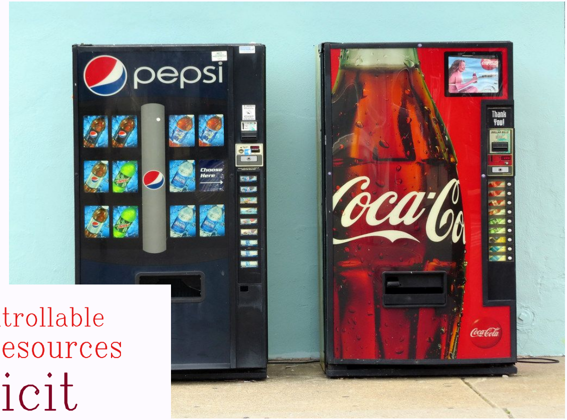
Filling the gap between implicit and behavior: A Rasch modeling of the Implicit Association Test

Ottavia M. Epifania, Anselmi Pasquale, Egidio Robusto

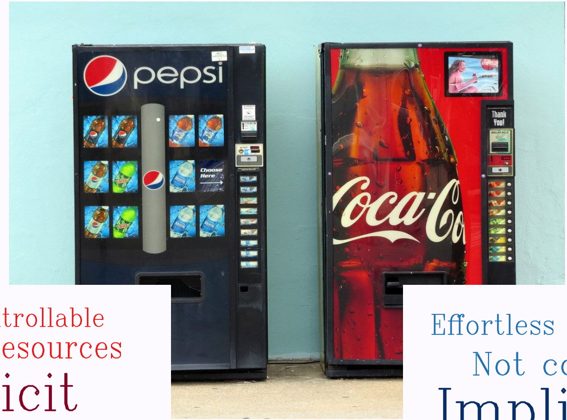
University of Padova, Italy

Cognitive Science Arena,
Bressanone-Brixen,
February 7th-9th 2020


pepsi
Choose Here
Thank You!
Coca-Cola



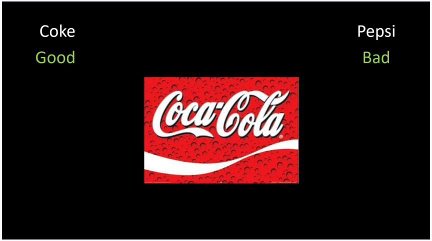
Controllable
Cognitive resources
Explicit
Deliberate



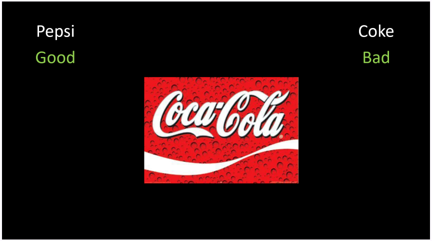
Controllable
Cognitive resources
Explicit
Deliberate

Effortless
Not controllable
Implicit
Automatic

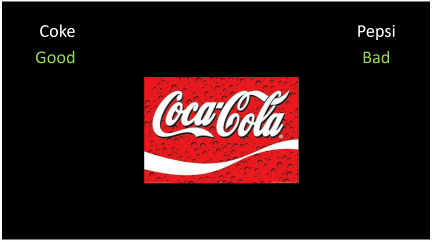
Coke Good/Pepsi Bad (CGPB)



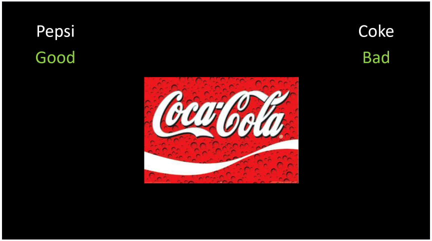
Pepsi Good/Coke Bad (CGPB)



Coke Good/Pepsi Bad (CGPB)



