



Behavioural Entropy as an Individual Difference Construct

A New Perspective from Massive Transactional Data

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About Me

- Senior Research Associate (2021-)
- PhD Behavioural Science (University of Warwick)
- Mixed background:
 - Psychology, data science, consumer research, public health



Introduction



Motivation

- Personality traits are important in psychological research (Swann & Seyle, 2005)
- Digital footprints data → opportunities for personality psychologists:

‘If personality traits can be inferred from digital footprints records, they can then be examined en masse in naturalistic settings, mapped to geospatial and temporal dimensions, and used to predict real-life socioeconomic outcomes on national levels’



One way to infer personality traits from DF data is through the lens of *entropy*



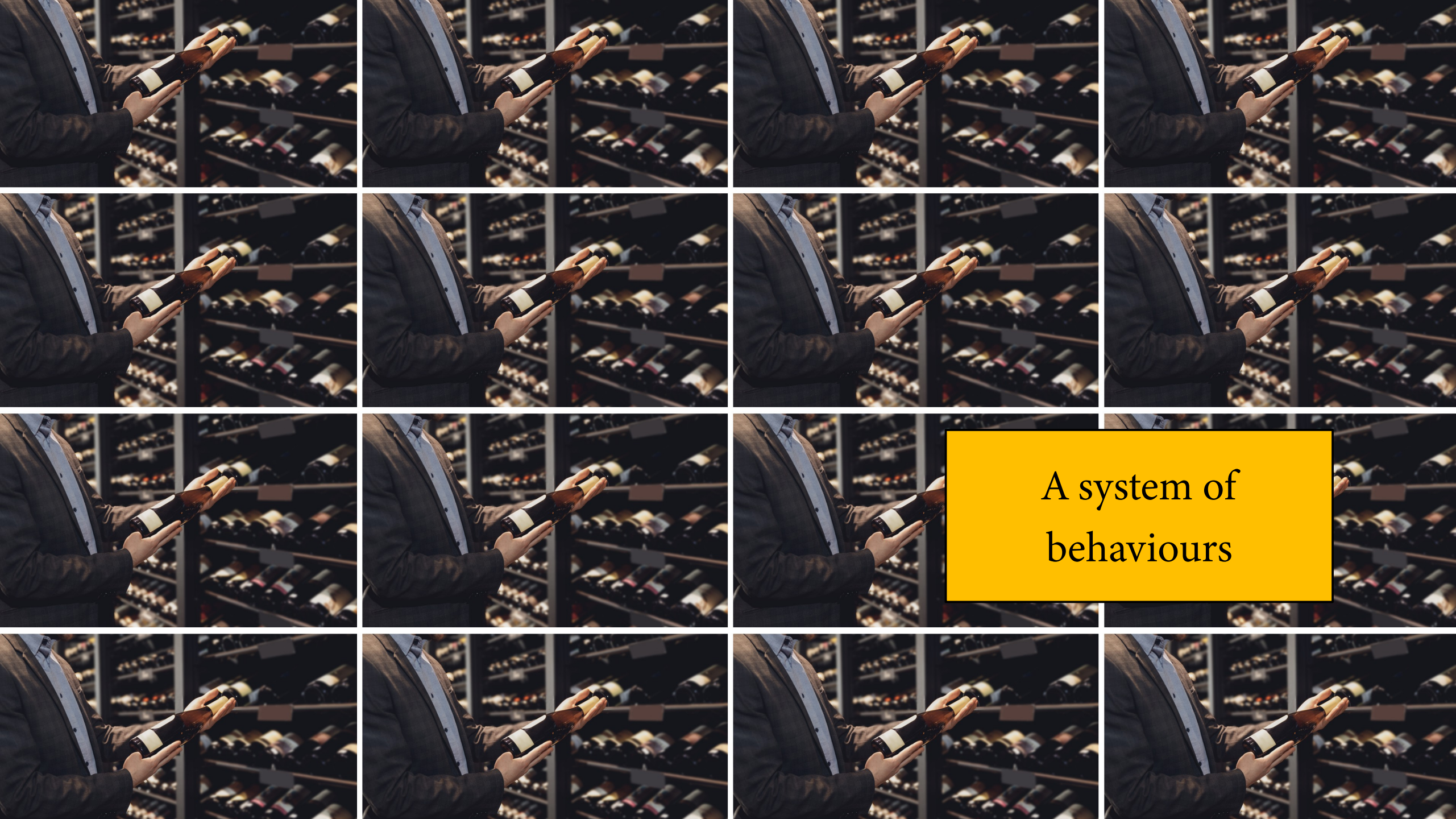
Entropy

- Measure of the degree of randomness of a probabilistic system (Shannon, 1948)
- In psychology:
 - Long-term patterns of a series of human behaviours can be understood as a system consisted of probabilistic processes
 - Entropy can be computed to measure the extent to which such processes are organised
- Consider shopping behaviour of a customer in a retail store:
 - Given the frequency of each item being chosen by relative to those of other items
 - Entropy captures how predictable that individual's consumption pattern is





A choice



A system of
behaviours

Entropy

$$H(S) = - \sum_{i=1}^n p(s_i) \log_b p(s_i)$$

- where $p(s_i)$ is the probability of product i being purchased by that individual
- $-\log_b p(s_i)$ is Shannon information (= understood as uncertainty)
- Entropy $H(S)$ is thus: average amount of (weighted) uncertainty associated with products purchased by an individual
 - An inconsistent or unpredictable shopping pattern: high entropy value



Research Questions

- Does entropy actually reflect personality traits?
- Does entropy predict external behavioural outcomes?



