

**Keynote talk Presented the SEM Working Group Meetings  
March 15, 2018, Amsterdam, Netherlands**



# *One The Merits of Parcels, or Why the Items vs Parcels Controversy Needn't Be One*

Todd D. Little

*Co-Director, IMMAP*

*Founder "Stats Camp" (Statscamp.org)*



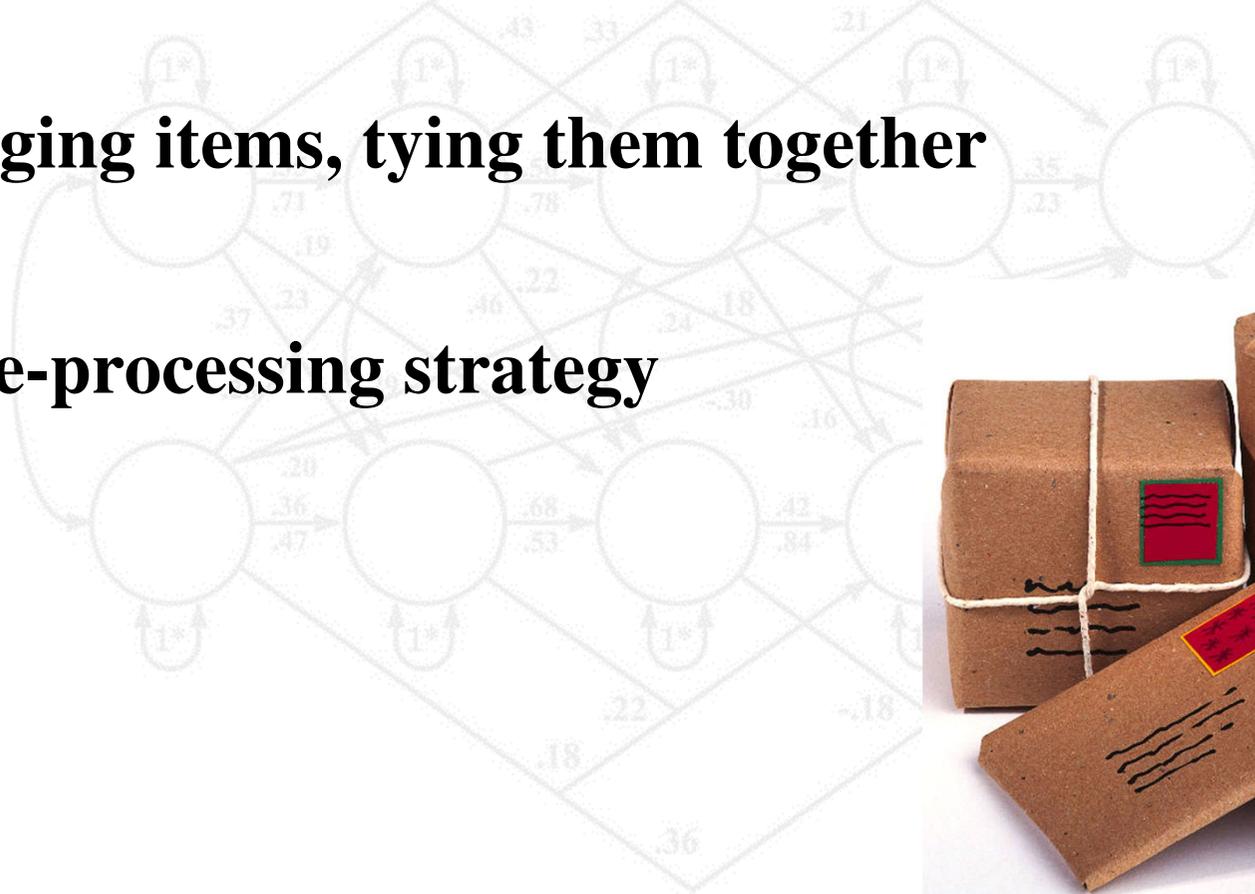
# What is Parceling?



**Parceling: Averaging (or summing) two or more items to create more reliable indicators of a construct**

**≈ Packaging items, tying them together**

**Data pre-processing strategy**



# Using I FEEL Items



## Example: Positive and Negative Affect

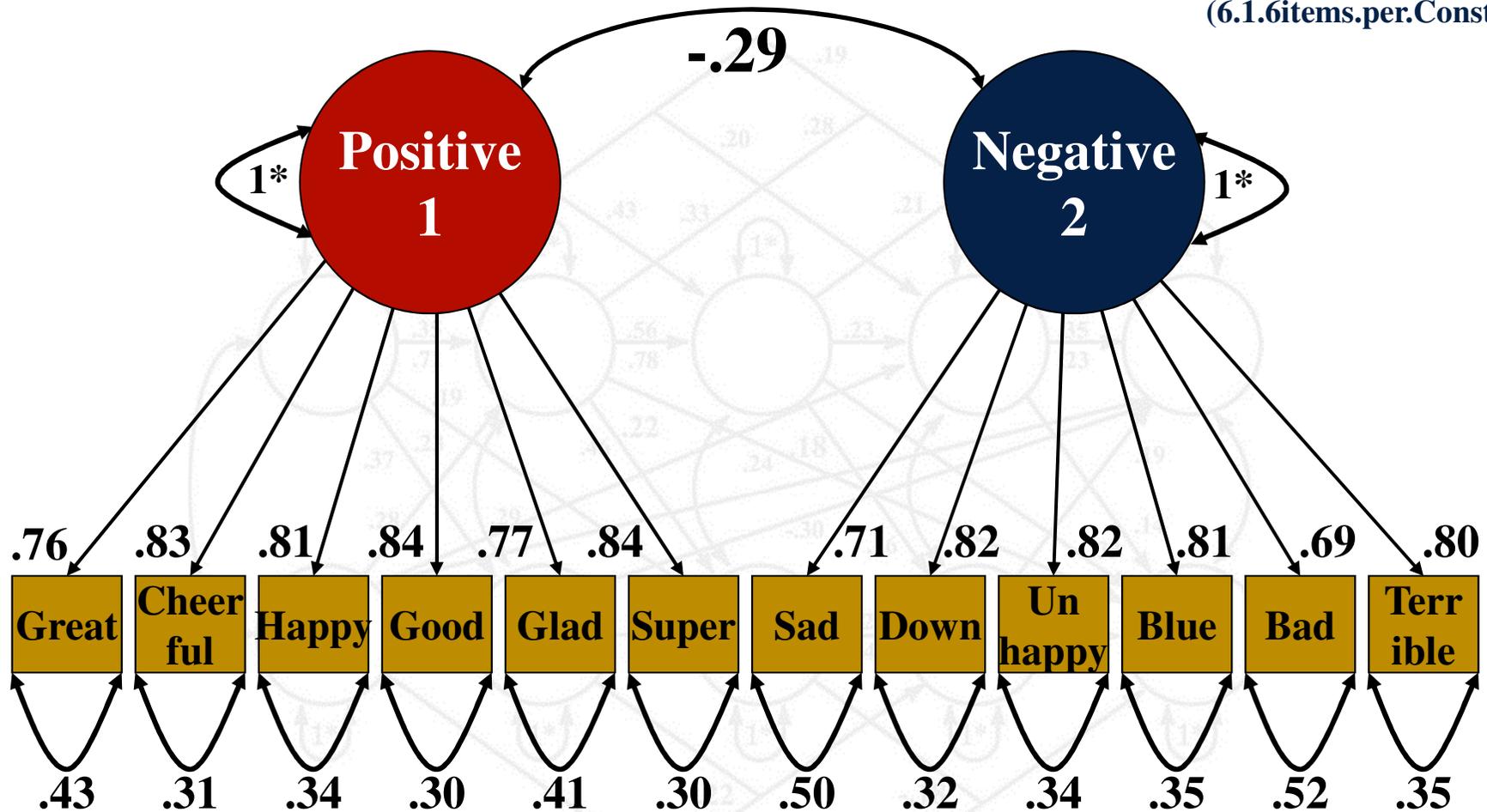
“In the last two weeks, I have felt...”

- |             |              |
|-------------|--------------|
| 1. Great    | 7. Sad       |
| 2. Cheerful | 8. Down      |
| 3. Happy    | 9. Unhappy   |
| 4. Good     | 10. Blue     |
| 5. Glad     | 11. Bad      |
| 6. Super    | 12. Terrible |

# Initial CFA: No Parcels



(6.1.6 items per Construct)



Model Fit:  $\chi^2_{(53, n=759)} = 180.95$ ; RMSEA = .057<sub>(.048-.066)</sub>; CFI = .987; TLI/NNFI = .984