Pepsi Good/Coke Bad (CGPB)



$$Dscore = \frac{M_{\text{cgpb}} - M_{\text{pgcb}}}{s_{\text{cgpb,pgcb}}}$$

Predictive Ability

D-score has a low predictive ability of behavioral outcomes

Predictive Ability

D-score has a low predictive ability of behavioral outcomes

Type of behavior

Deliberate vs Non-deliberate

Predictive Ability

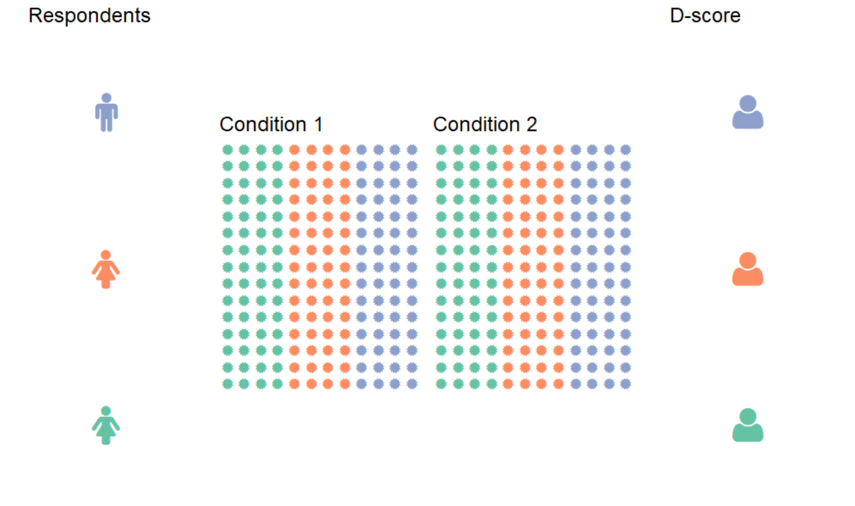
D-score has a low predictive ability of behavioral outcomes

Type of behavior

Deliberate vs Non-deliberate

Computation

IAT data structure completely ignored


Respondents
D-score
Condition 1
Condition 2

Linear Mixed Effect Models (LMMs) allow for:

- Accounting for (potentially) all the sources of variability and dependency
- Gathering information at the stimuli level
- Estimating Rasch and Log-normal models parameters

