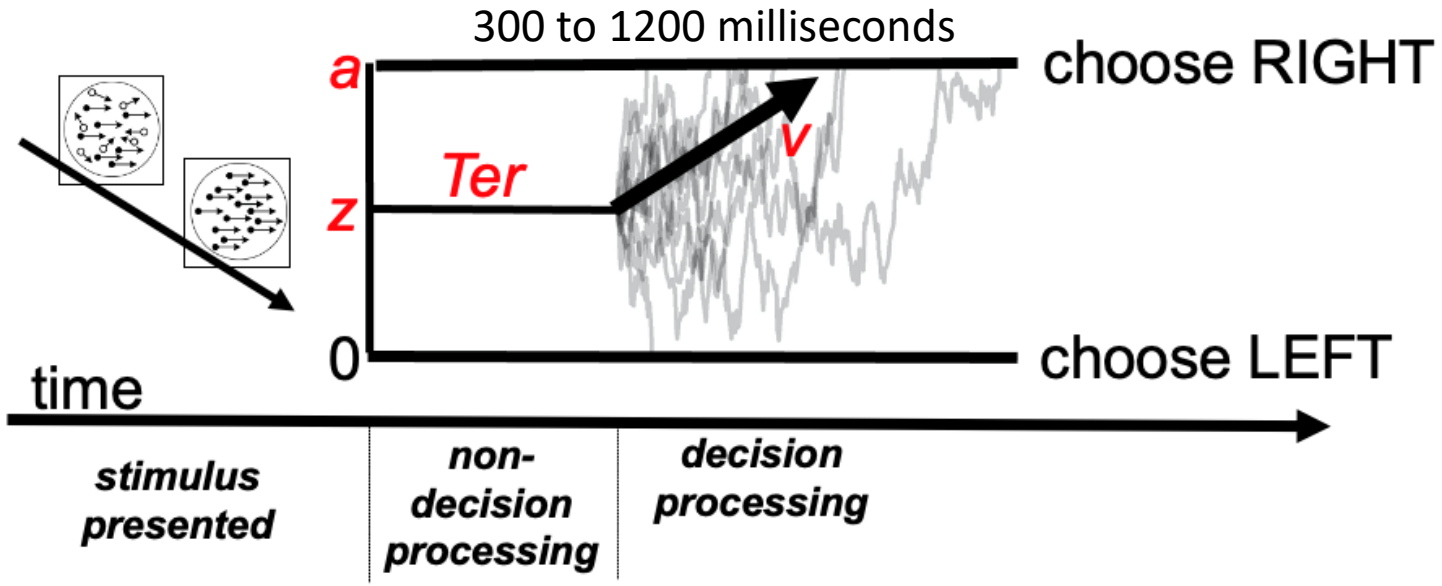


A decision variable (noisy gray traces) evolves to a decision boundary based on noisy evidence.

