UNIVERSITY OF PLYMOUTH

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G-DISTANCE
ON THE COMPARISON OF MODEL AND HUMAN HETEROGENEITY

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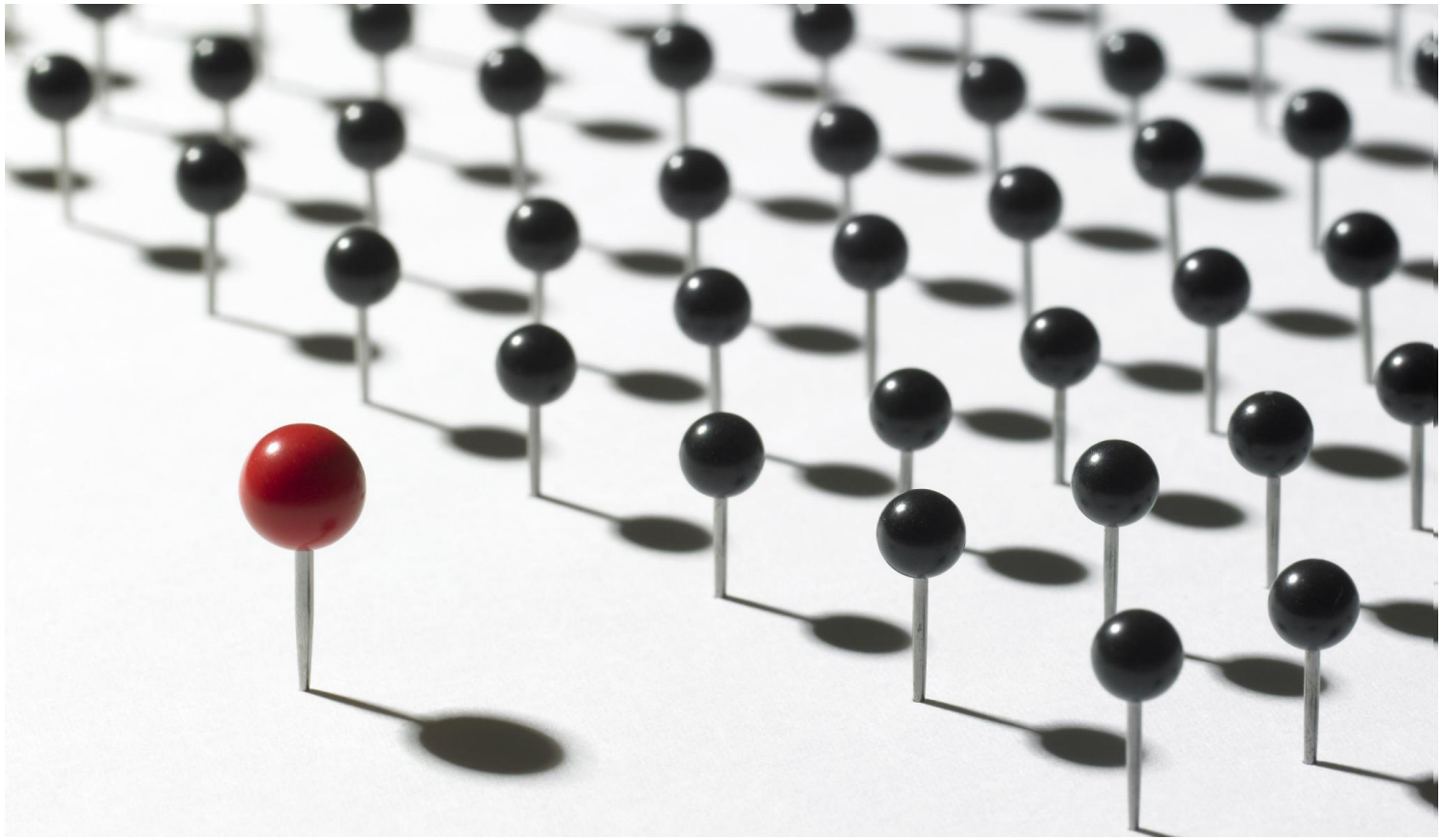
@ajwills72



WHAT IS A MODEL?

A mathematically-specified theory that is implemented as a computable algorithm for the purpose of simulating some aspect of human, or animal, behaviour.