Investigate the predictive ability of the IAT

Investigate the predictive ability of the IAT

D-score

Rasch and Log-normal model estimates

Investigate the predictive ability of the IAT

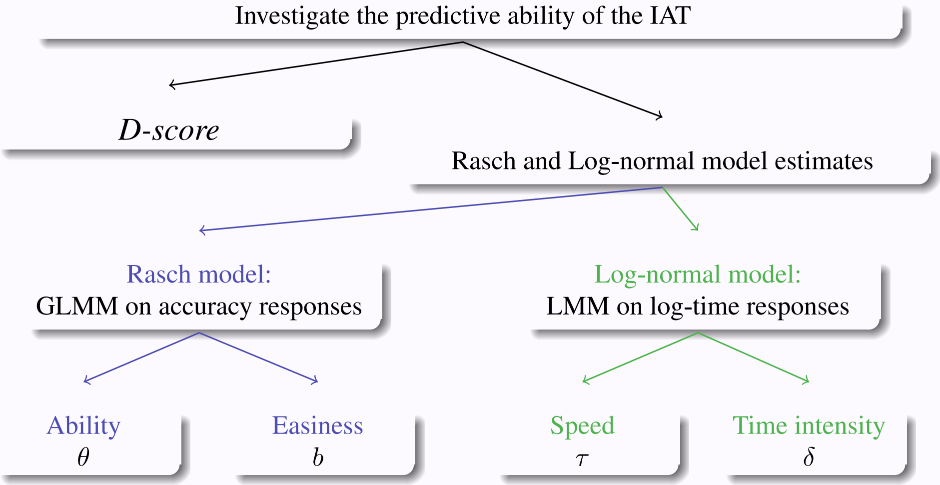
D-score

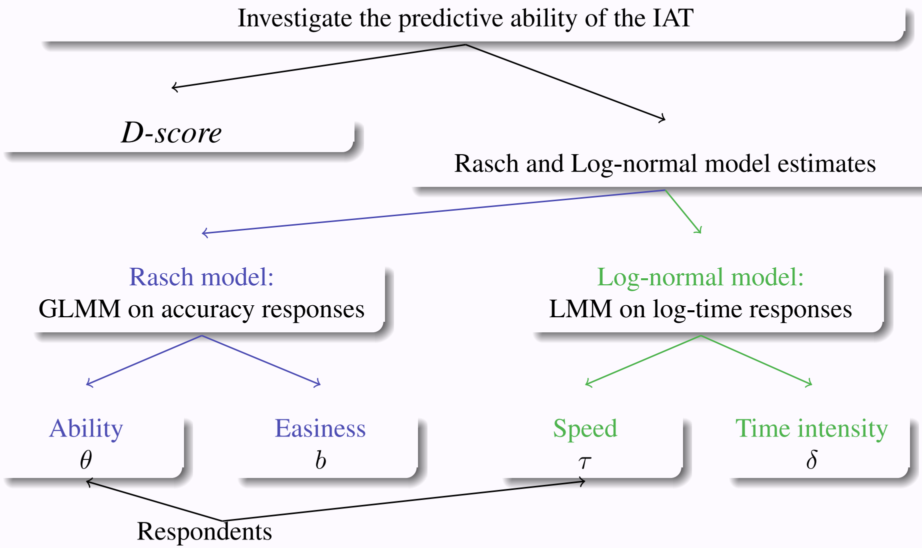
Rasch and Log-normal model estimates

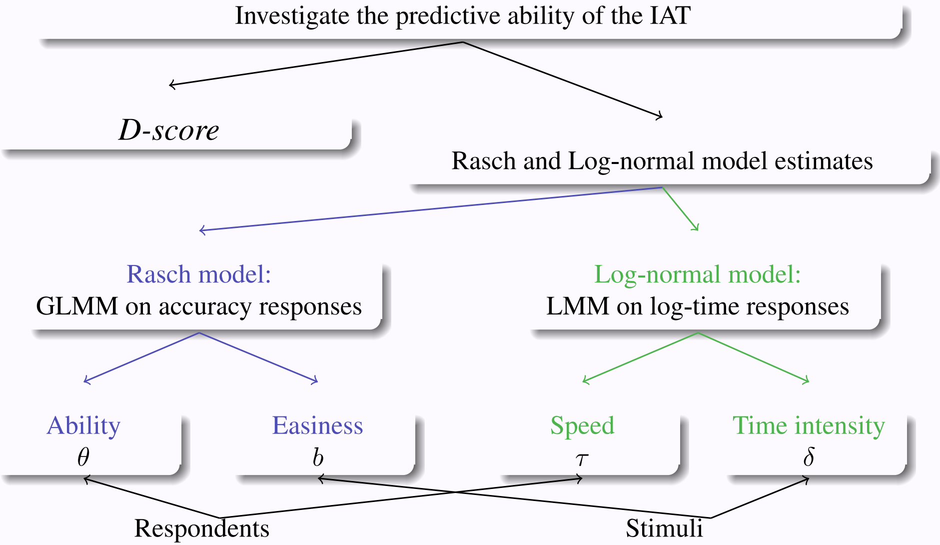
Rasch model:
GLMM on accuracy responses

Ability
θ

Easiness
b


Investigate the predictive ability of the IAT
D-score
Rasch and Log-normal model estimates
Rasch model:
GLMM on accuracy responses
Log-normal model:
LMM on log-time responses
Ability
θ
Easiness
b
Speed
τ
Time intensity
δ


Investigate the predictive ability of the IAT
D-score
Rasch and Log-normal model estimates
Rasch model:
GLMM on accuracy responses
Log-normal model:
LMM on log-time responses
Ability
θ
Easiness
b
Speed
τ
Time intensity
δ
Respondents


Investigate the predictive ability of the IAT
D-score
Rasch and Log-normal model estimates
Rasch model:
GLMM on accuracy responses
Log-normal model:
LMM on log-time responses
Ability
θ
Easiness
b
Speed
τ
Time intensity
δ
Respondents
Stimuli