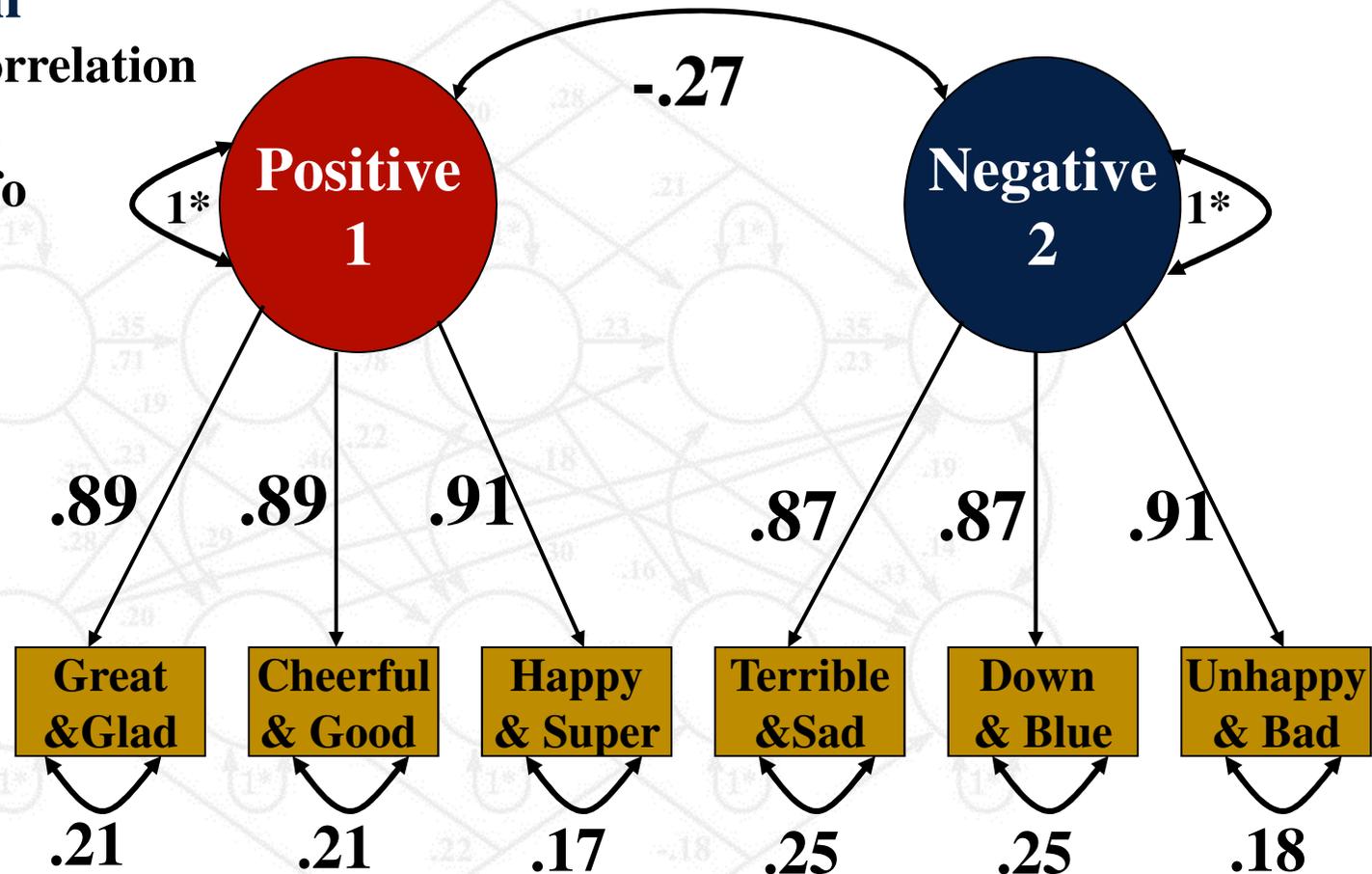
# CFA: Using Parcels



(6.2.Parcels)

## Similar solution

- Similar factor correlation
- Higher loadings, more reliable info
- Good model fit, improved  $\chi^2$



Model Fit:  $\chi^2_{(8, n=759)} = 26.76$ ; RMSEA =  $.055_{(.033-.079)}$ ; CFI =  $.994$ ; TLI/NNFI =  $.989$

# Philosophical Issues



**To parcel, or not to parcel...?**

# Empiricist / Conservative View



**“Parceling is akin to cheating because modeled data should be as close to the response of the individual as possible in order to avoid the potential imposition, or arbitrary manufacturing of a false structure”**

**Preferred terms: mask, conceal, camouflage, hide, disguise, cover-up, etc.**

From Little et al., 2002

# Pragmatic View



**“Given that measurement is a strict, rule-bound system that is defined, followed, and reported by the investigator, the level of aggregation used to represent the measurement process is a matter of choice and justification on the part of the investigator”**

**Preferred terms: remove unwanted, clean, reduce, minimize, strengthen, etc.**

# Psuedo-Hobbesian View



**Parcels should be avoided because researchers are ignorant (perhaps stupid) and prone to mistakes. And, because the unthoughtful or unaware application of parcels by unwitting researchers can lead to bias, they should be avoided.**

**Preferred terms: most (all) researchers are un\_\_\_ as in ... unaware, unable, unwitting, uninformed, unscrupulous, etc.**

## Psychometric Characteristics of Parcels (vs. Items)

- Higher reliability, communality, & ratio of common-to-unique factor variance
- Lower likelihood of distributional violations
- More, Smaller, and more-equal intervals

	Never	Seldom	Often	Always			
Happy	1	2	3	4			
Glad	1	2	3	4			
Mean	1	1.5	2	2.5	3	3.5	4
Sum	2	3	4	5	6	7	8

# More Empirical Pros



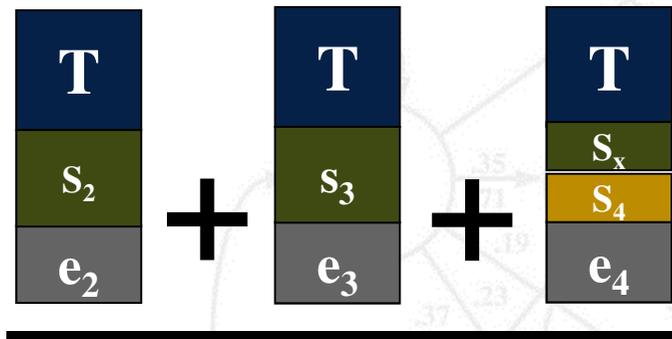
## Model Estimation and Fit with Parcels (vs. Items)

- Fewer parameter estimates
- Lower indicator-to-subject ratio
- Reduces sources of parsimony error (population misfit of a model)
  - Lower likelihood of correlated residuals & dual factor loading
- Reduces sources of sampling error
- Makes large models tractable/estimable

# Simple Parcel

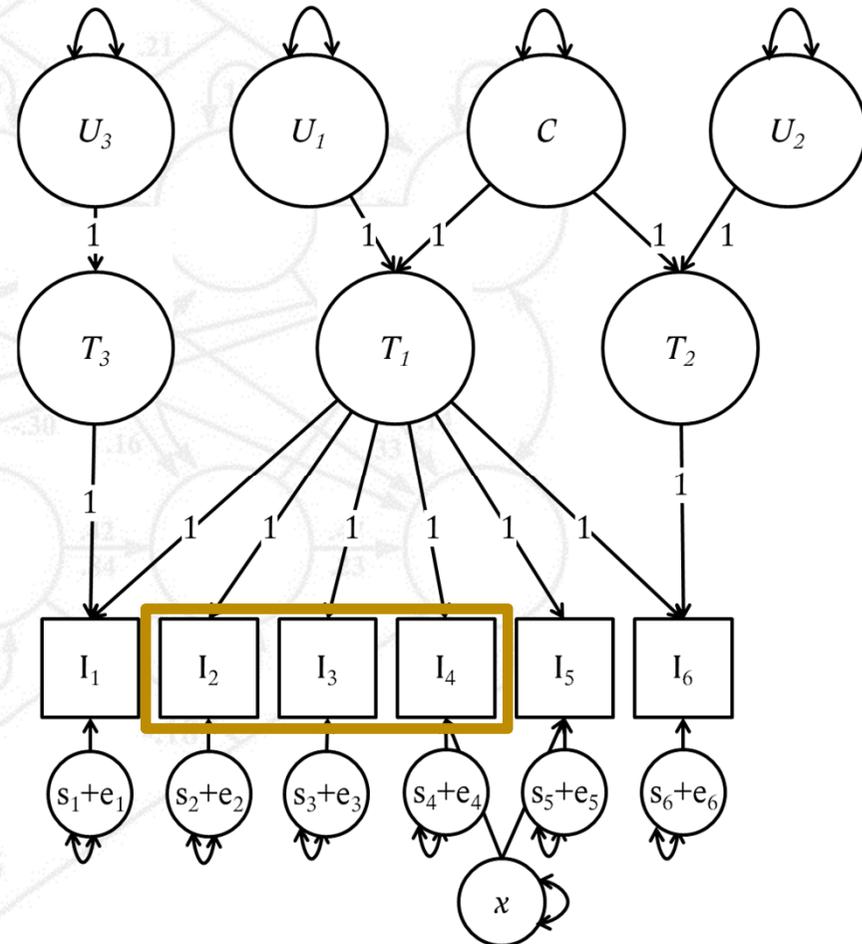
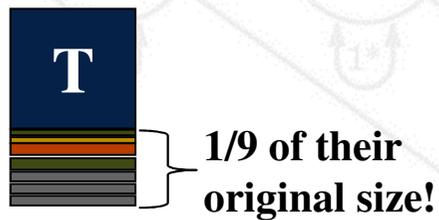


$$\text{var}\left(\frac{(I_2 + I_3 + I_4)}{3}\right) = \text{var}(T_1) + \frac{1}{9} \left[ \text{var}(s_2) + \text{var}(s_3) + \text{var}(s_4) + \text{var}(x) + \text{var}(e_2) + \text{var}(e_3) + \text{var}(e_4) \right]$$



