

Latent Variable Modeling of Cognitive Reserve

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ADC Data Core Meeting
October 10, 2009



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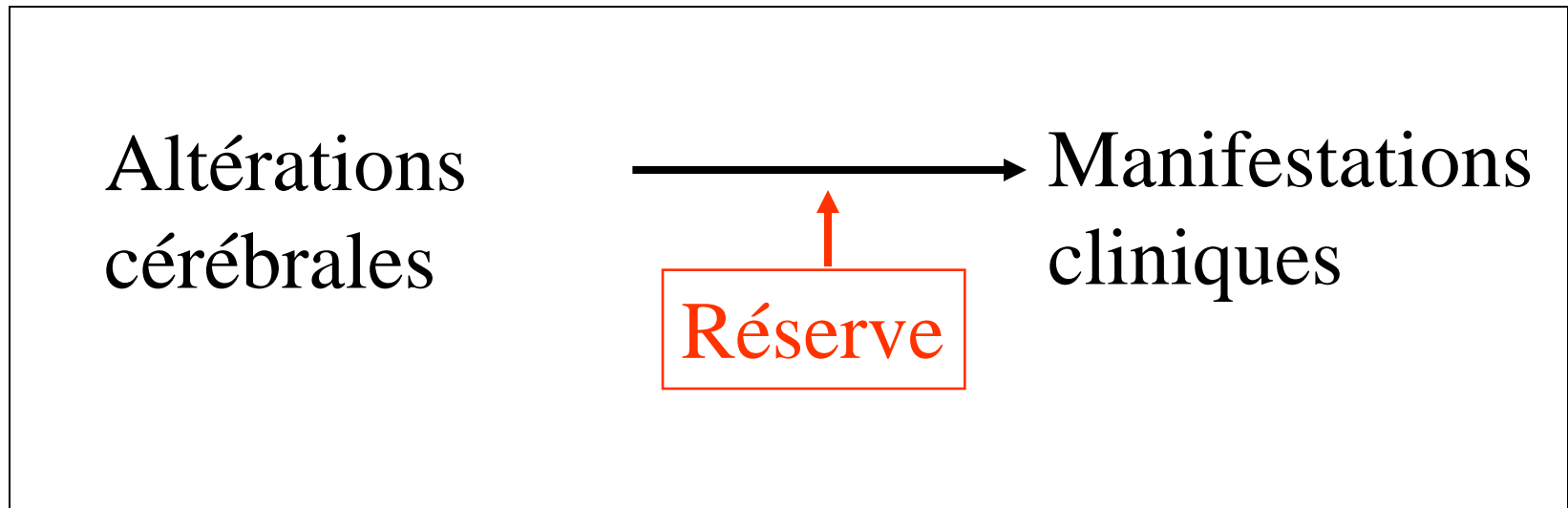
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Overview

- What is cognitive reserve?
- What is a latent variable?
- How has reserve been approached as a latent variable?
- Formative vs. Reflective Measurement of latent variables
- Opportunities in Rush studies of aging, cognition and dementia

Qu'est-ce que la réserve?



La réserve peut expliquer la disjonction entre le degré d'altération cérébrale et les manifestations cliniques de ces lésions.

From Yaakov Stern's *Cognitive Reserve: Conceptual and Scientific Background*. Friday Harbor Advanced Psychometrics Workshop. August 31, 2009. Used without permission, but I don't think he would mind. http://alzheimer.ucdavis.edu/fhpsych/points/Stern_Cognitive_Reserve.ppt.

Cognitive Reserve

- Encompasses the quantity, efficiency, and flexibility of the brain (neurons, networks)
- Allows persons to maintain function in the presence of pathology
- Called to explain educational and other socioeconomic and sociodemographic effects in cognitive decline and dementia
 - *low education level may be the most significant risk factor for the disease described to date (Mortimer and Graves, 1993 *Neurology* 43:S39-S44)*

Latent Variables

- Variables not directly observed
- Presence inferred from a mathematical or statistical model
- May or may not be conceived of as physically real constructs

Latent Variable Theory: Ontological Positions

- Realism
- Constructivist
- Instrumentalism
 - Operationalist

Denny Borsboom et al.

The theoretical status of latent variables. Psychological Review, 2003. **110**(2): p. 203-218.

Measuring the Mind. 2005. Cambridge University Press.