The expected response y for the observation $i = 1, \dots, I$ for respondent $j = 1, \dots, J$ on stimulus $k = 1, \dots, K$ in condition $l = 1, \dots, L$:

Model 1:

$$y_i = logit^{-1}(\alpha + \beta l_i + \alpha_{k[i]} + \beta_{j[i]} l_i + \epsilon_i)$$

$\alpha_k \sim \mathcal{N}(0, \sigma_k^2)$, between–stimuli variability.
$\beta_l \sim \mathcal{MVN}(0, \Sigma_l)$, within–respondents between–conditions variability

Model 2:

$$y_i = logit^{-1}(\alpha + \beta l_i + \alpha_{j[i]} + \beta_{k[i]} l_i + \epsilon_i)$$

$\alpha_j \sim \mathcal{N}(0, \sigma_j^2)$, between–respondents variability.
$\beta_k \sim \mathcal{MVN}(0, \Sigma_l)$, within–stimuli between–conditions variability.

Model 3:

$$y_i = logit^{-1}(\alpha + \beta l_i + \alpha_{j[i]} + \alpha_{k[i]} + \epsilon_i)$$

$\alpha_j \sim \mathcal{N}(0, \sigma_j^2)$, between–respondents variability.
$\alpha_k \sim \mathcal{N}(0, \sigma_k^2)$, between–stimuli variability.

Accuracy: $\epsilon \sim \mathcal{L}(0, \sigma^2)$
Log-time: $\epsilon \sim \mathcal{N}(0, \sigma^2)$

Fixed Effects

Accuracy model (Rasch Model estimates):

	Respondents parameters	**Stimuli parameters**
Model 1	Condition–specific (θ_{jl})	Overall (b_k)
Model 2	Overall (θ_j)	Condition–specific (b_{kl})
Model 3	Overall (θ_l)	Overall (b_k)

Log-time model (Log-normal Model estimates):

	Respondents parameters	**Stimuli parameters**
Model 1	Condition–specific (τ_{jl})	Overall (δ_k)
Model 2	Overall (τ_j)	Condition–specific (δ_{kl})
Model 3	Overall (τ_j)	Overall (δ_k)

Method

Valenced words

- Positive words (n = 13): good, laughter, pleasure, glory, peace, happiness, joy, love, marvelous, beautiful, excellent, paradise, wonderful
- Negative words (n = 13): evil, bad, horrible, terrible, annoying, pain, failure, hate, nasty, disaster, agony, ugly, disgust

Chocolate images (Milk = 7, Dark = 7)

Behavioral choice at the end of the experiment

Participants: 74 (F $= 71.62\%$, Age = 24.08 ± 2.88 years), $I_{jl} = 60$

Results

	Accuracy			Response times		
Model	AIC	BIC	Deviance	AIC	BIC	Deviance
1	Failed to converge			7159.23	7208.87	7145.23
2	3625.58	3668.13	3613.58	Aberrant estimates		
3	3627.71	3656.07	3619.71	7856.45	7891.91	8875.00

	Accuracy			Response times		
Model	AIC	BIC	Deviance	AIC	BIC	Deviance
1	Failed to converge			7159.23	7208.87	7145.23
2	3625.58	3668.13	3613.58	Aberrant estimates		
3	3627.71	3656.07	3619.71	7856.45	7891.91	8875.00

Accuracy model:
Model 2

- b_{dgmb}: Stimuli easiness in Dark-Good/Milk-Bad Condition.
- b_{mgdb}: Stimuli easiness in Milk-Good/Dark-Bad Condition.
- Overall participants' ability (θ_j), across stimuli/conditions.