Research Questions

Openness (one of the
Big Five traits)

- Does entropy actually reflect personality traits?
- Does entropy predict external behavioural outcomes?



Research Questions

- Does entropy actually reflect personality traits?
- Does entropy predict external behavioural outcomes?

EU referendum
(Brexit)



Methods



Transactional Data

- Provided by the largest pharmacy chain in the UK:
 - 2014-2015
 - 20,550,952 unique customers
 - 1,202,094,999 items
- We know the post codes of the stores:
 - Compute entropy for customers
 - Aggregated entropy for each local authority district (LAD) by mapping customers to stores to LADs



Personality Data

- Collected by BBC, reported in Rentfrow et al. (2015)
 - Data collection period: 2009-2011
- Big Five traits of 386,375 individuals
- We know the LAD in which each individual lived
 - Aggregated personality traits for each LAD



Brexit Data

- Released by the Electoral Commission in 2019
- No. of votes (Remain vs Leave) by LAD



Models



Entropy \leftarrow Personality

$$\text{Entropy} = \beta_0 + \beta_1 \text{Neuroticism} + \beta_2 \text{Extraversion} + \beta_3 \text{Openness} + \beta_4 \text{Agreeableness} + \beta_5 \text{Conscientiousness} + \beta_6 \log_2(\text{No. Distinct Items}) + \varepsilon$$

- Unit of Observations: LAD
- Controlled for number of distinct items available in each LAD



Brexit ← Entropy

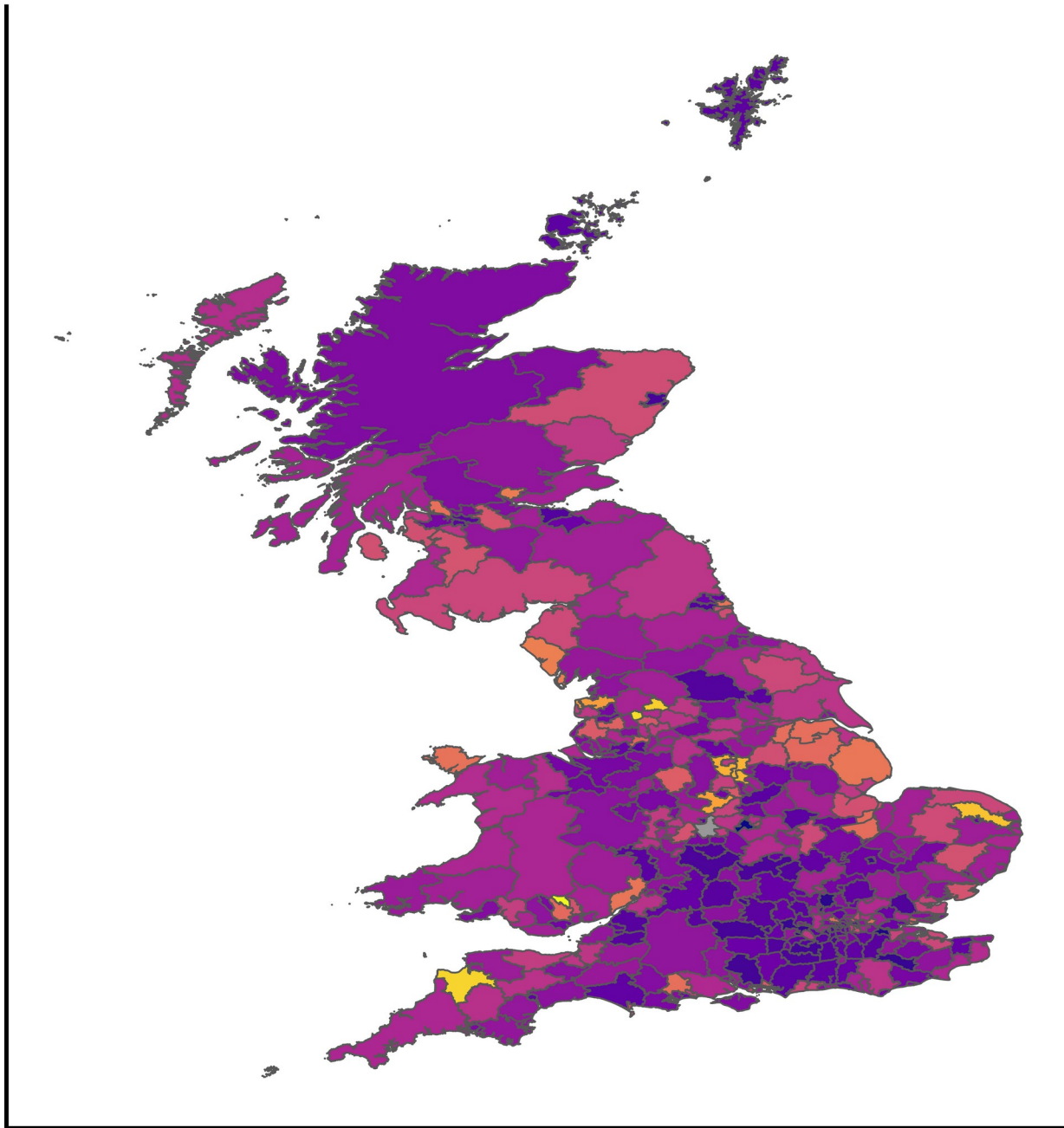
$$\text{Percent Remain} = \beta_0 + \beta_1 \text{Entropy} + \beta_2 \log_2(\text{Median Income}) + \beta_3 \log_2(\text{No Distinct Items}) + \varepsilon$$