Realism

- The latent variable exists independent of measurement
- For example
 - Electrons prior to 1897
 - Dark matter/energy nowadays
 - Francis Galton's view of intelligence
- An implementation of a correspondence view of truth
- Only view of latent variables that results in a logically consistent philosophy of measurement science

Constructivist

- The latent variable is a construction of the human mind
 - The construct is a socially agreed upon concept negotiated by practicing scientists
 - An anti-realist view
 - For Example
 - SJ Gould's view on *intelligence*

Borsboom, Mellenbergh *et al.*, 2003 *Psychol Rev* 110:203-18

Gould SJ. The Mismeasure of Man. 1981.

Operationalist

- **Operationalist and Instrumentalist**
- The latent variable is nothing more than a mathematical abstraction
- Similar to constructivism, but
 - broader and
 - empirically based
- For example
 - Gould's view on *IQ*

Borsboom, Mellenbergh *et al.*, 2003 *Psychol Rev* 110:203-18

Gould SJ. The Mismeasure of Man. 1981.

Cognitive Reserve

- We have no direct measure of reserve,
- So it is a latent attribute, a hypothetical construct
- Adopt a realist philosophy
- Identify measures of CR

Proxies for Reserve

Valenzuela and Sachdev, 2006 *Psychol Med* **36**:441-54

Valenzuela and Sachdev, 2006 *Psychol Med* **36**:1065-73

Number of articles cited by outcome and proxy class.

	Dementia	Cognitive Decline
Education	16	13
Occupation	12	4
Mental Activities	6	6
Premorbid IQ	2	NA

There is a conceptual problem with measures of crystallized ability, such as reading tests, which are used by some investigators to operationalize or measure concepts such as “Premorbid IQ” and by other investigators to operationalize educational quality (e.g., Christensen, Hofer et al., 2001 *Psychol Med* 31:15-28; Manly, Byrd et al., 2004 *Int J Psychol* 39:47-60).

Reflective Measurement

The latent variable
CAUSES
the observables

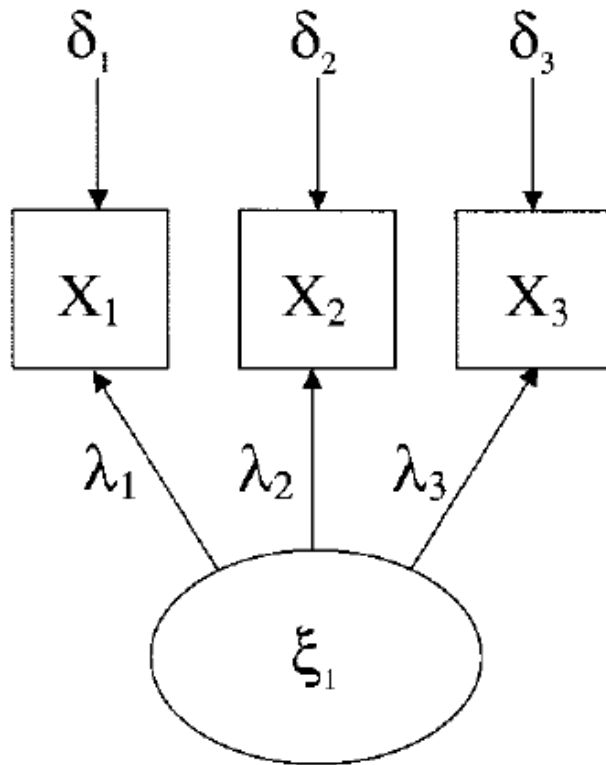


Figure 1. Two models for measurement. The left panel is the reflective measurement model. The X s are observed variables, ξ is the latent variable, λ s are factor loadings, and the δ s are error terms. The right panel shows the formative model. The latent variable is denoted η , the γ s are the weights of the indicators, and ζ is a residual term.