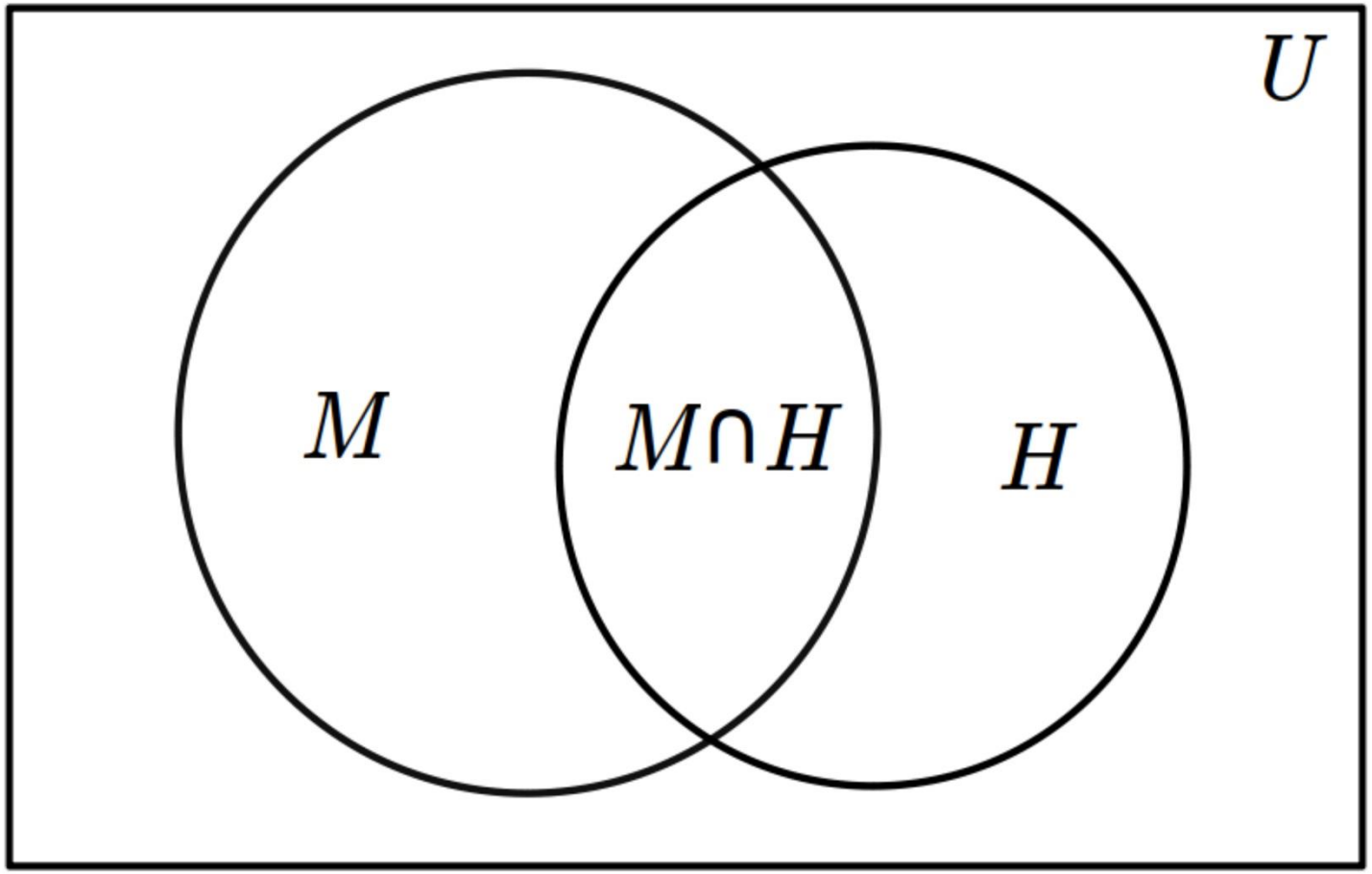
Wills & Pothos (2012)

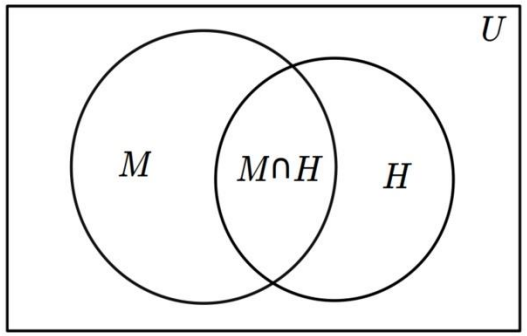
IS THIS MODEL ANY GOOD?