3

=



# Empirical Cons



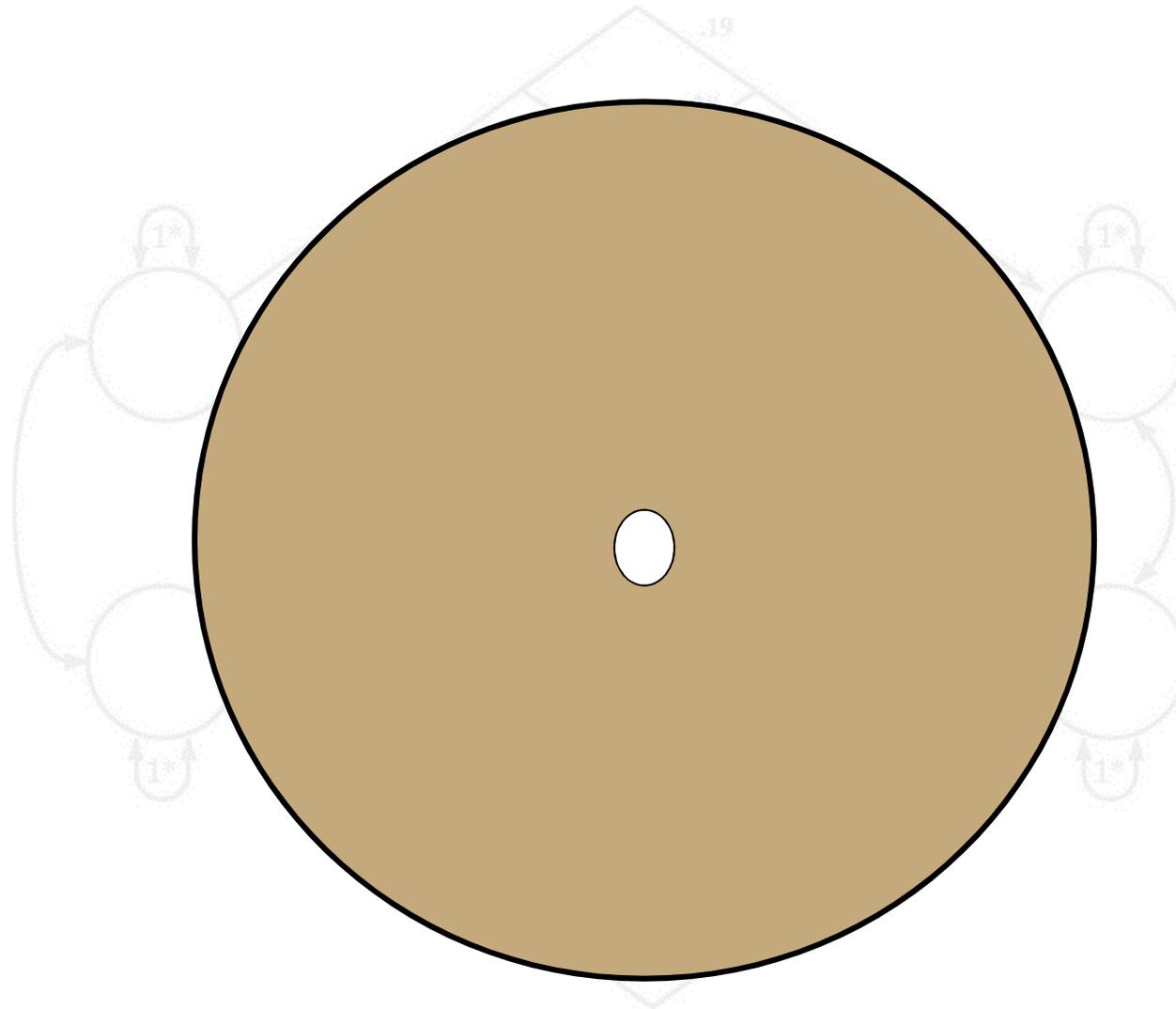
- **Multidimensionality**
  - **Constructs and relationships can be hard to interpret if done improperly**
- **Model misspecification**
  - **Can get improved model fit, regardless of whether model is correctly specified**
  - **Increased Type II error rate if question is about the items**
- **Parcel-allocation variability**
  - **Solutions depend on the parcel allocation combination (Sterba & MacCallum, 2010; Sterba, 2011)**
    - **Applicable when only when sampling error is high such as with small sample sizes – thus critical to be thoughtful**

# Psychometric Issues

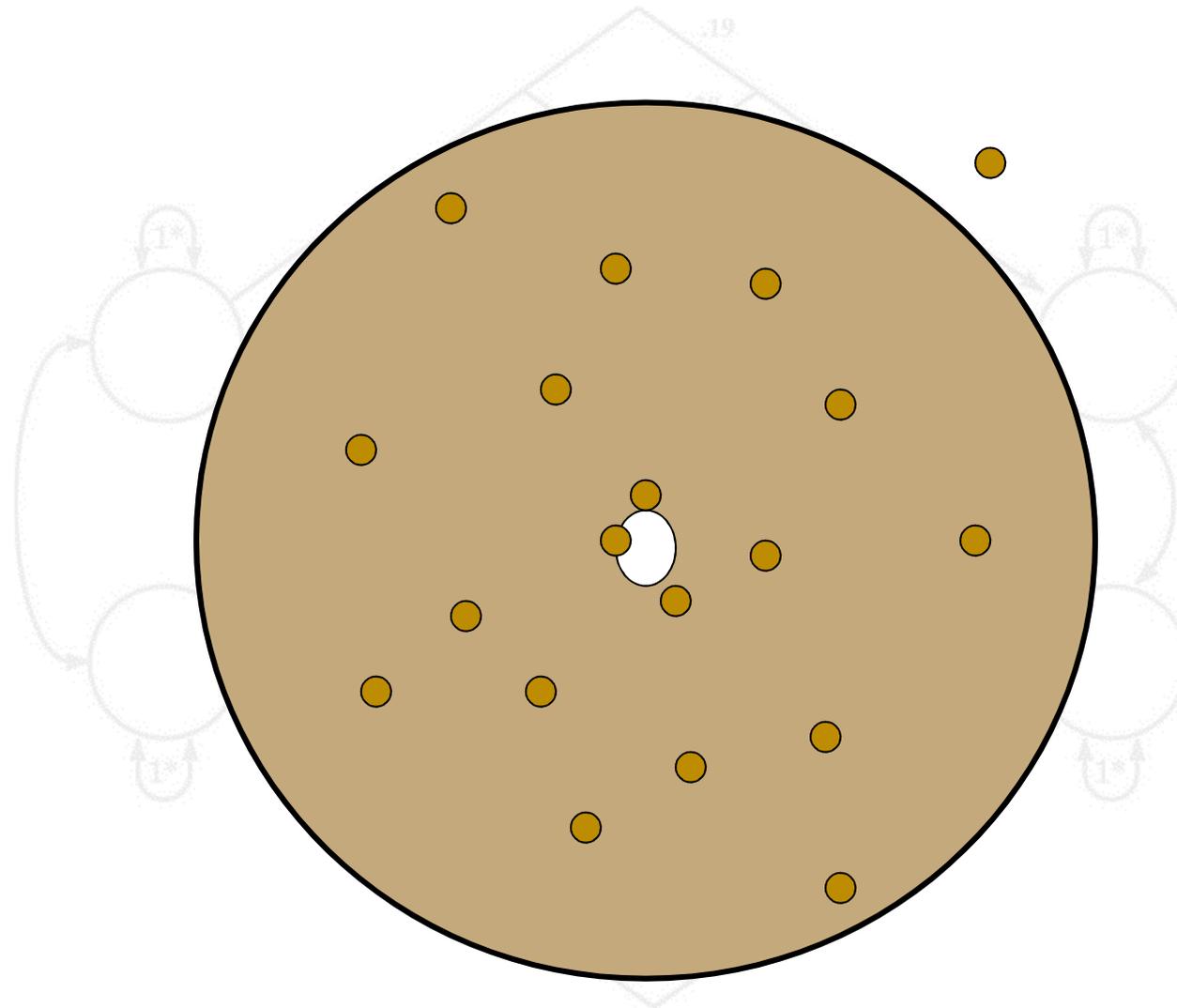


- **Principles of Aggregation (e.g., Rushton et al.)**
  - Any one item is less representative than the average of many items (selection rationale)
  - Aggregating items yields greater precision
- **Law of Large Numbers**
  - More is better, yielding more precise estimates of parameters (and a person's true score)
  - Normalizing tendency