Formative Measurement

The latent variable
IS CAUSED BY
the observables

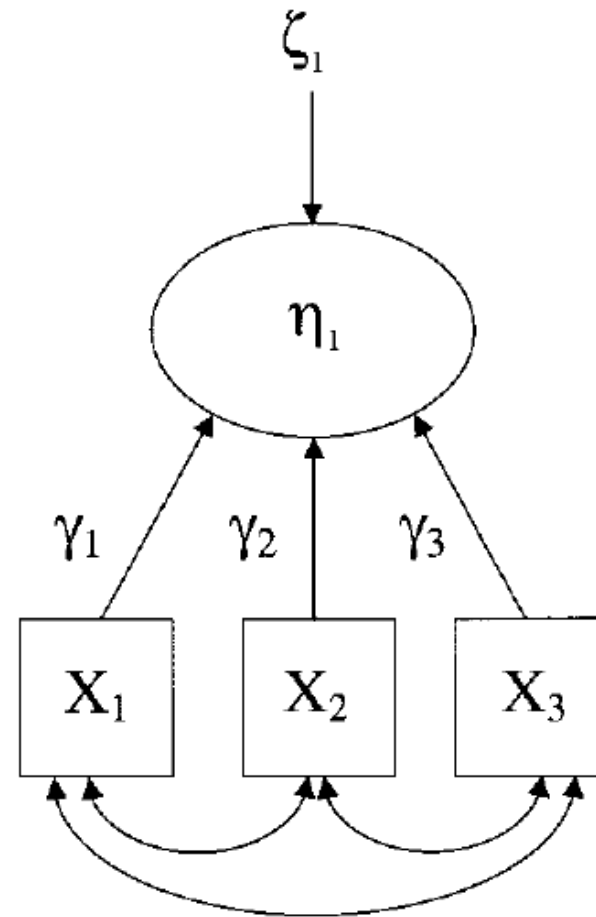


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Siedlecki, Stern et al., 2009 *J Int Neuropsychol Soc* 15:606-12

PPVT - Picture Vocabulary Test
WRAT/WAT - Performance on the reading subtest of either the WRAT or the WAT.

Each of these variables presumably reflects life experiences, above and beyond that of age, that have the potential to provide protection against Clinical manifestation of disease in the brain and has been used in the literature as a proxy for cognitive reserve.

See also
Scarmeas, Zarahn et al., 2004
Arch Neurol 61:73-8

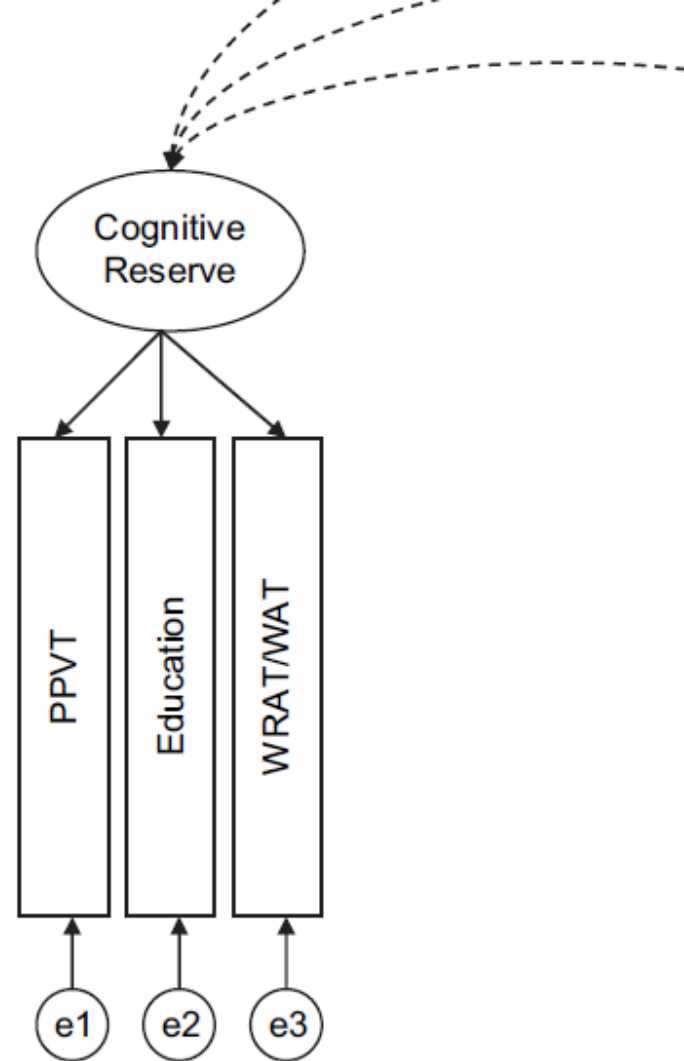


Fig. 1. Four-factor Model B of the construct v latent variables (represented by circles) represented by rectangles. The single-headed arrow loading of each task on the latent variable. The ated with each observed variable.