Key Parameters of the Model

v – drift rate, strength of evidence favoring a response

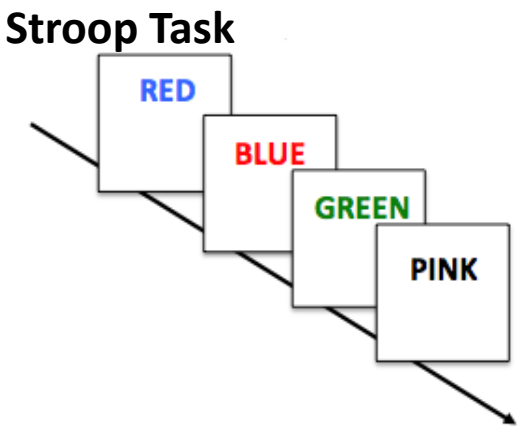
z – start point bias

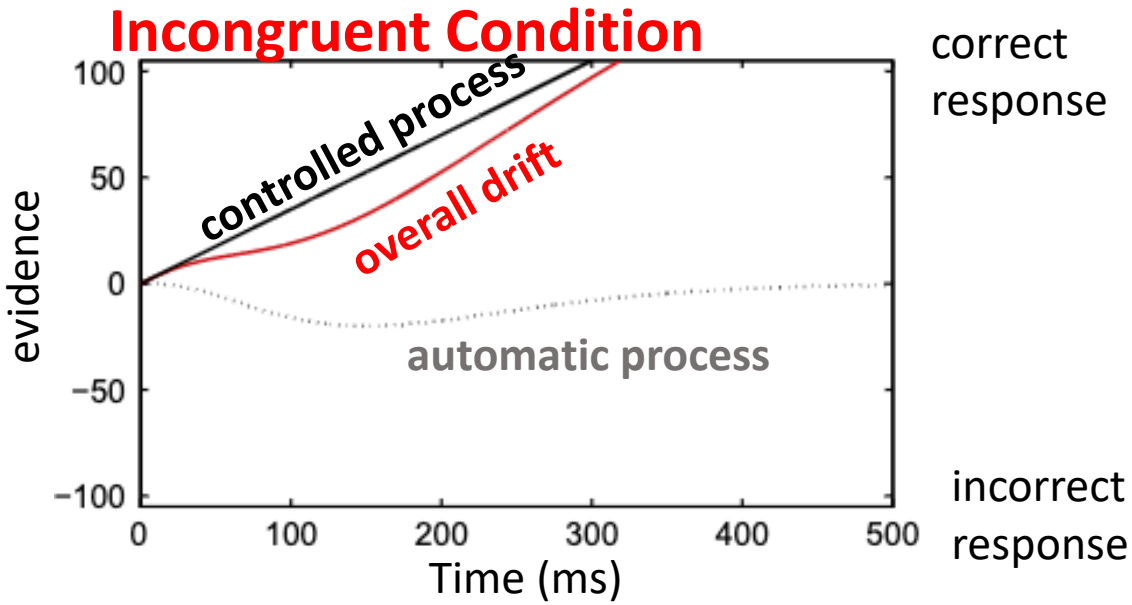
a – threshold, which reflects response caution

ter – non-decision time

Ratcliff R (1978). *Psychological review* 85: 59.
Usher M, McClelland JL (2001) *Psychological review* 108: 550.
Brown SD, Heathcote A (2008). Cognitive Psychology 57: 153–178.
Gold JI, Shadlen MN. (2007). Annual review of neuroscience. 30.