- Unit of Observations: LAD
- Controlled for number of distinct items available in each LAD

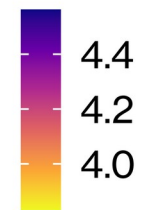


Results





Entropy (Mean by LAD)



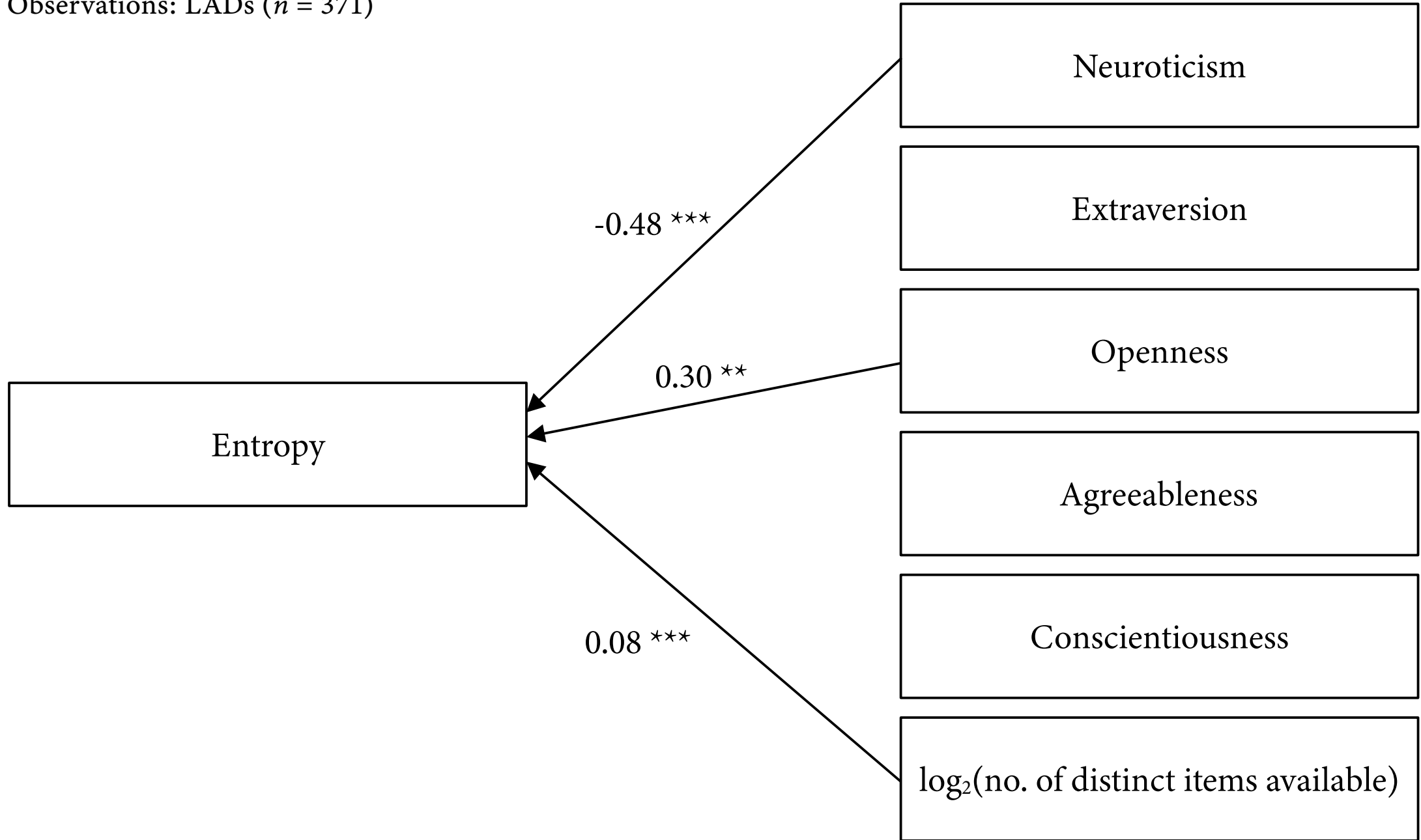
Unit of Observations: LADs ($n = 371$)