Model	Accuracy AIC	Accuracy BIC	Accuracy Deviance	Response times AIC	Response times BIC	Response times Deviance
1	Failed to converge			7159.23	7208.87	7145.23
2	3625.58	3668.13	3613.58	Aberrant estimates		
3	3627.71	3656.07	3619.71	7856.45	7891.91	8875.00

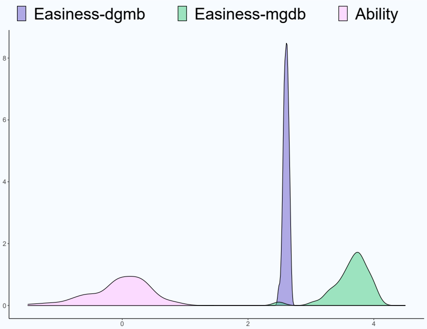
Accuracy model:
Model 2

- b_{dgmb}: Stimuli easiness in Dark-Good/Milk-Bad Condition.
- b_{mgdb}: Stimuli easiness in Milk-Good/Dark-Bad Condition.
- Overall participants' ability (θ_j), across stimuli/conditions.

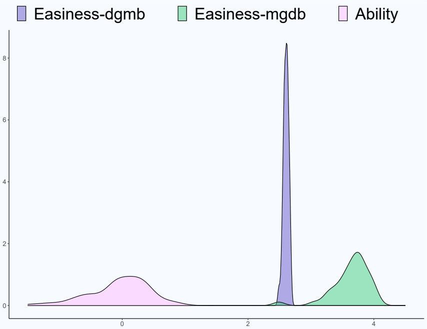
Log-time model:
Model 1

- τ_{dgmb}: Participants' speed in Dark-Good/Milk-Bad Condition.
- τ_{mgdb}: Participants' speed in Milk-Good/Dark-Bad Condition.
- Overall stimuli time intensity (δ_k), across participants/across conditions.

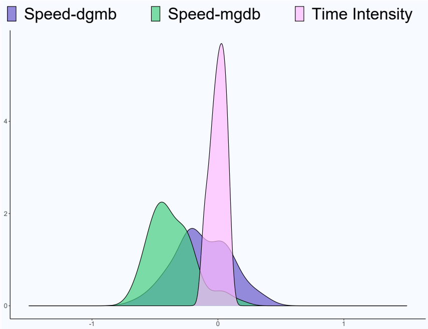
Rasch model:



Rasch model:



Log-normal model:



Dark Chocolate Choice (DCC) = 0

Milk Chocolate Choice (MCC) = 1

Differential measures:

Choice $\sim$ *D-score*

Choice $\sim$ *Speed-differential*

Single components:

Choice $\sim M_{\text{dgmb}} + M_{\text{mgdb}}$

Choice $\sim \tau_{\text{dgmb}} + \tau_{\text{mgdb}}$

$\textit{speed-differential} = \tau_{\text{dgmb}} - \tau_{\text{mgdb}}$

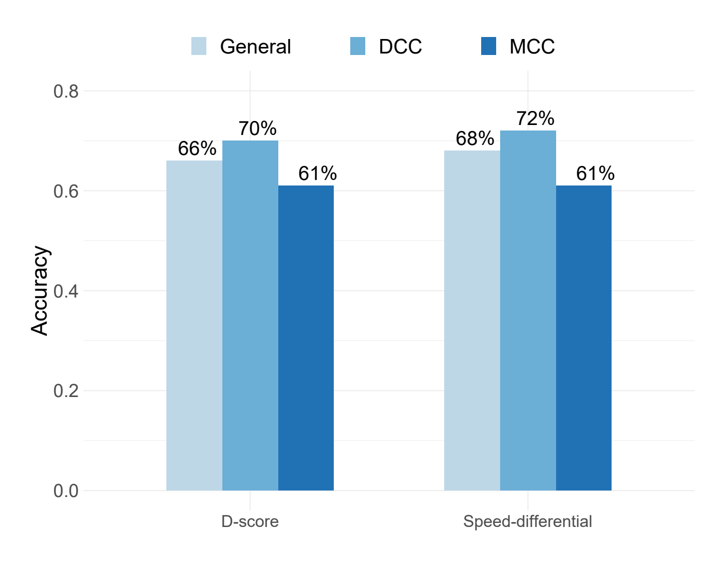
		Expected			
		Dark	Milk		
Observed	Dark	a	b	$a+b$	DCCs
	Milk	c	d	$c+d$	MCCs
		$a+c$	$b+d$		