Goodness of fit: Extent to which a model can accommodate already-observed data pattern(s).

Model and human **heterogeneity**

MODEL ADEQUACY AS OVERLAPPING SETS





$$\alpha = \frac{|M \cap H|}{|H|}$$

Accommodation

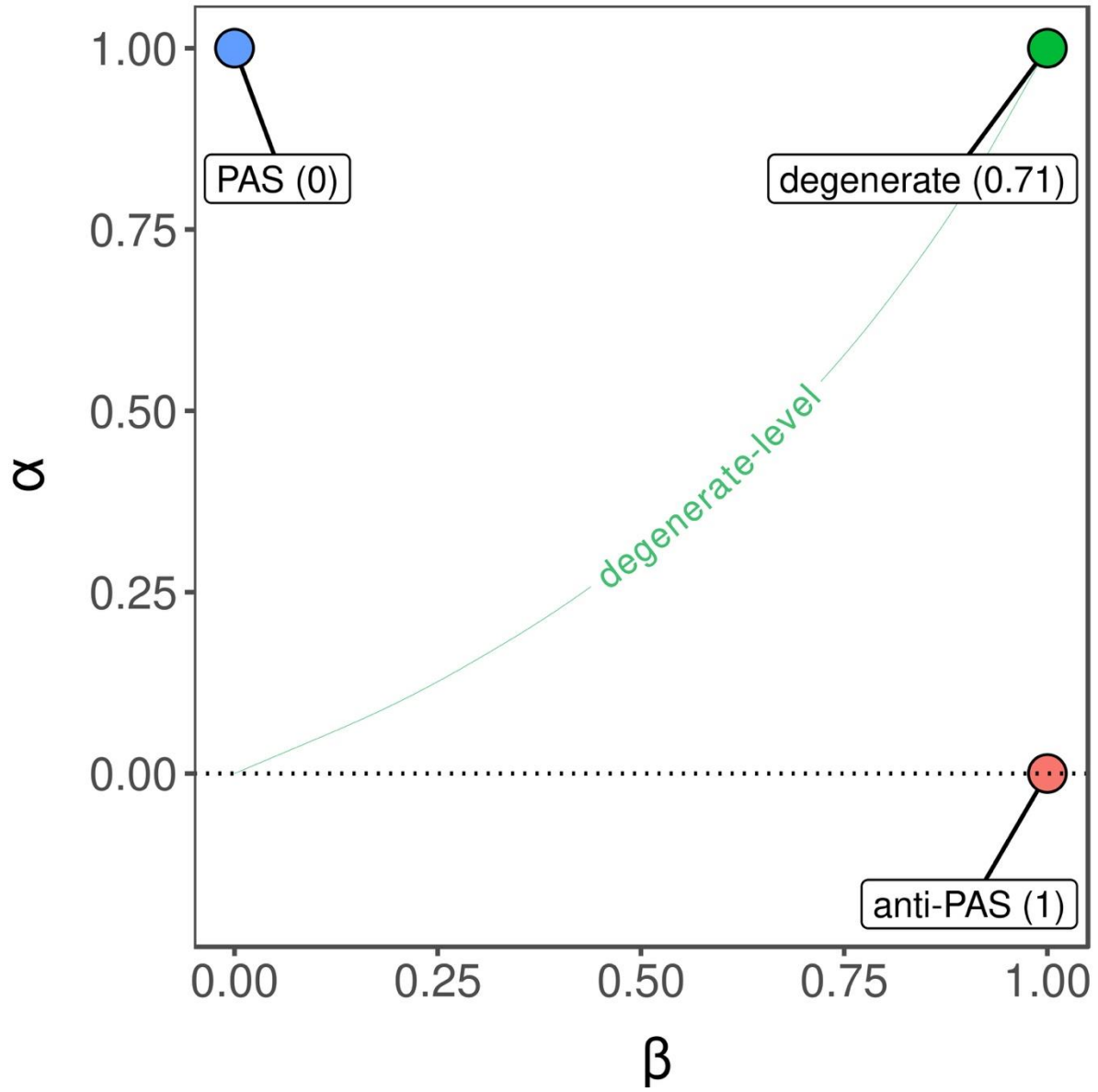
$$\beta = \frac{|M \cap H'|}{|H'|}$$

Excess flexibility

MODEL ADEQUACY AS OVERLAPPING SETS