Entropy

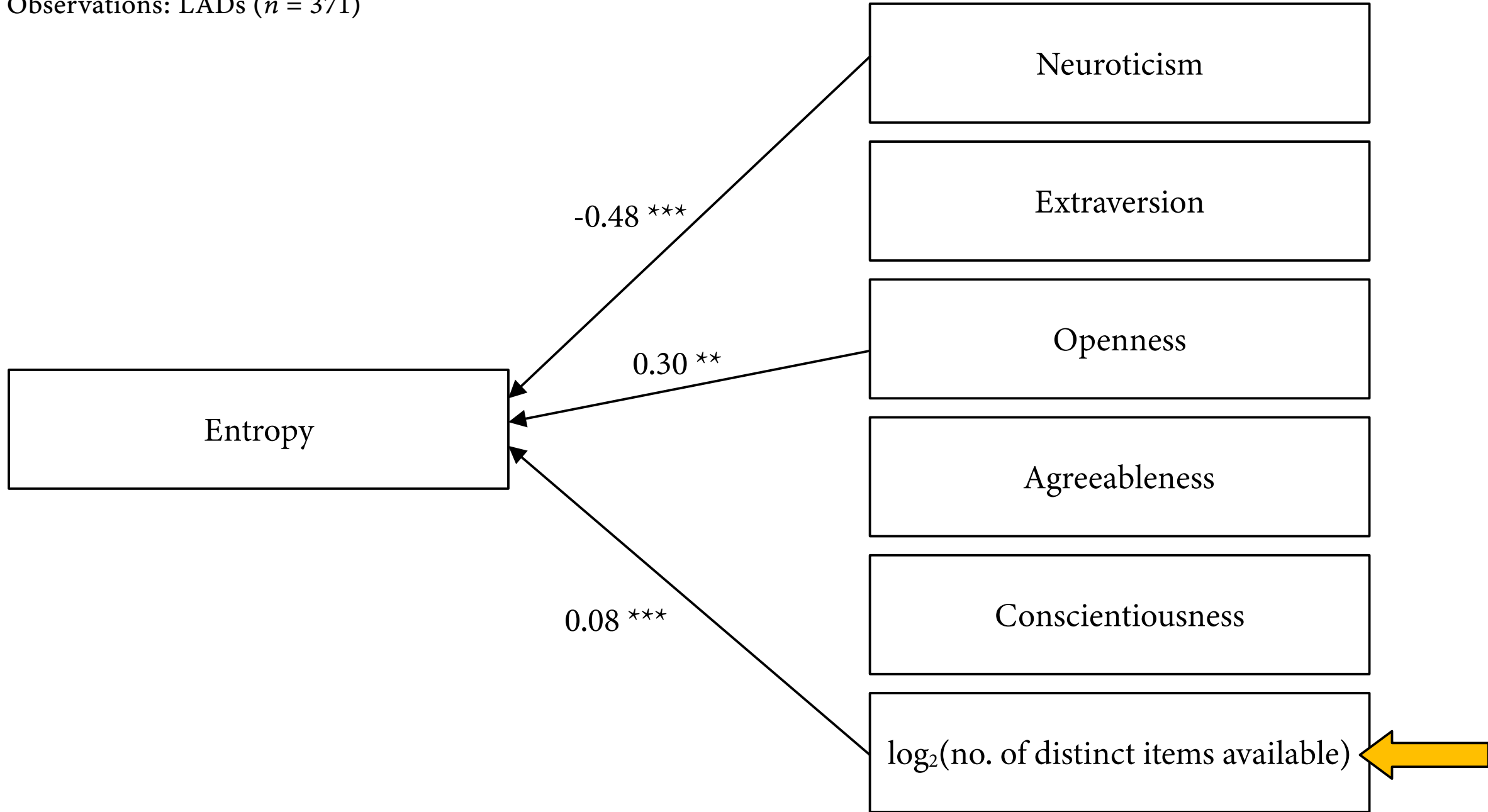
	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness	Entropy
Neuroticism		-0.46	-0.14	-0.21	-0.42	-0.23
Extraversion	-0.46		0.43	-0.21	-0.07	0.26
Openness	-0.14	0.43		-0.43	-0.4	0.23
Agreeableness	-0.21	-0.21	-0.43		0.51	-0.17
Conscientiousness	-0.42	-0.07	-0.4	0.51		-0.02
Entropy	-0.23	0.26	0.23	-0.17	-0.02	