$\frac{a+d}{a+b+c+d}$ **General Accuracy** (i.e., ratio between model correctly identified choices and total number of choices)

$\frac{a}{a+b}$ **DCC Accuracy** (i.e., ratio between model correctly identified DCCs and observed number of DCCs)

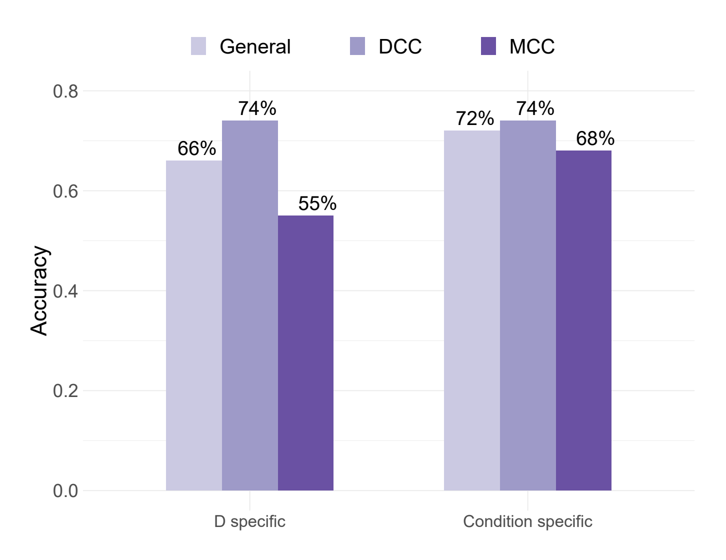
$\frac{d}{c+d}$ **MCC Accuracy** (i.e., ratio between model correctly identified MCCs and observed number of MCCs)

Differential measures



Nagelkerke R^2 0.19 0.20

Single components

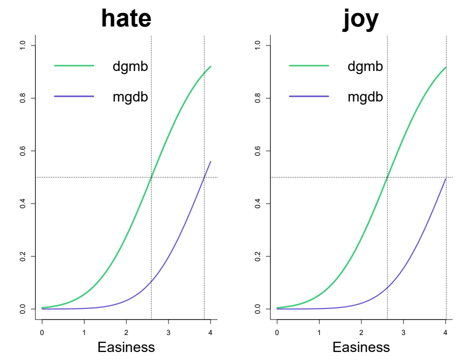


Nagelkerke R^2	0.21	0.20

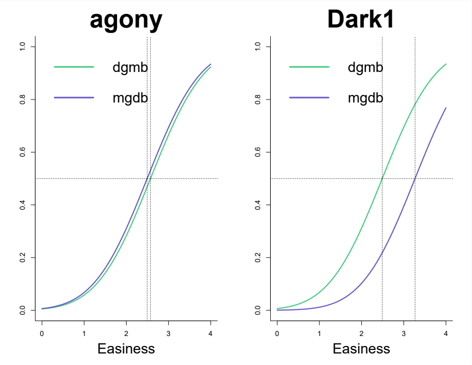
Not over yet!