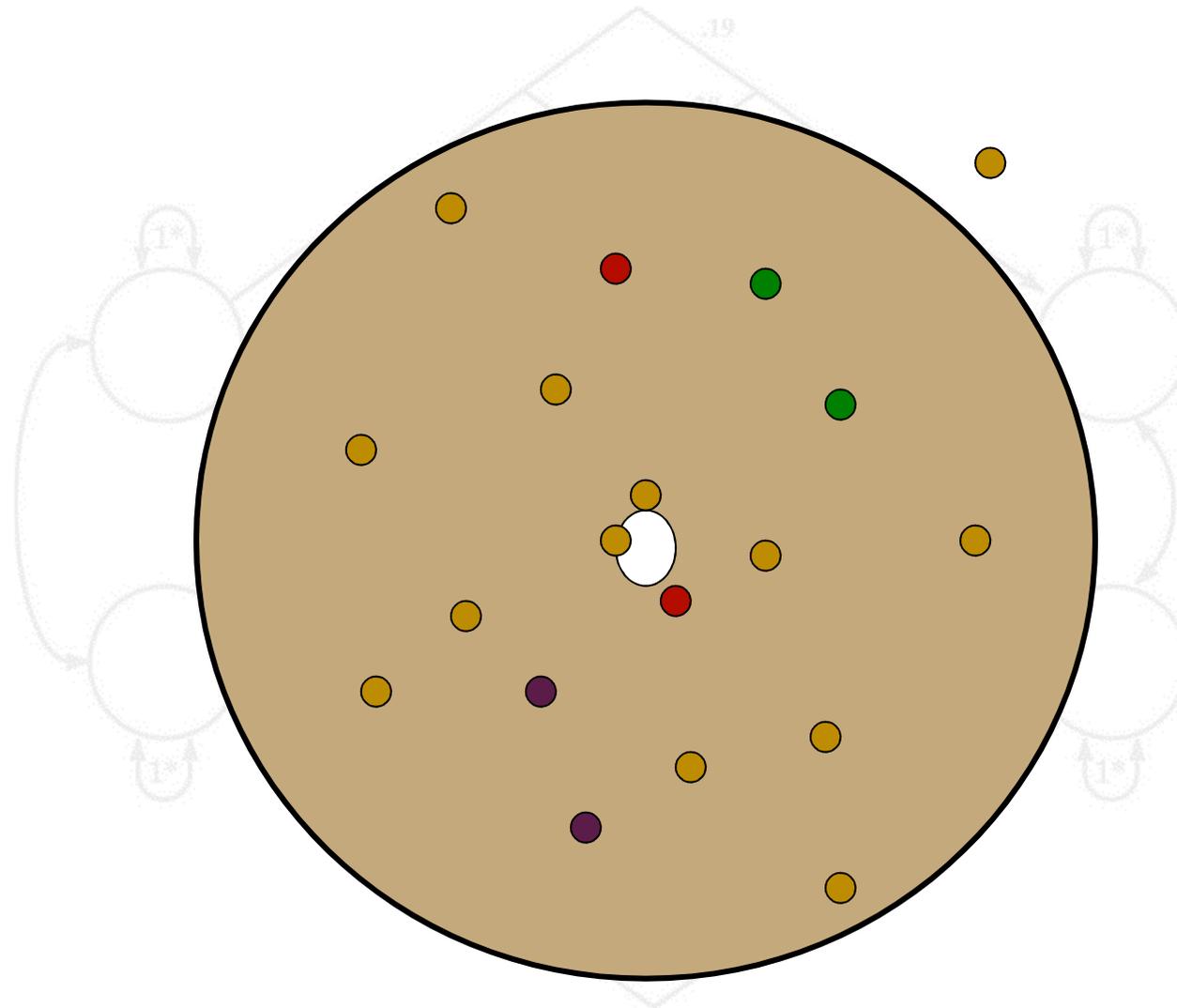
# Construct Space with Centroid



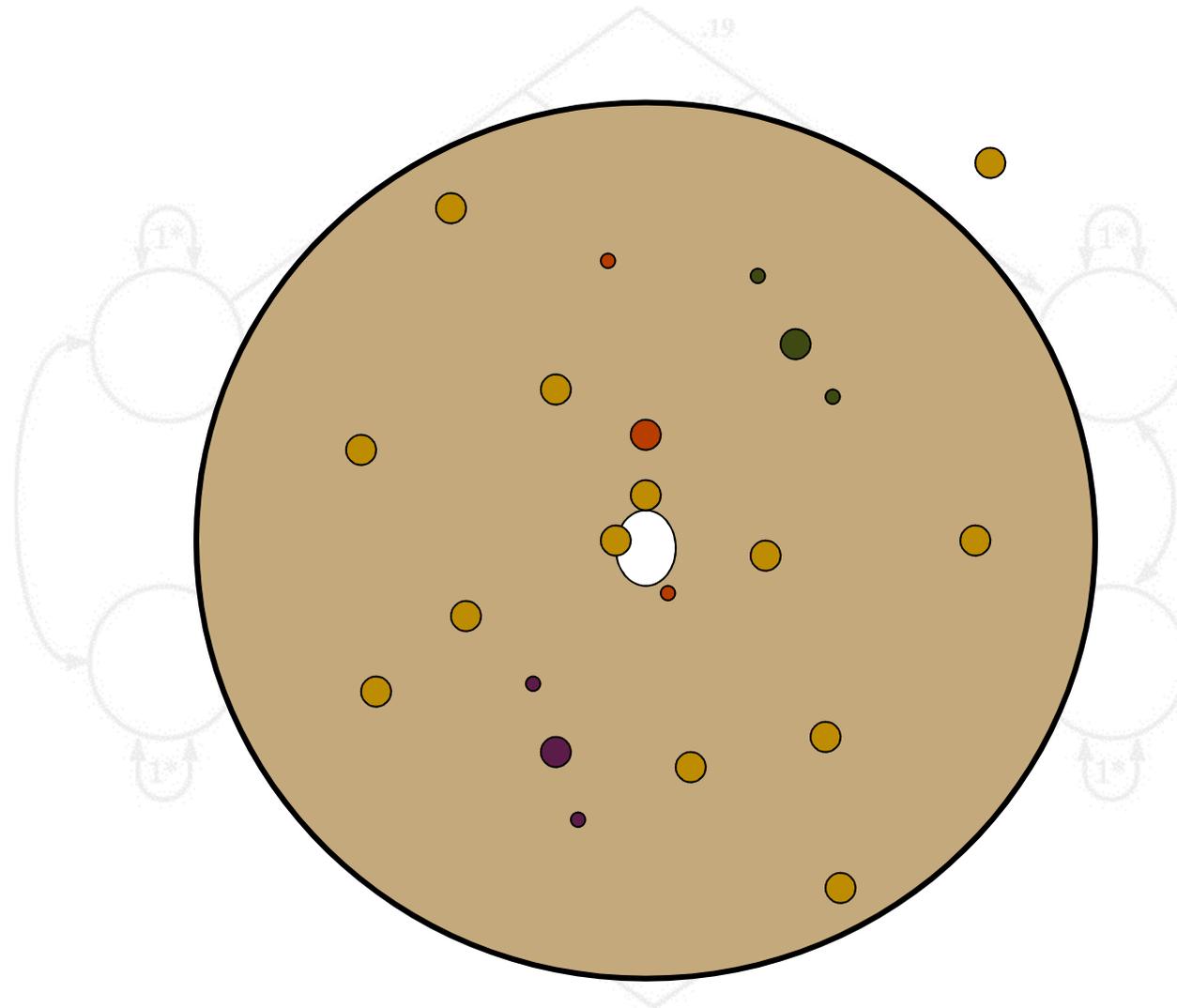
# Potential Indicators of the Construct



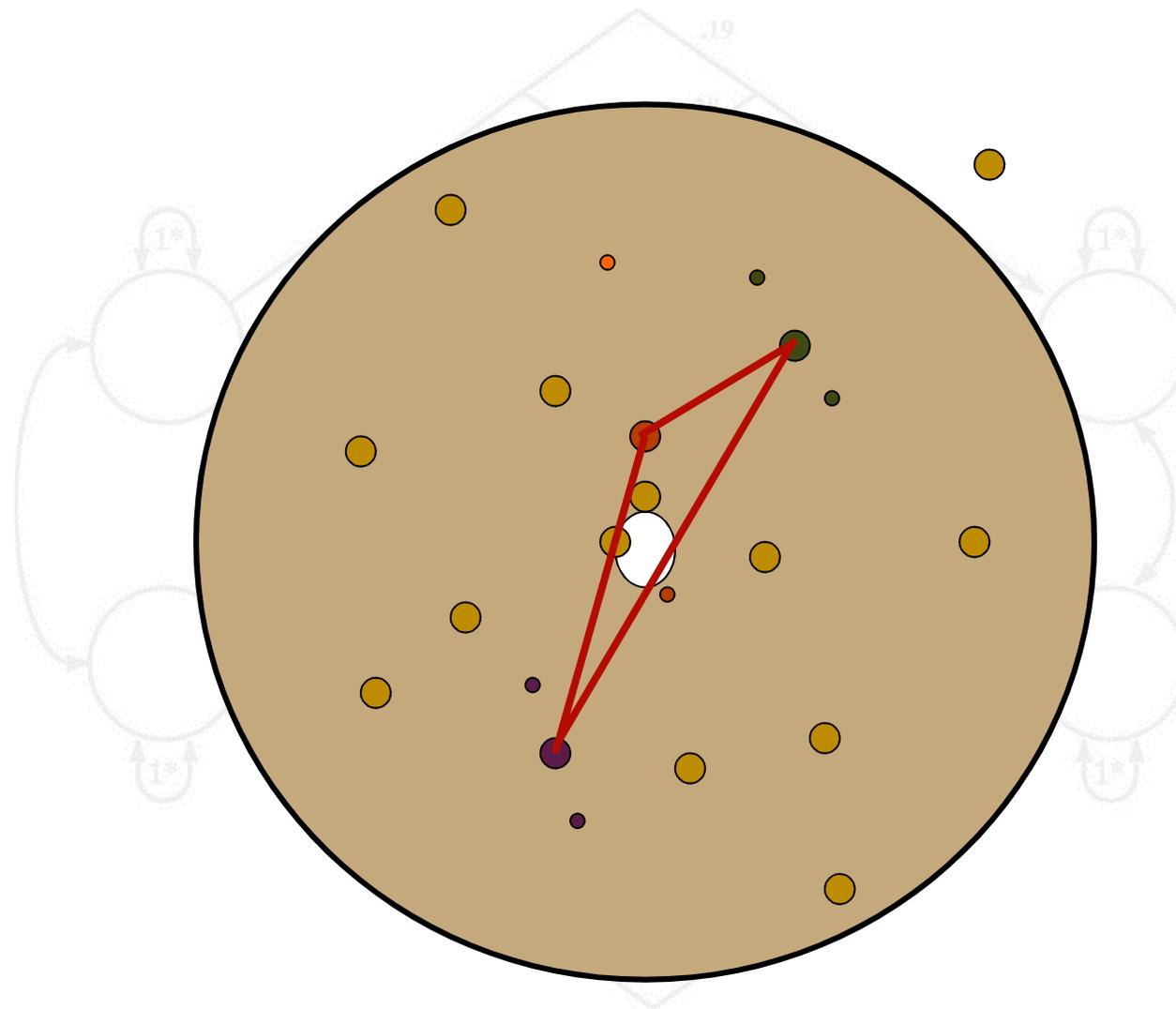
# Selecting Six (Three Pairs)



# ... take the mean



# ... and find the centroid



# Building Parcels



- **Theory – Know thy S and the nature of your items**
- **Balancing technique**
  - **Combine items with higher loadings with items having smaller loadings [Reverse serpentine pattern]**
- **Using a priori designs (e.g., CAMI)**
  - **Develop new tests or measures with parcels as the goal for use in research**
- **Random assignment of items to parcels when many indicators are possible (e.g., fMRI)**

# Techniques: Multidimensional Case



**Example: ‘Intelligence’ ~ Spatial, Verbal, Numerical**

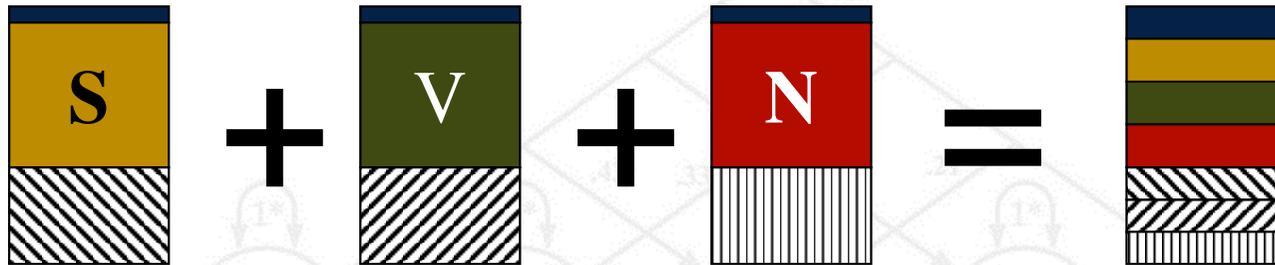
- **Domain Representative Parcels**

- Has mixed item content from various dimensions
- Parcel consists of: 1 Spatial item, 1 Verbal item, and 1 Numerical item

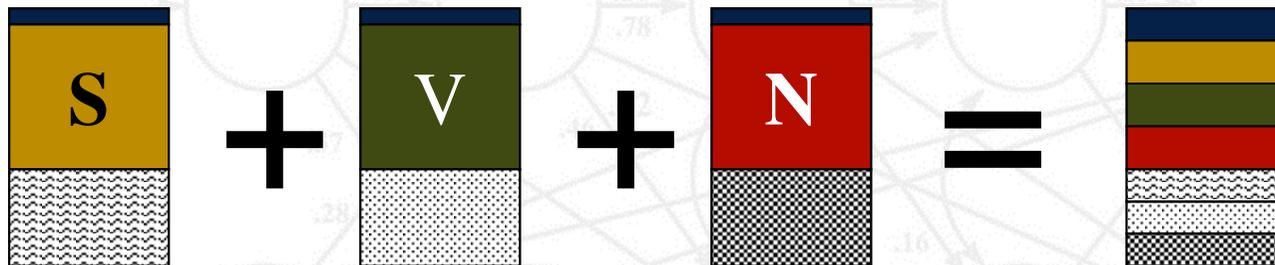
- **Facet Representative Parcels**

- Internally consistent, each parcel is a ‘facet’ or ‘subscale’ or singular dimension of the construct
- For example, 1 Parcel consists of all 3 Spatial items
- Recommended method – 99.9% of the time.