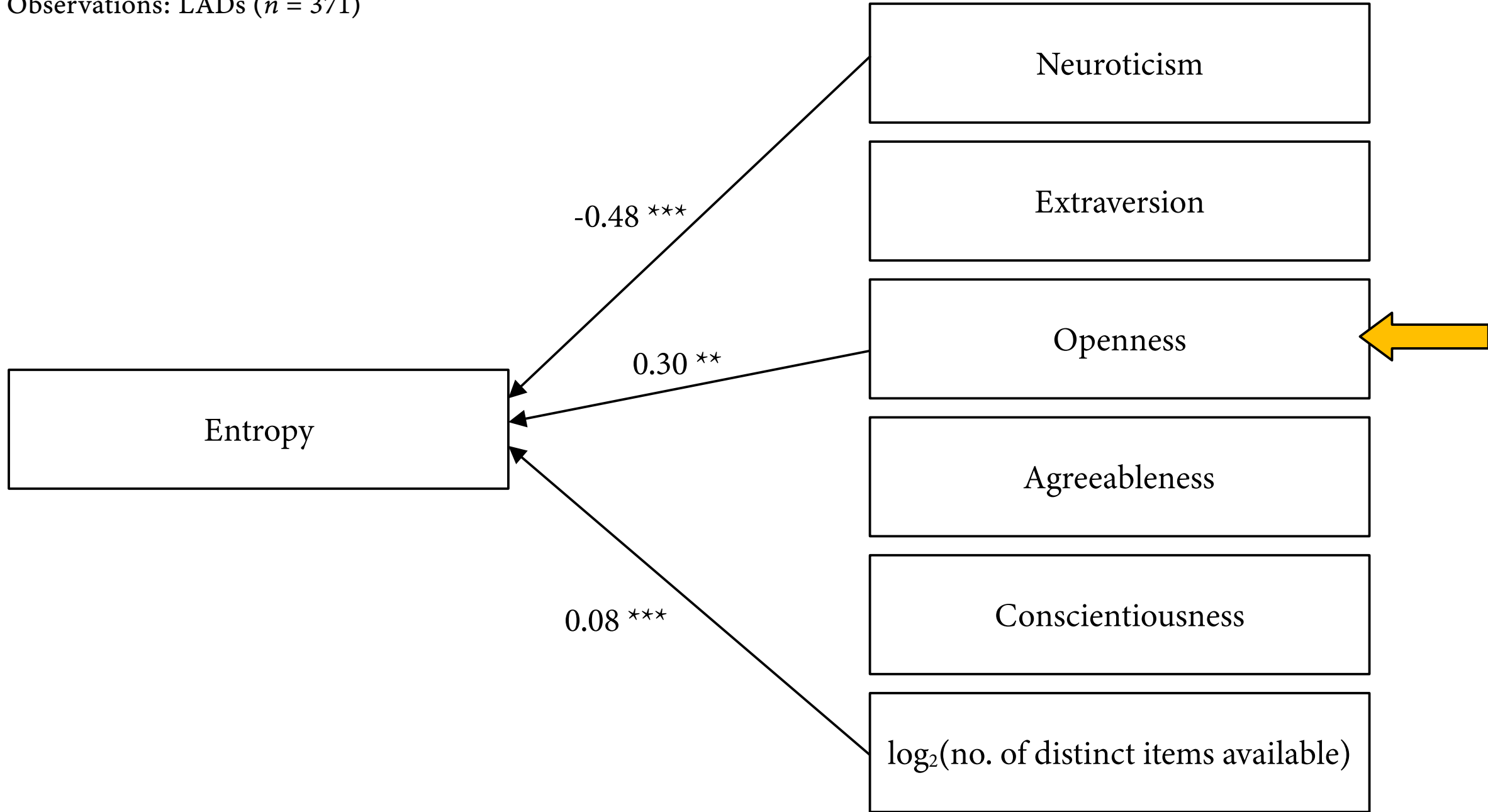
Unit of Observations: LADs ($n = 371$)