Mueller and Parcel. Measures of socioeconomic status: Alternatives and recommendations. 1981 *Child Dev* 52:13-30

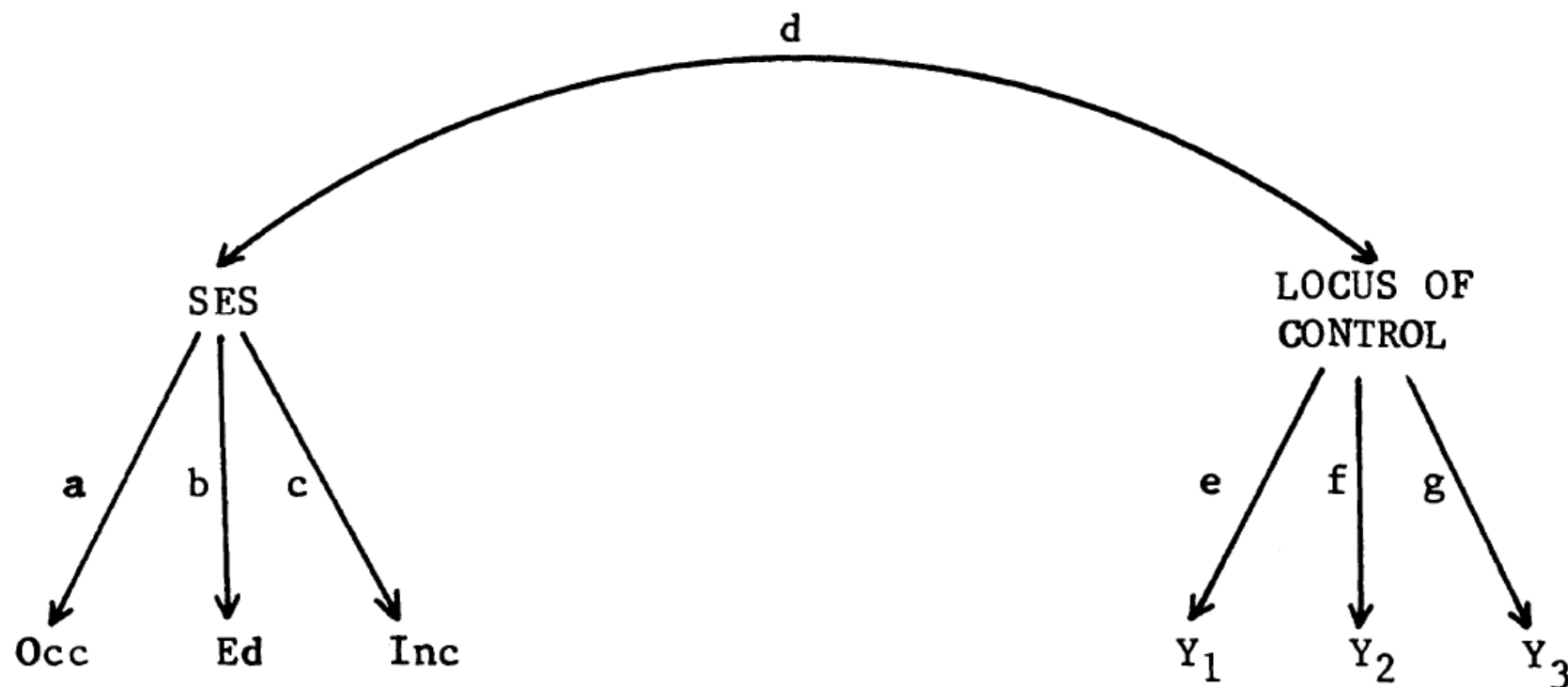


FIG. 1.—Multiple indicators model representing the correlation between SES and locus of control.

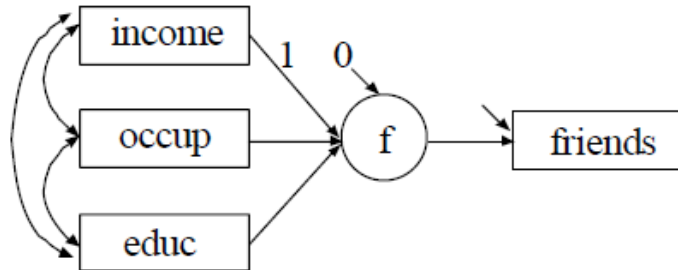
¹⁰ This representation suggests that SES “causes” occupation, education, and income. This may be misleading, since sociologists usually view SES as a composite of standing on occupation, education, income, and other status dimensions. Thus, as one reviewer has suggested, it is perhaps more appropriate to view the relationships in terms of a canonical model where the causal arrows go from the indicators to the SES construct. However, the formulation shown in fig. 1 has been used in empirical research (Jöreskog & Sörbom 1978; Sörbom & Jöreskog, Note 4).