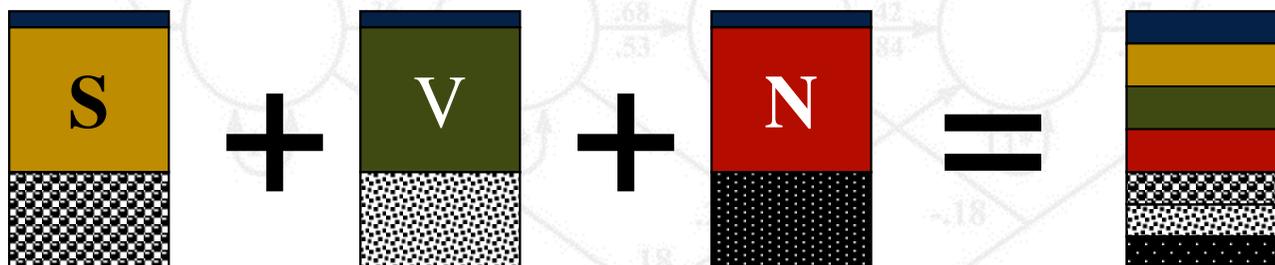
# Domain Representative Parcels



Parcel #1



Parcel #2



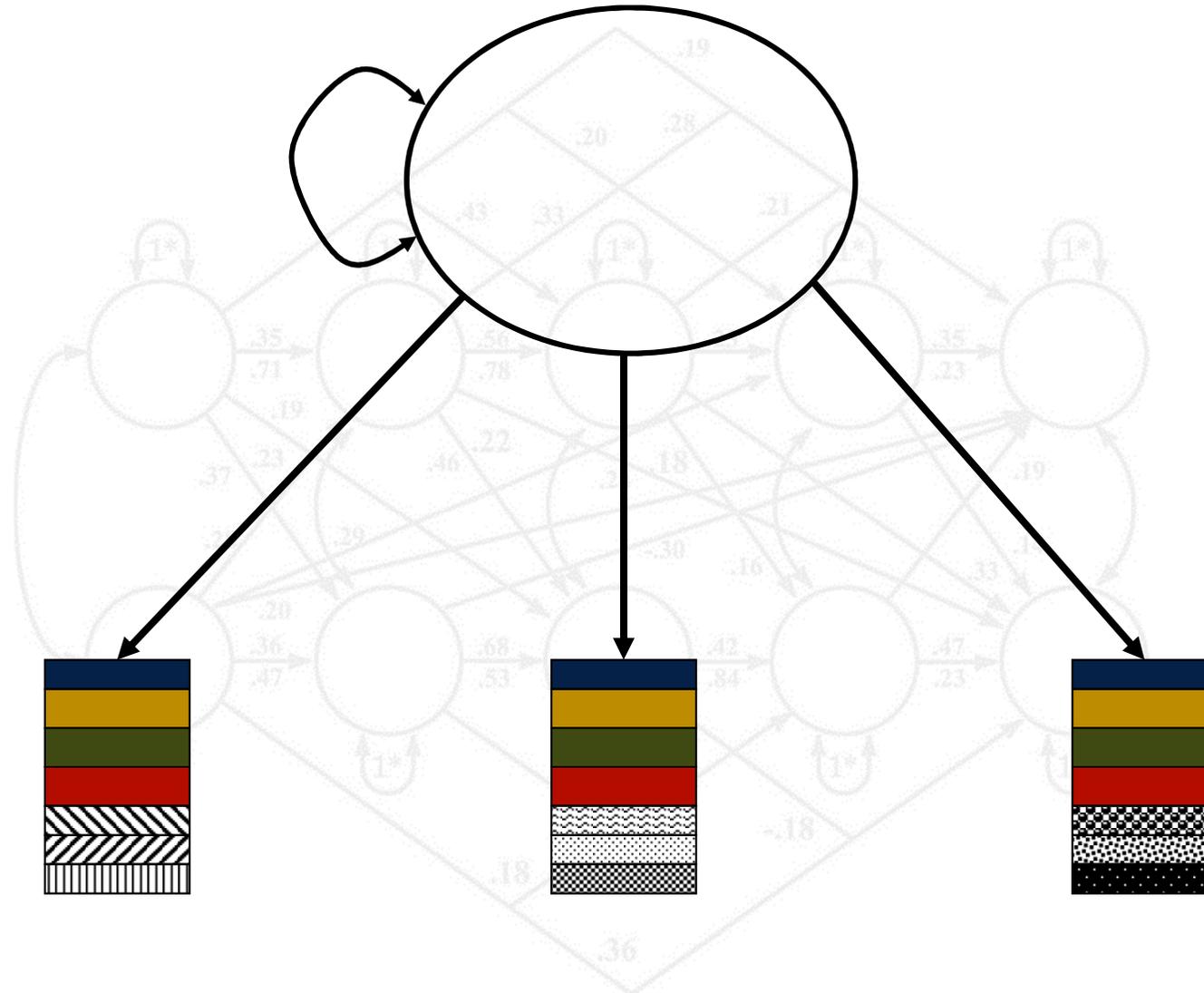
Parcel #3

Spatial

Verbal

Numerical

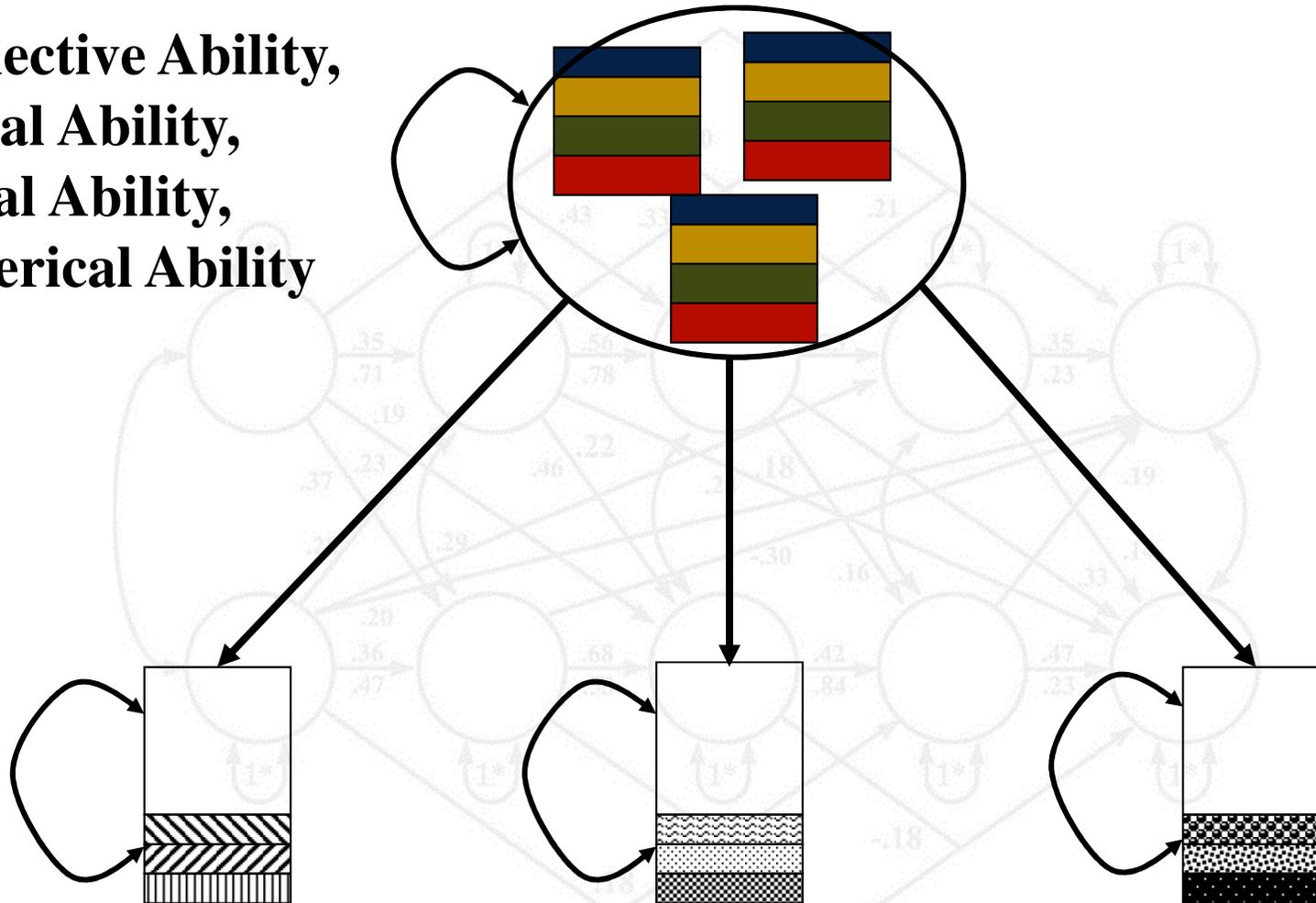