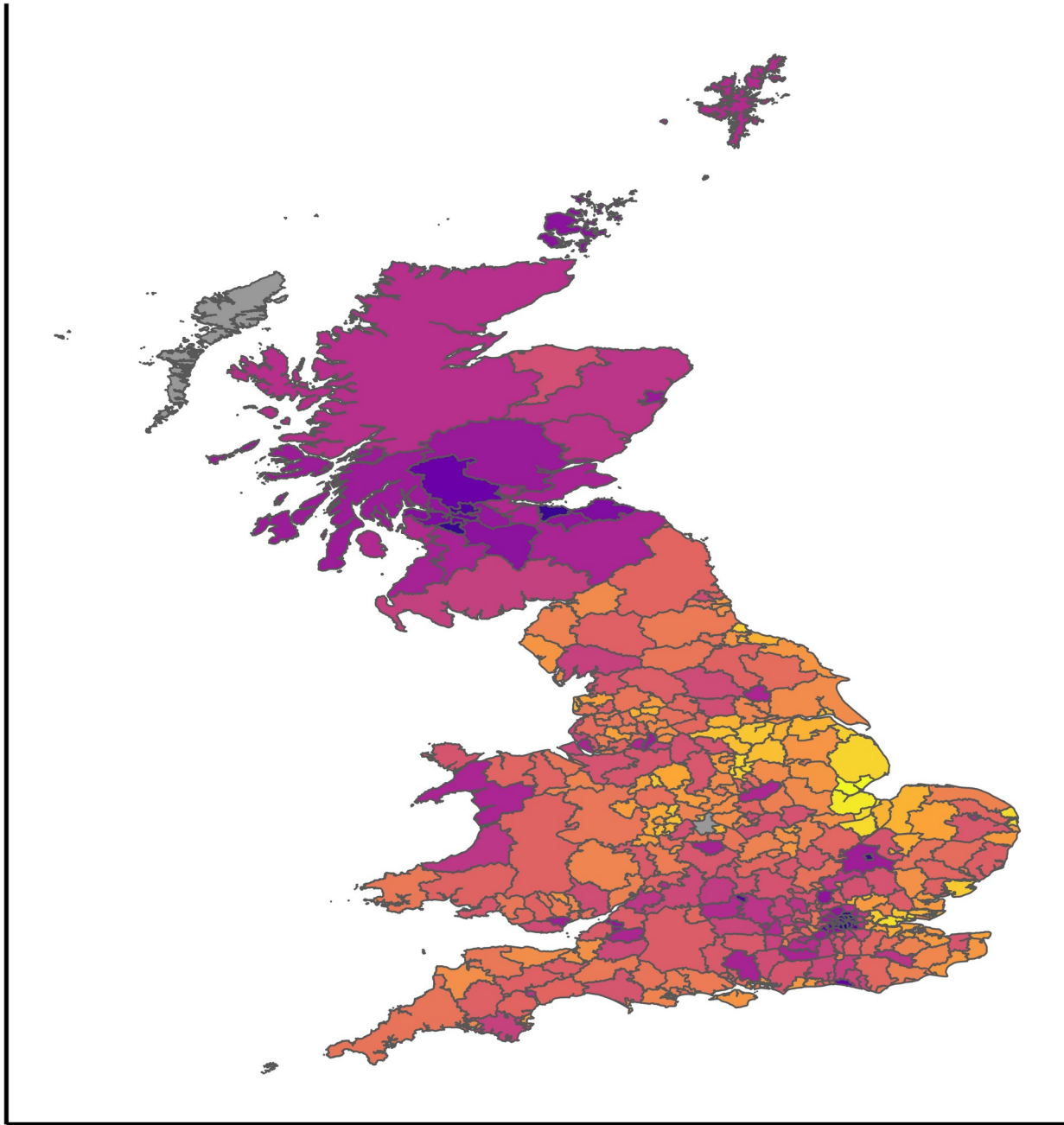


Unit of Observations: LADs ($n = 371$)

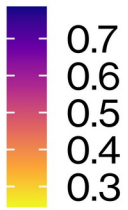


Unit of Observations: LADs ($n = 371$)