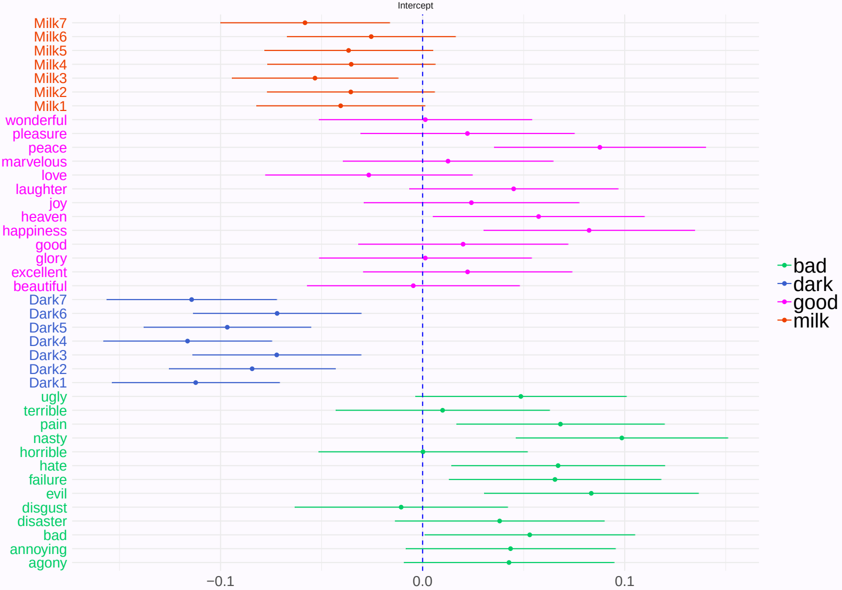
Item Characteristic Curves (ICC)

High contribution stimuli



Low contribution stimuli




Intercept
Milk7
Milk6
Milk5
Milk4
Milk3
Milk2
Milk1
wonderful
pleasure
peace
marvelous
love
laughter
joy
heaven
happiness
good
glory
excellent
beautiful
Dark7
Dark6
Dark5
Dark4
Dark3
Dark2
Dark1
ugly
terrible
pain
nasty
horrible
hate
failure
evil
disgust
disaster
bad
annoying
agony
−0.1
0.0
0.1
bad
dark
good
milk

Conclusions

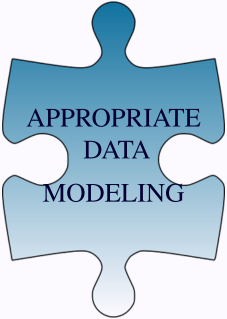
IAT functioning & meaning

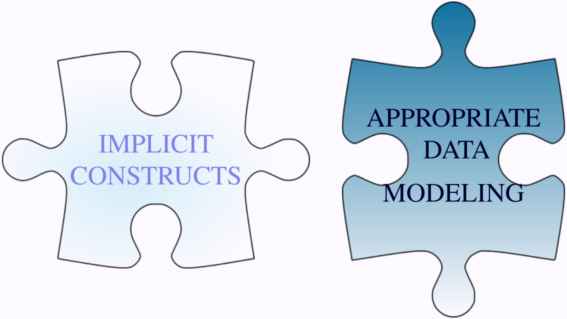
Fine-grained analysis:

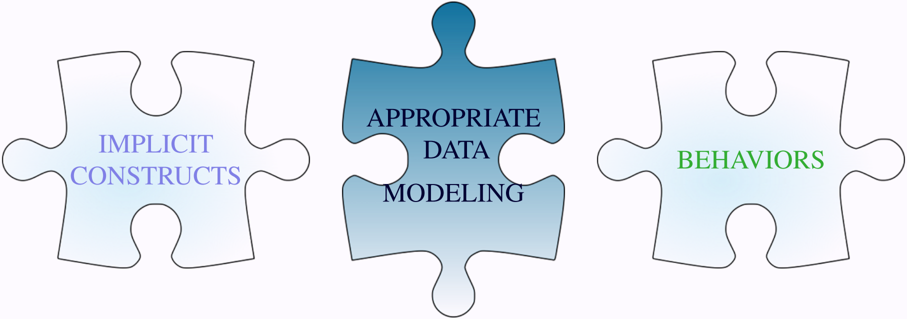
1. Stimuli level:
   - Malfunctioning stimuli
   - Stimuli driving the IAT effect
2. Respondents' level:
   - Respondents' accuracy consistent between conditions
   - Respondents' speed affected by the associative condition

Choice prediction

- Differential measures vs single components
- Random noise with appropriate random structure & behavioral outcomes


APPROPRIATE
DATA
MODELING


IMPLICIT
CONSTRUCTS
APPROPRIATE
DATA
MODELING


IMPLICIT CONSTRUCTS
APPROPRIATE DATA MODELING
BEHAVIORS

Thank you!