# Domain Representative



# Domain Representative

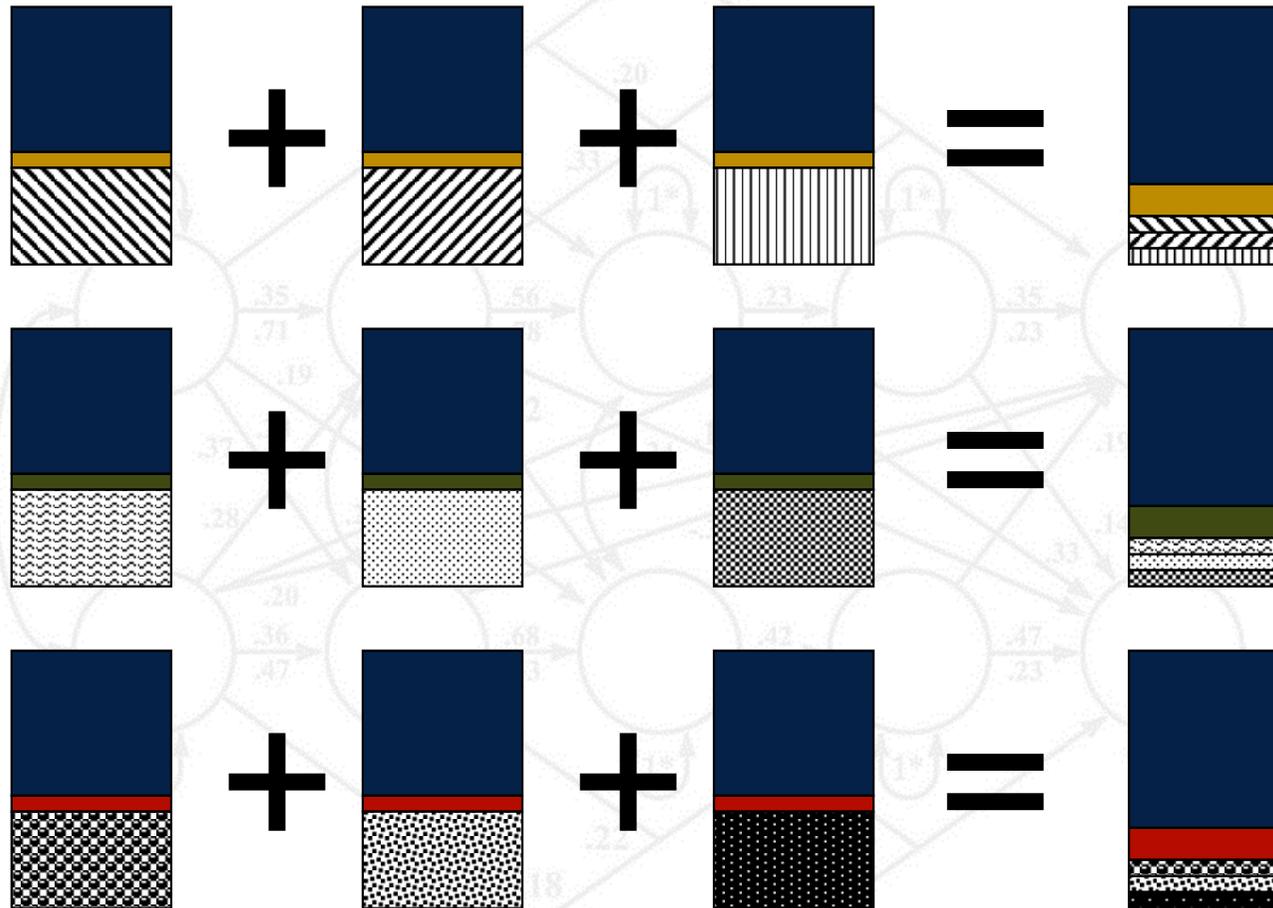


**Intellective Ability,  
Spatial Ability,  
Verbal Ability,  
Numerical Ability**



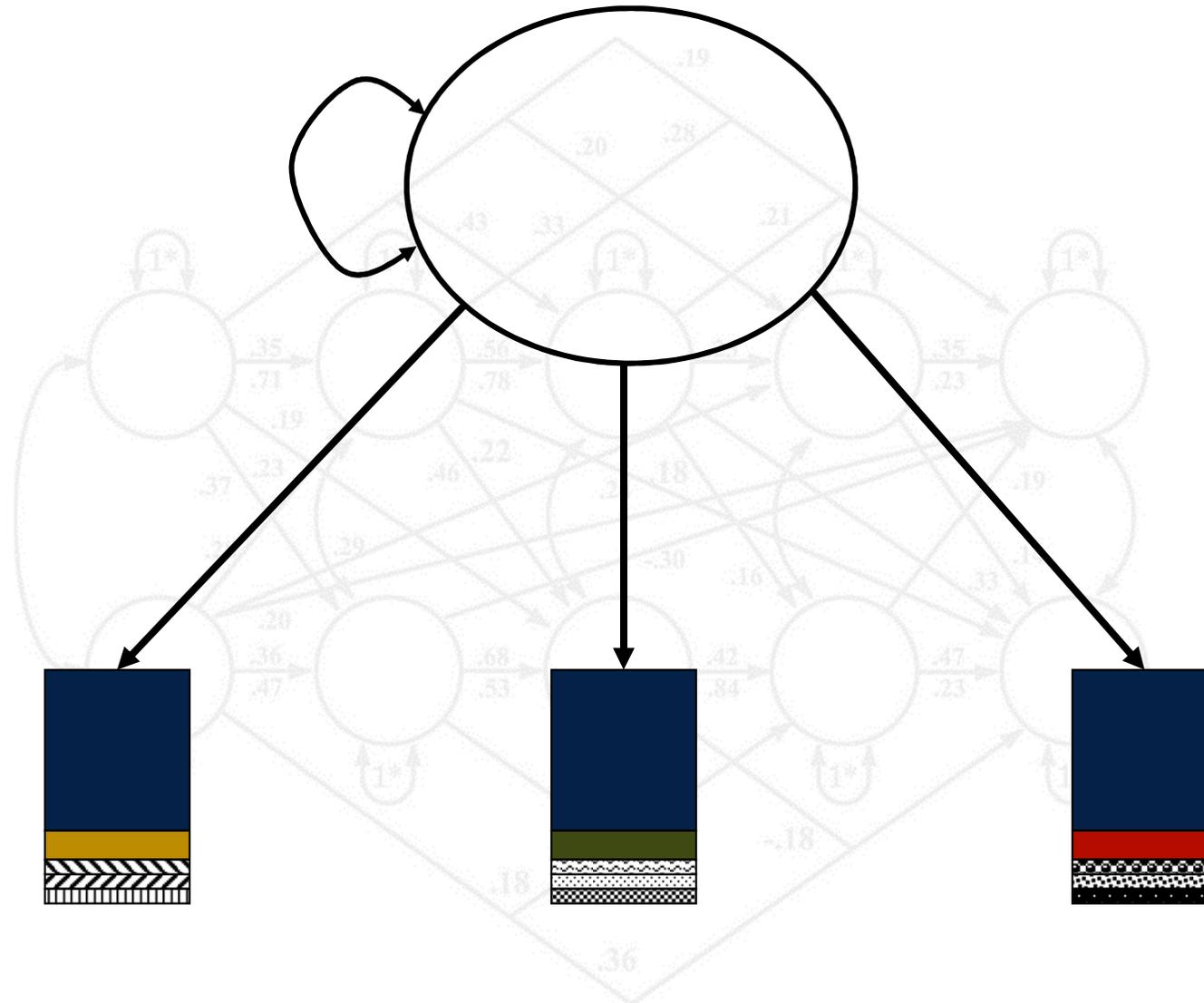
**But which facet is driving the correlation among constructs?**