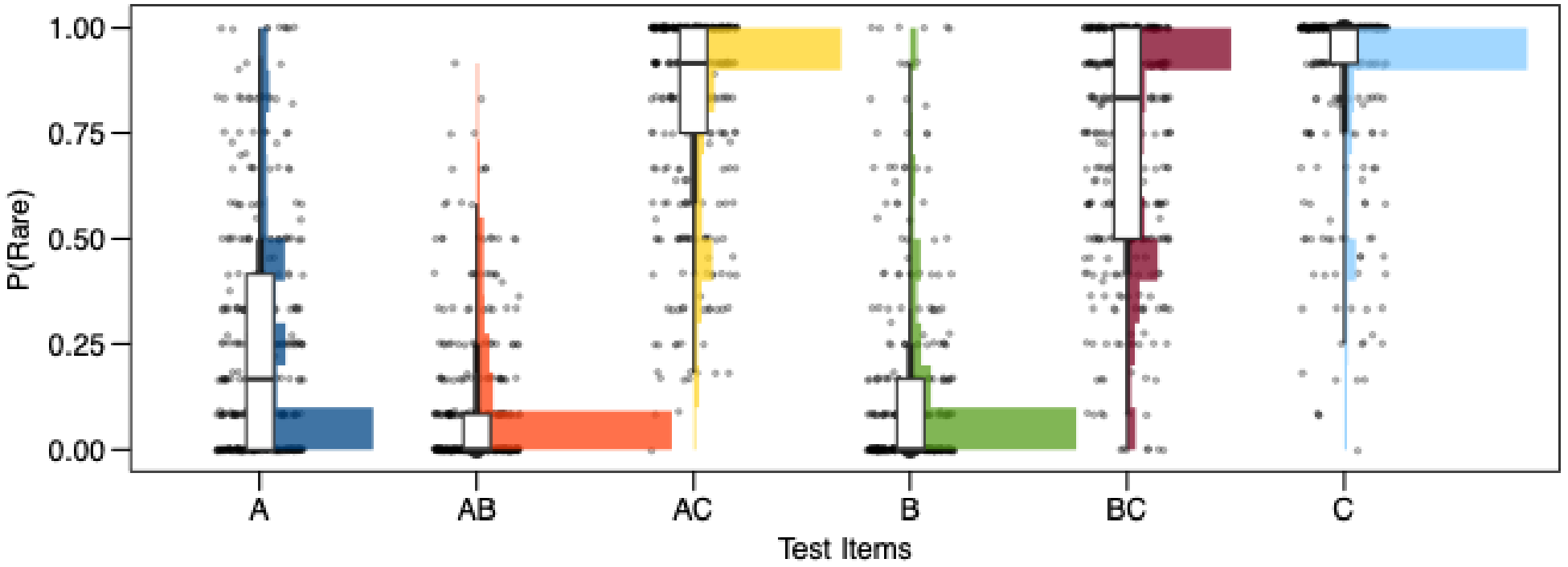
G-DISTANCE

$$g = \sqrt{\frac{(1-\alpha)^2 + \beta^2}{2}};$$



INVERSE BASE-RATE EFFECT

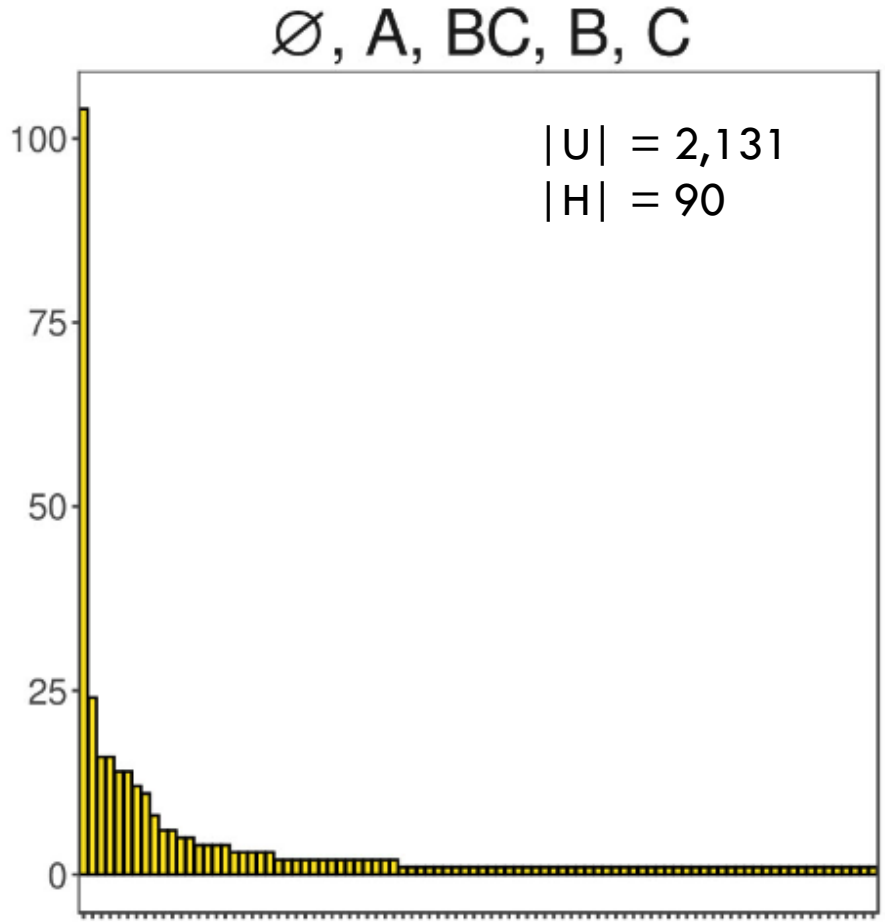
Training (Relative Frequencies)	Test
$AB \rightarrow 1$ (x 3)	A, B, C,
$AC \rightarrow 2$ (x 1)	AB, AC, BC, x 12



INVERSE BASE-RATE EFFECT

Training (Relative Frequencies)	Test
$AB \rightarrow 1$ (x 3)	A, B, C,
$AC \rightarrow 2$ (x 1)	AB, AC, BC, x 12

Ordinal Pattern	Frequency
$A \simeq B < \emptyset < BC \simeq C$	104
$A \simeq B < \emptyset < BC < C$	24
$B < A < \emptyset < BC < C$	16
$B < A < \emptyset < BC \simeq C$	16
$B < A \simeq \emptyset < BC < C$	14
$B < A < \emptyset \simeq BC < C$	14