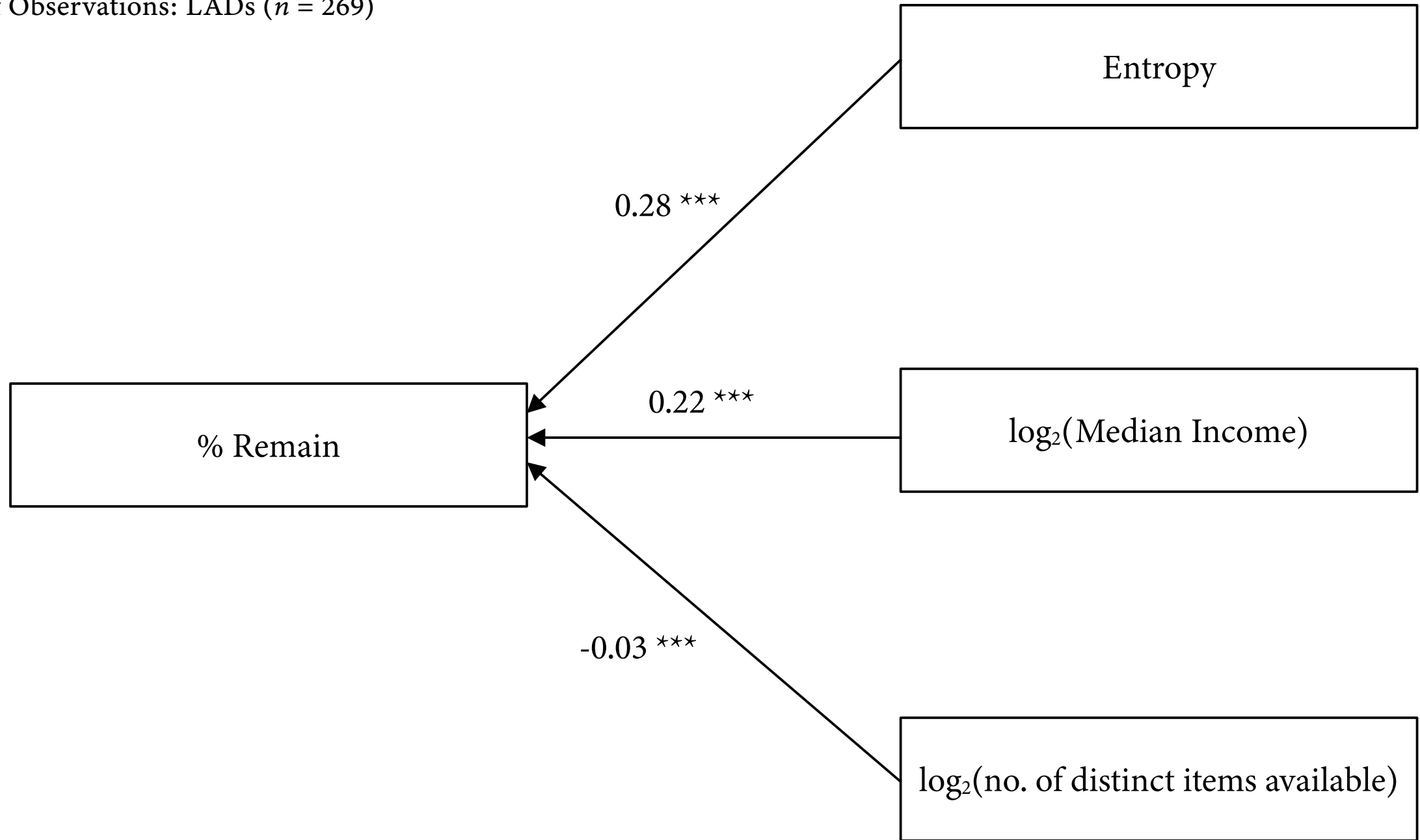


% Remain

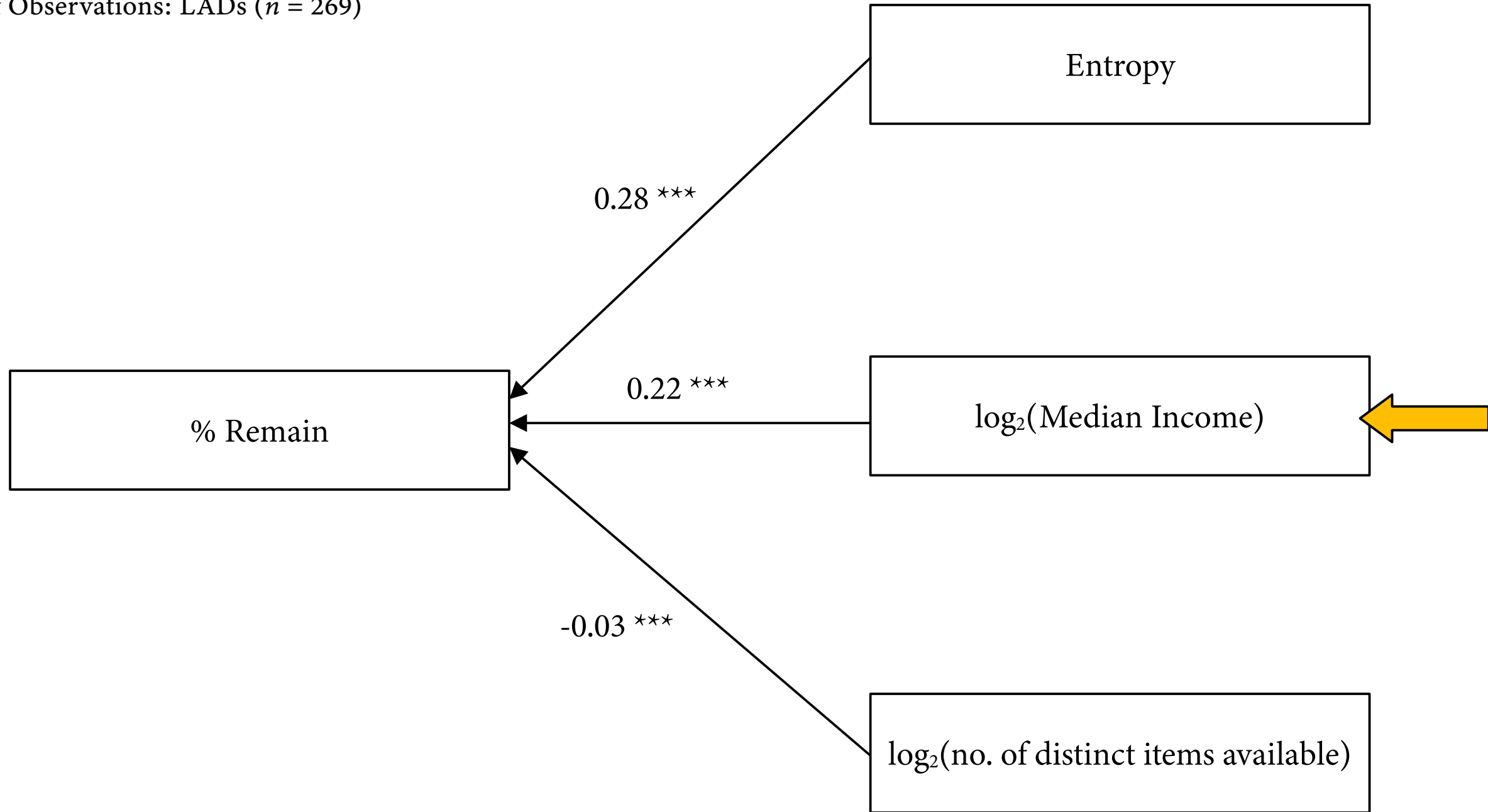


• % here is between 0 and 1

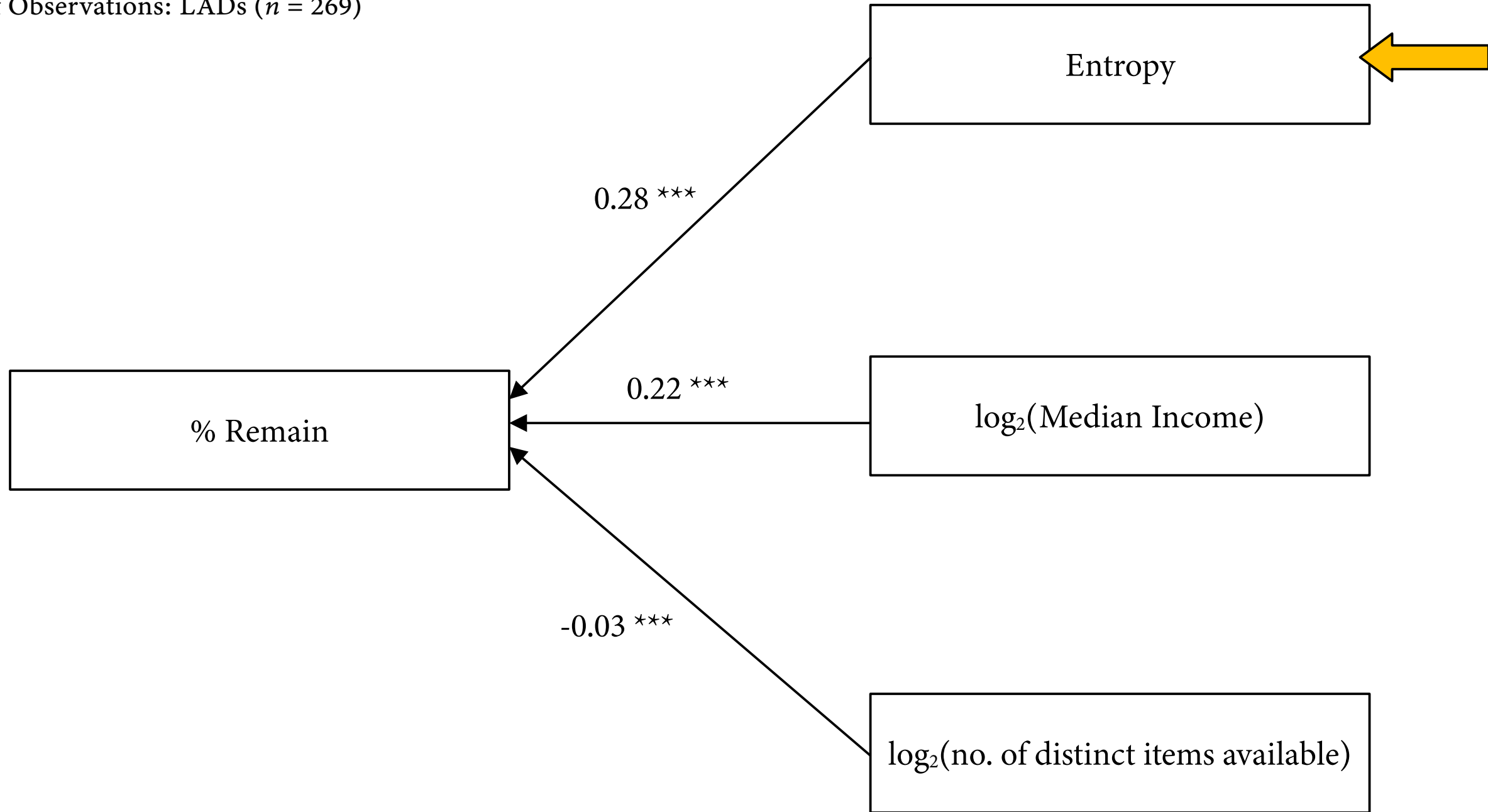
Unit of Observations: LADs ($n = 269$)



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General Discussion

- Entropy reflects openness to experience
- Entropy predicts Brexit
 - The explanation is ad-hoc, but makes sense
- Is that just a general “urban-rural” effect?
 - We did control for item availability and income
- Other external outcomes: election results