# Facet Representative Parcels



**A more realistic case with higher communalities**

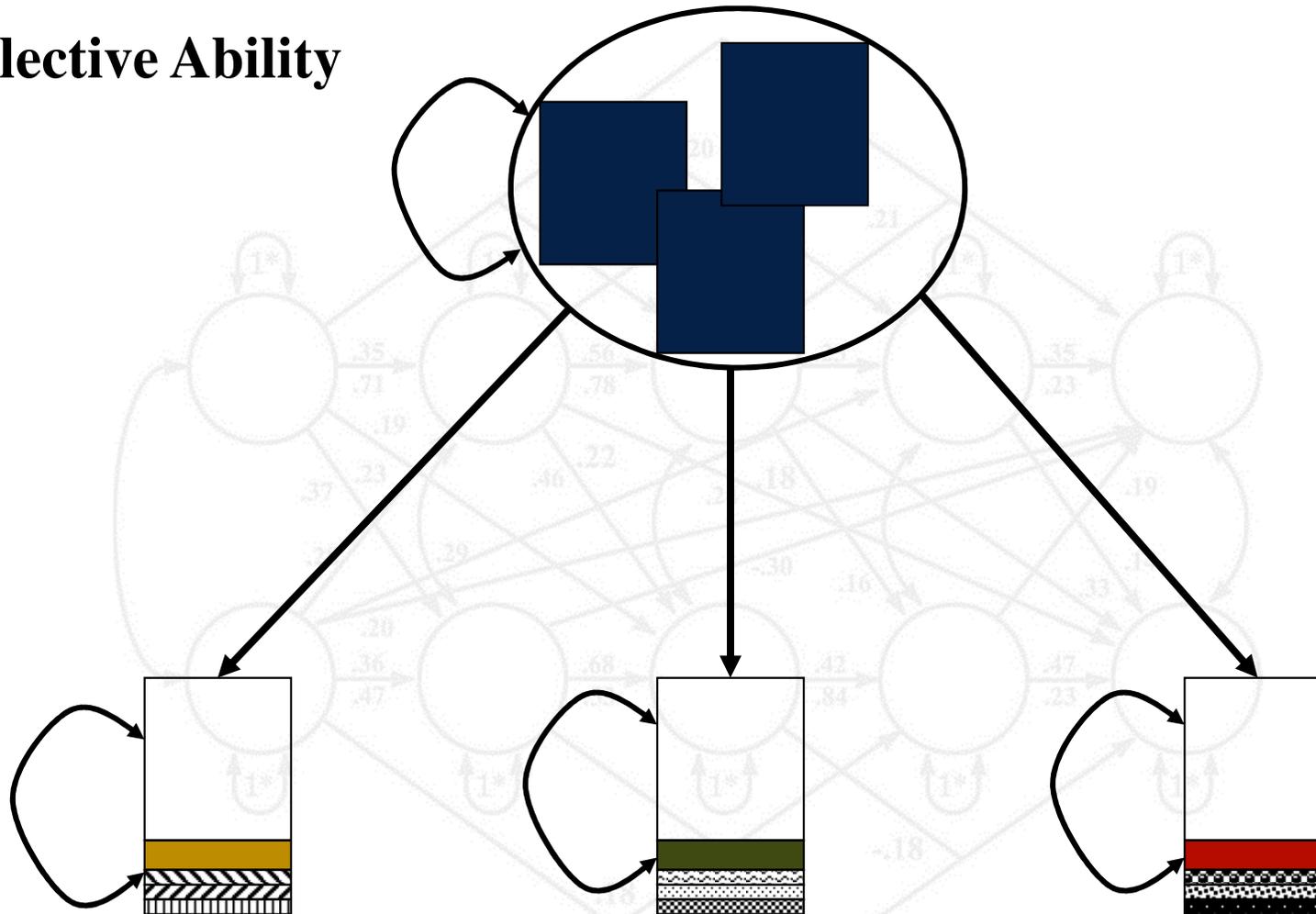
# Facet Representative



# Facet Representative



## Intellective Ability

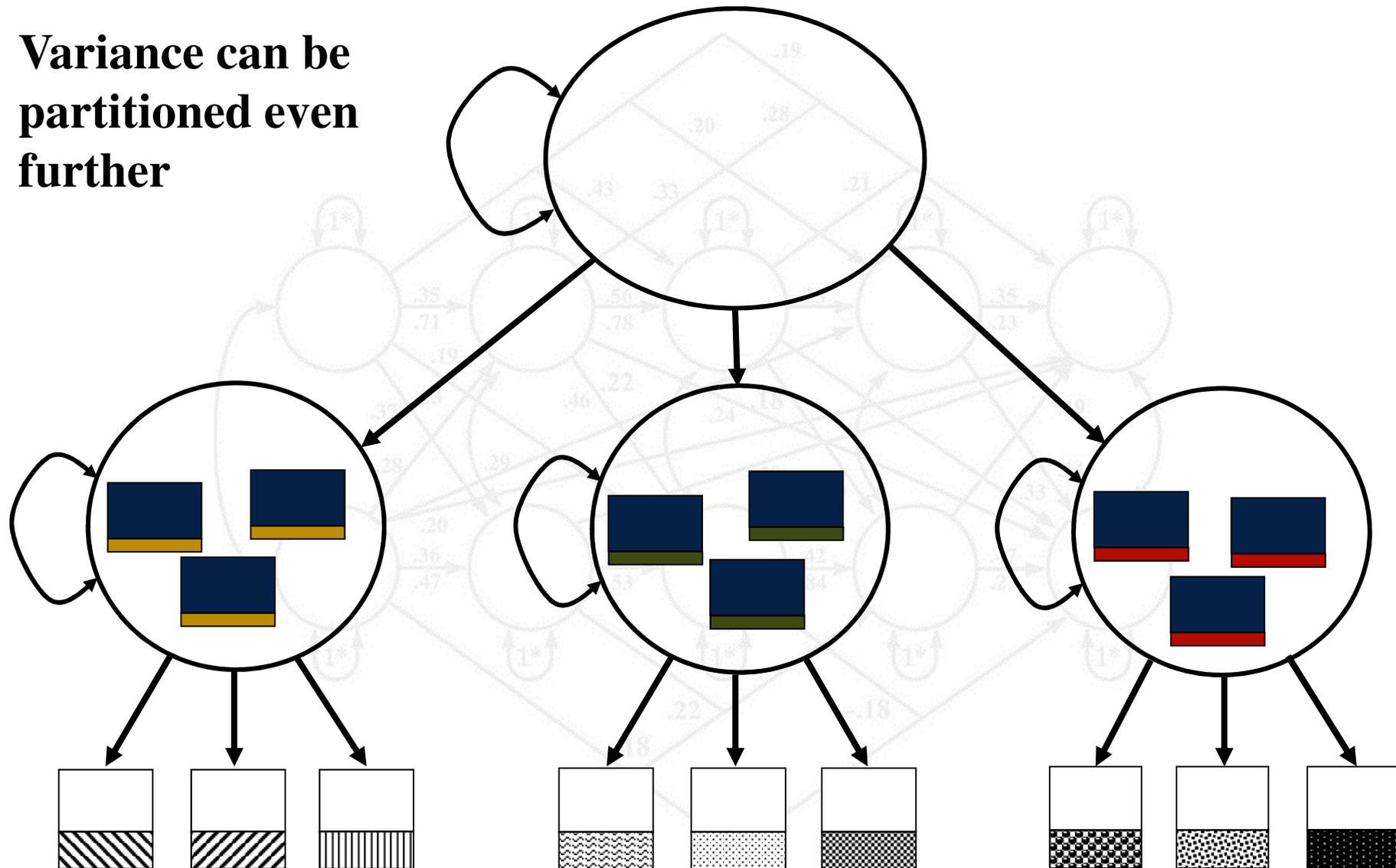


**Parcels have more reliable information**

# 2<sup>nd</sup> Order Representation



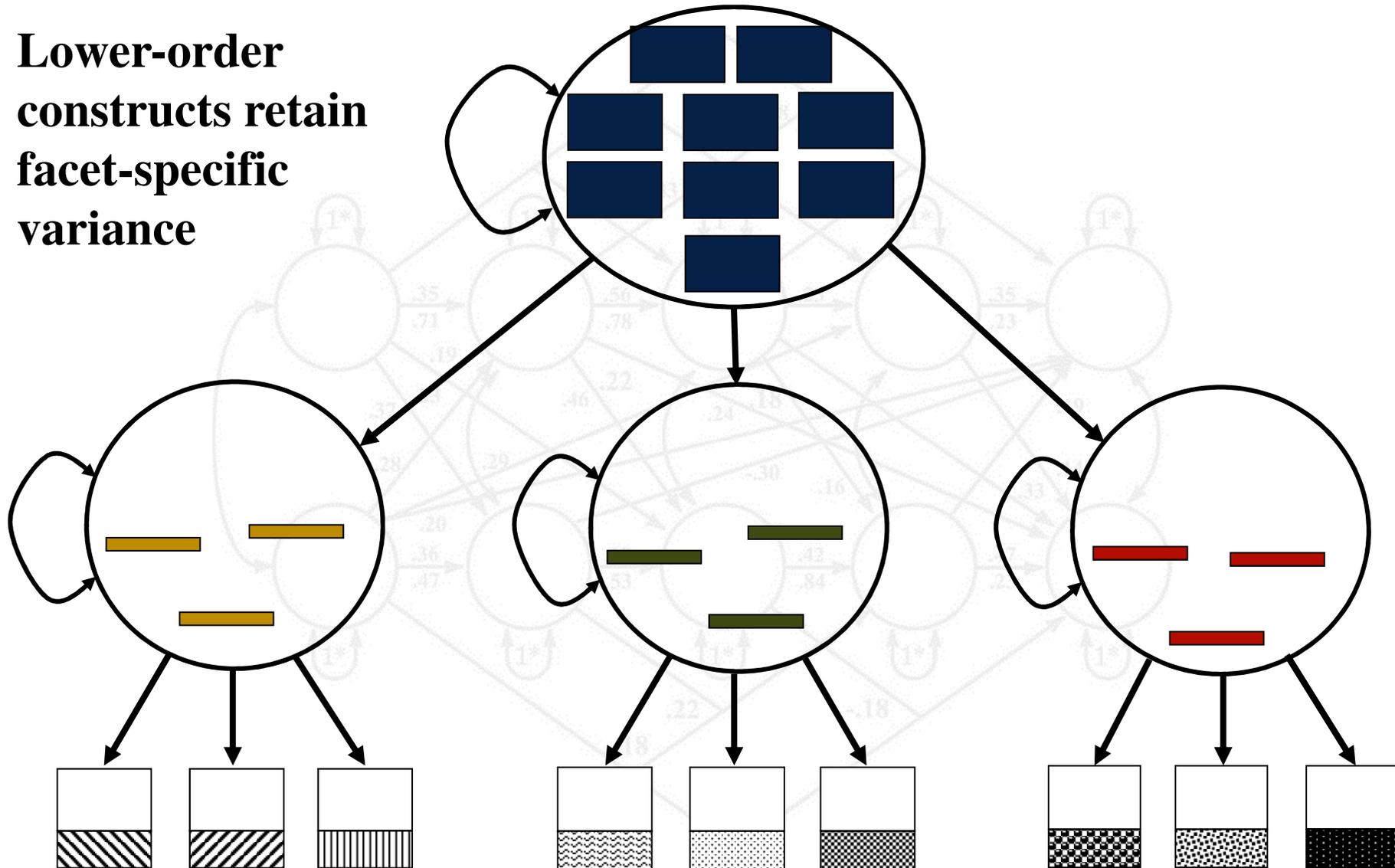
Variance can be partitioned even further