MODELS OF THE IBRE

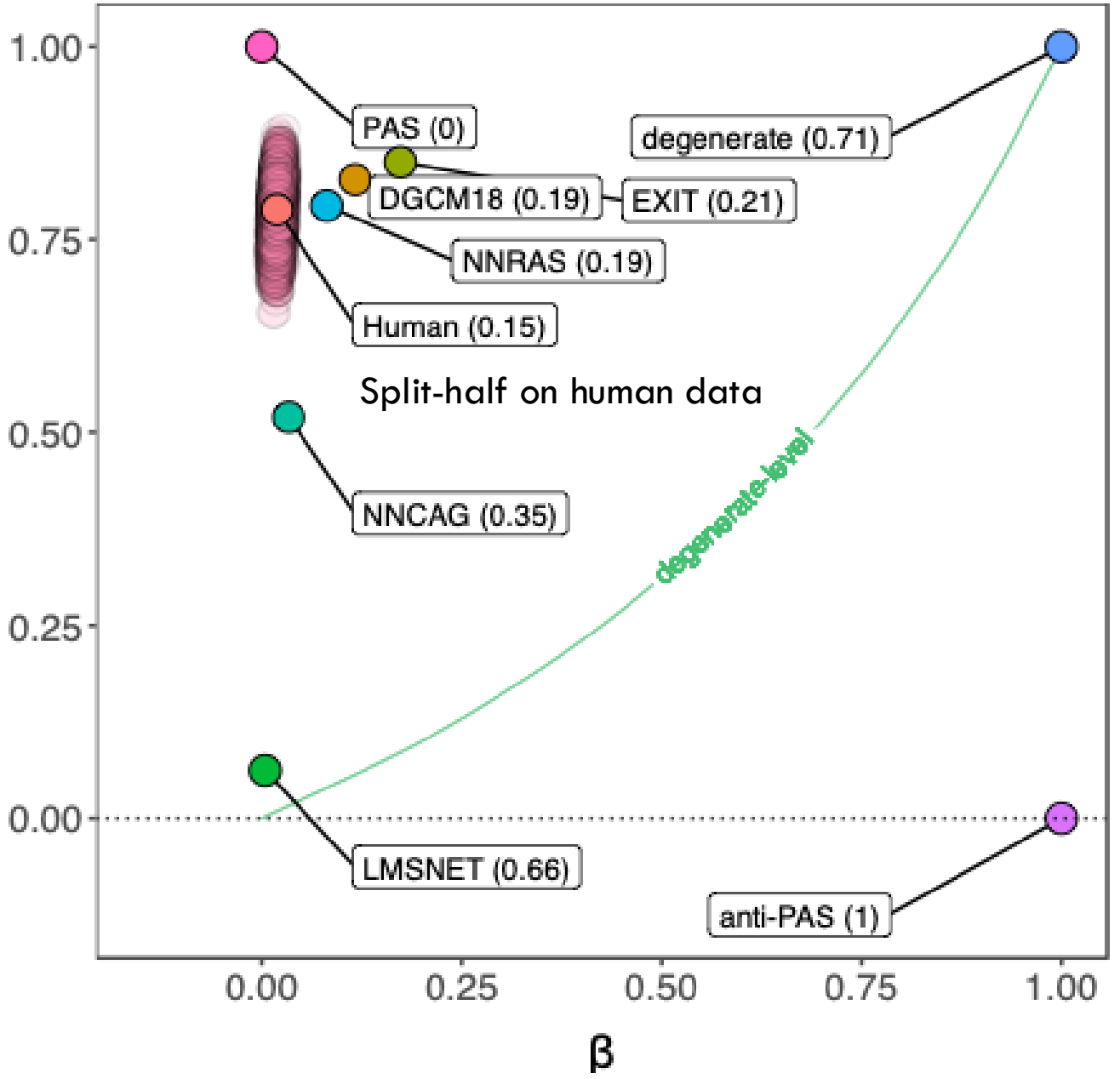
- Attentional associative-learning models
  - EXIT (Kruschke, 2001) - "Market leader"
  - NNRAS, NNCAG (Jones & Paskewitz, 2020) – Simplified versions of EXIT

- Plain-associative model (**known poor model)**
  - LMSNET (Gluck & Bower, 1988; see also Rescorla & Wagner, 1972).

- Dissimilarity-Exemplar models
  - DGCM18 (O'Bryan et al., 2018)

MODEL ADEQUACY

model	BIC	NLL	g	α	β
LMSNET	25770.05	11514.62	0.66	0.06	0.004
NNCAG	28097.40	11307.89	0.35	0.52	0.03
NNRAS	29320.45	11234.21	0.19	0.80	0.08
DGCM18	30661.65	11219.61	0.19	0.83	0.12
EXIT	31476.40	10941.78	0.21	0.85	0.17



SUMMARY

- g-distance is a formal measure of model adequacy, which combines:
  - Accommodation
  - Excess flexibility

- The inverse base-rate effect (IBRE) is a robust non-rational learning phenomenon.

- Applying g-distance to models of the IBRE
  - The success of 'market leader' model EXIT may be due to its excess flexibility
  - It's simpler derivative (NNRAS) and a notable alternative (DGCM18) generally outperformed EXIT

- At least in the current case, g-distance better captures model adequacy than the commonly-used Bayesian Information Criterion (BIC) metric.

Dome, L. & Wills, A.J. (2025). g-distance: On the comparison of model and human heterogeneity. *Psychological Review, 132*, 632–655.

behavioral sciences

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