Evidence Accumulation Models Can Be Extended to Conflict Tasks

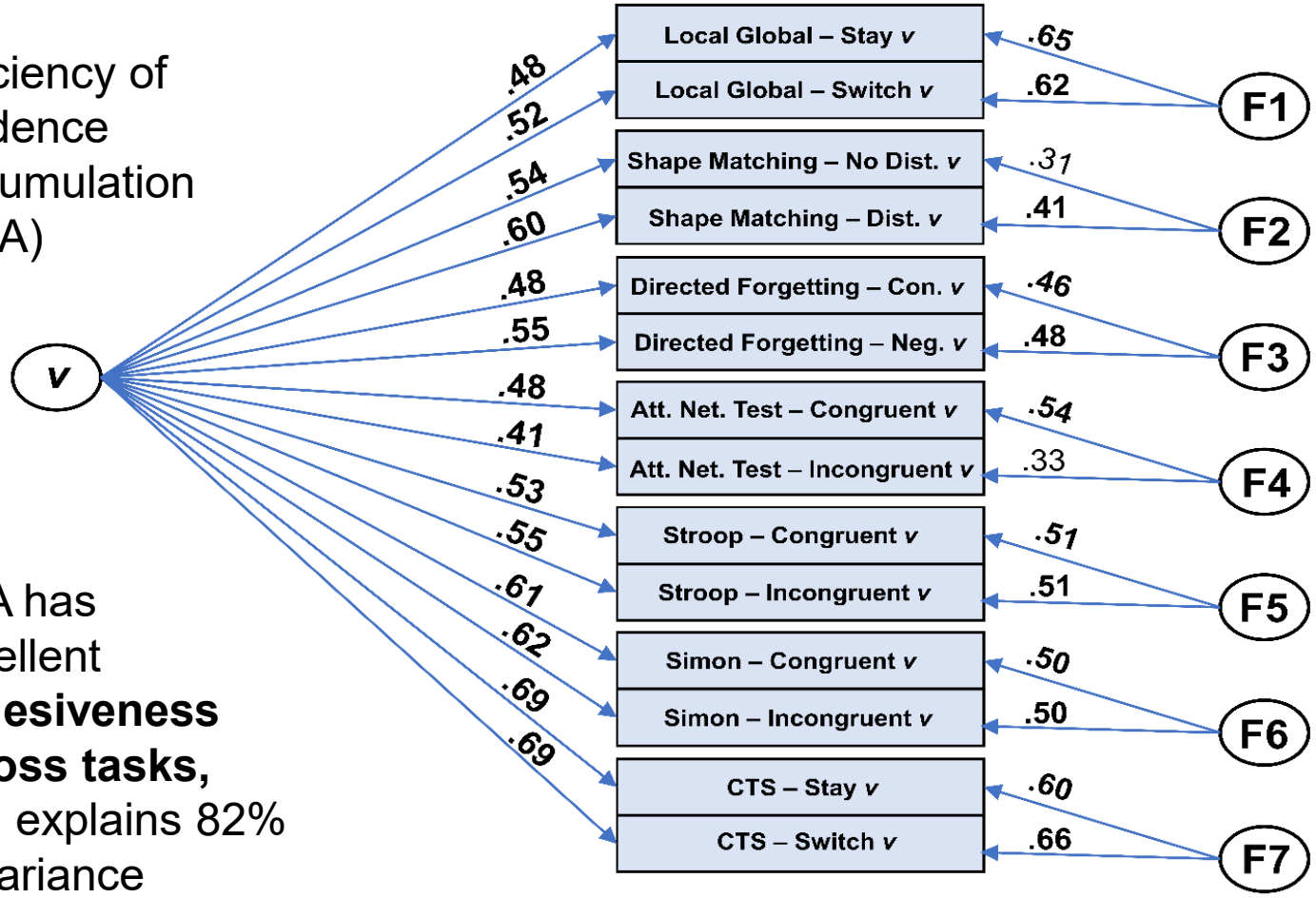




Ulrich, R., Schröter, H., Leuthold, H. & Birngruber, T. 2015

Efficiency of Evidence Accumulation (EEA) Exhibits Has Strong Cohesiveness, Test-Retest Reliability, and Predictive Validity

Efficiency of Evidence Accumulation (EEA)



EEA has excellent **cohesiveness across tasks, and** explains 82% of variance across tasks

Weigard, Clark, and Sripada (2021)

EEA has good to excellent **test-retest reliability**

0.78-081 ICC

2nd session 2-8 months after first)

EEA has good **predictive validity**

Lower EEA linked to psychiatric disorders:

- Substance use
- ADHD
- Schizophrenia
- Bipolar Disorder

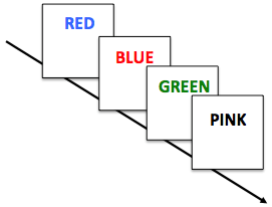
Heathcote et al., 2015; Huang-Pollock et al., 2020; Weigard et al., 2019; Ziegler et al., 2016; Weigard et al., 2021, Sripada and Weigard 2020, Weigard, Clark, and Sripada 2021

Summary

It is widely thought that substance use disorders involve reduced "top-down control"

"Top-Down" control is measured with conflict tasks, which are standardly analyzed with "difference metrics"

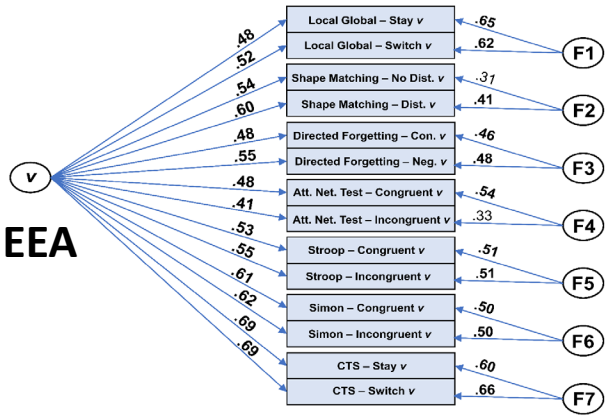
Stroop Task



However, the "difference metric" approach has very poor psychometric properties

- Poor test-retest reliability
- Poor cohesiveness across tasks
- Poor predictive validity

These problems can be remedied by adopting a computational approach that focuses on task-general efficiency of evidence accumulation (EEA)

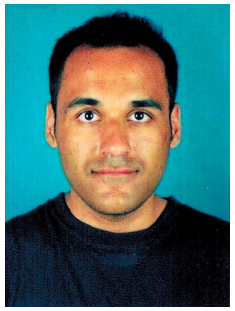


Future studies should systematically examine links between EEA and alcohol use disorders

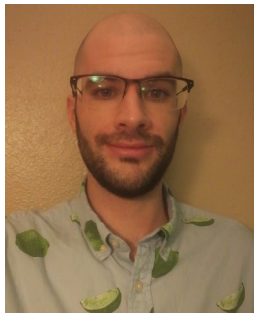
Thanks to my collaborators:

Alex Weigard

Mike Angstadt



Aman Taxali



David Clark

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-R01 MH123458

The End