# 2<sup>nd</sup> Order Representation



Lower-order constructs retain facet-specific variance

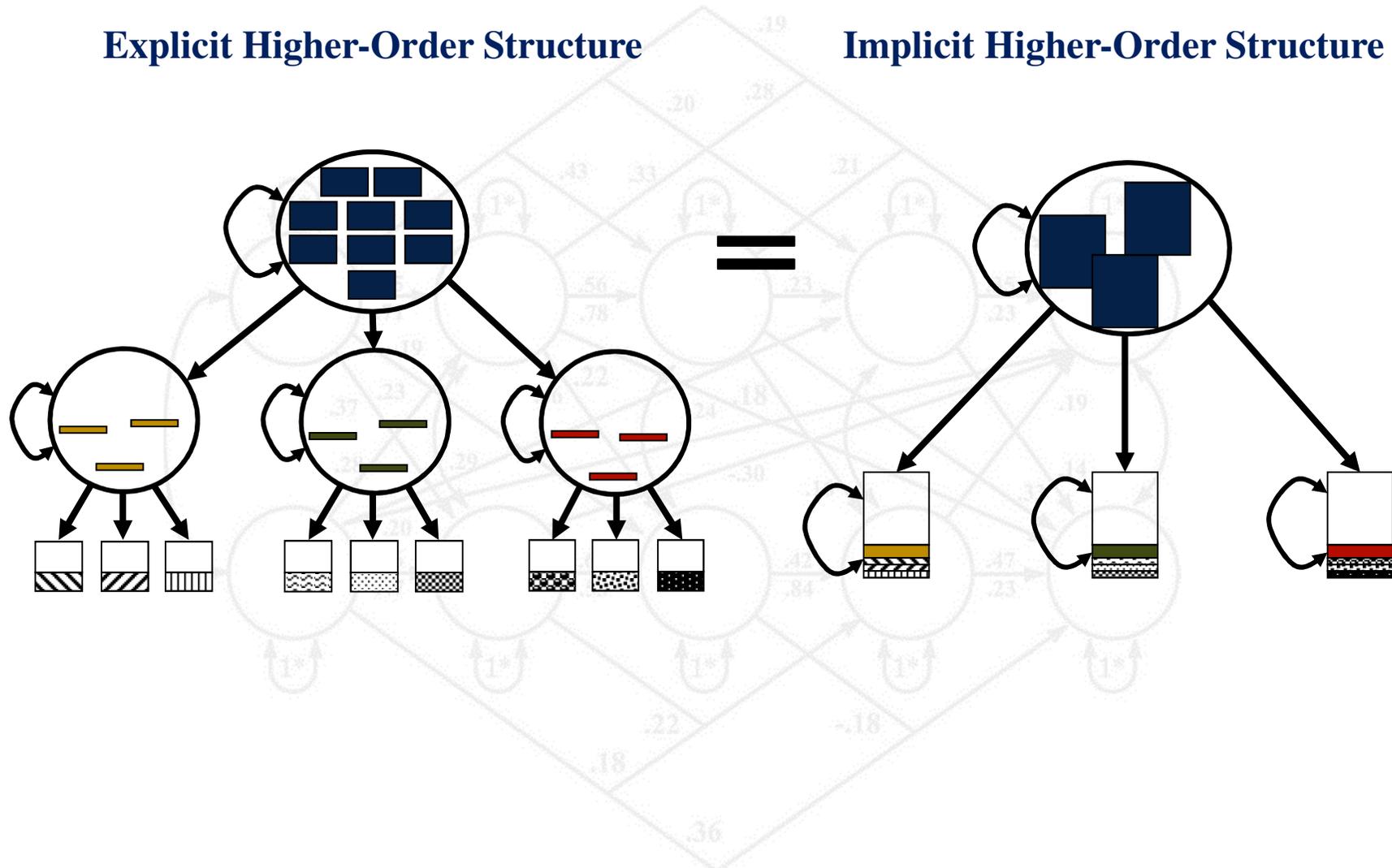


# Functionally Equivalent Models



Explicit Higher-Order Structure

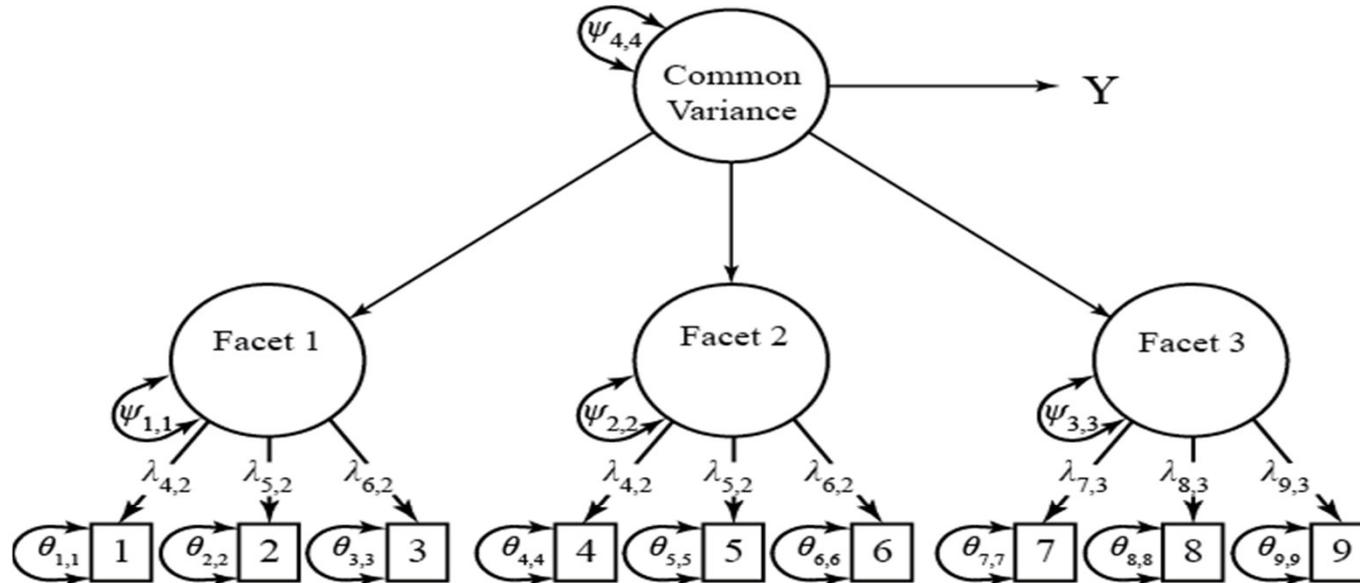
Implicit Higher-Order Structure



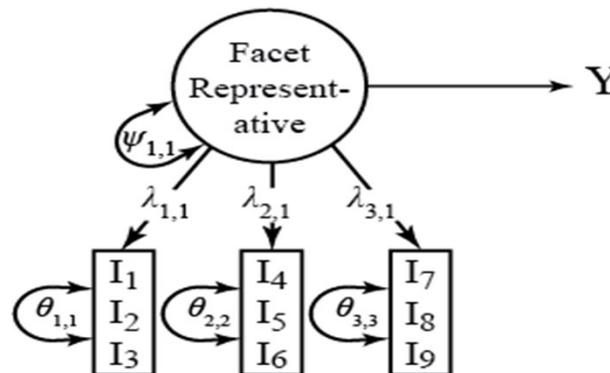
# When Facet Representative Is Best



A) A higher-order representation of three related constructs



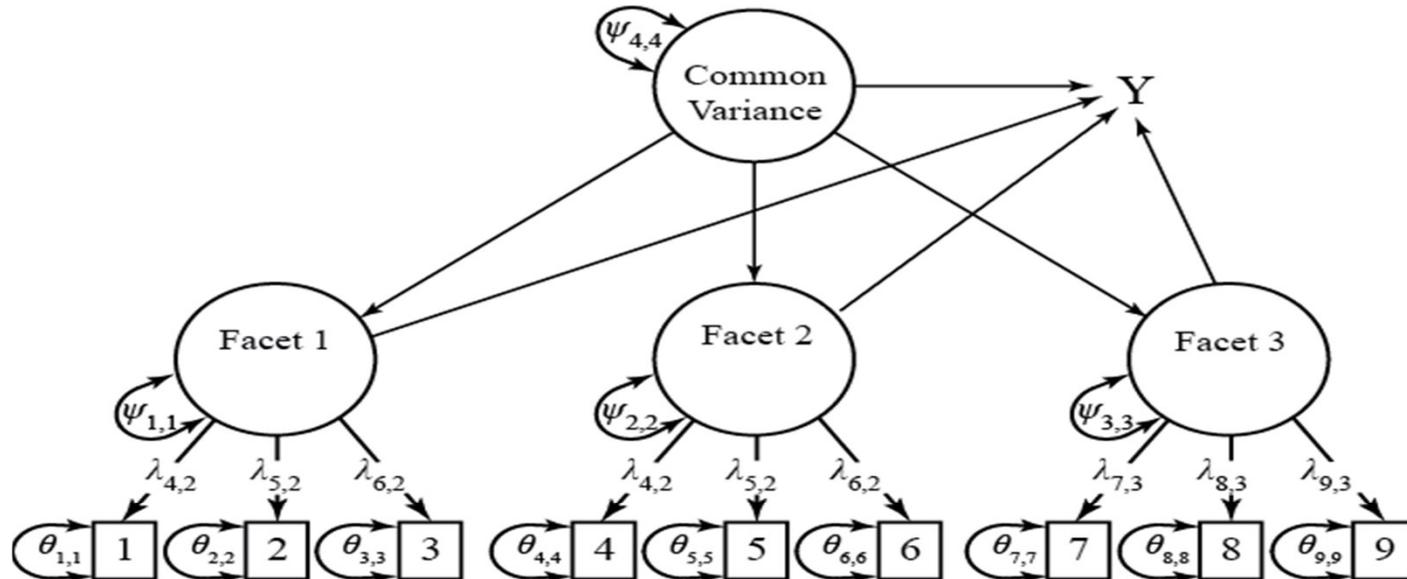
B) An equivalent facet-representative parcel-based version



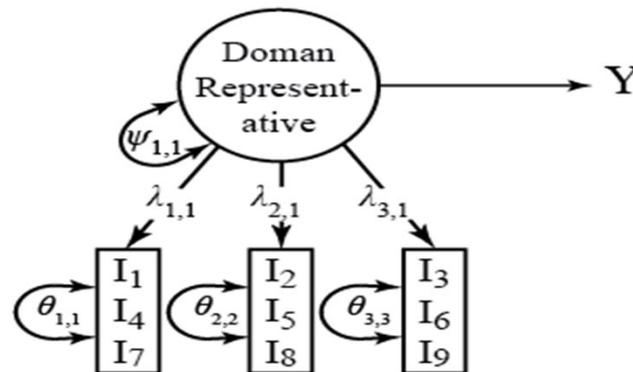
# When Domain Representative Is Best



A) A higher-order representation of three related constructs



B) An equivalent domain-representative parcel-based version



# Key Sources and Acknowledgements



- **Special thanks to: Mijke Rhemtulla, Kimberly Gibson, Alex Schoemann, Wil Cunningham, Golan Shahar, John Graham & Keith Widaman**
- **Little, T. D., Rhemtulla, M., Gibson, K., & Schoemann, A. M. (2013). Why the items versus parcels controversy needn't be one. *Psychological Methods, 18*, 285-300.**
- **Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling, 9*, 151-173.**
- **Little, T. D., Lindenberger, U., & Nesselroade, J. R. (1999). On selecting indicators for multivariate measurement and modeling with latent variables: When "good" indicators are bad and "bad" indicators are good. *Psychological Methods, 4*, 192-211.**