Mueller and Parcel. Measures of socioeconomic status: Alternatives and recommendations. 1981 *Child Dev* 52:13-30

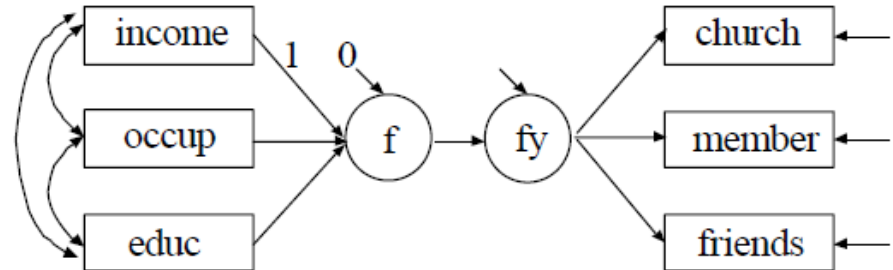
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Formative Indicators

Model 1

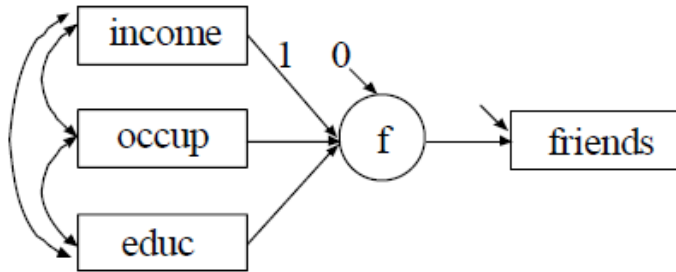


Model 2

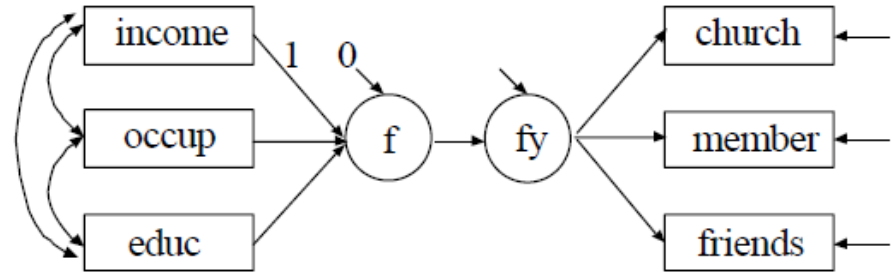


Formative Indicators

Model 1

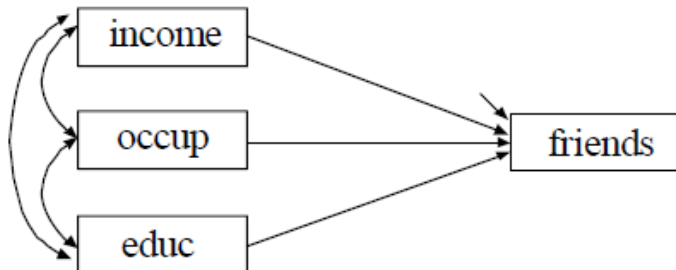


Model 2

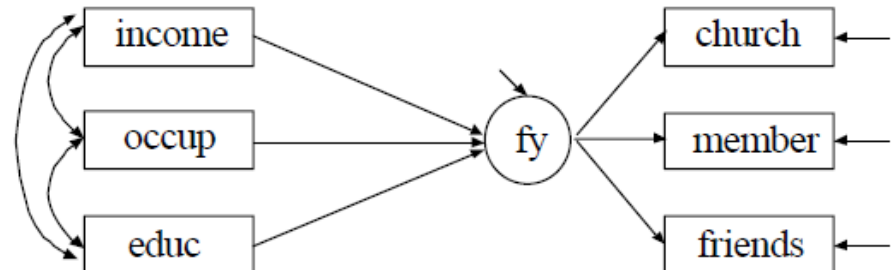


Equivalent Models

Model 3



Model 4



Data Analysis MAP

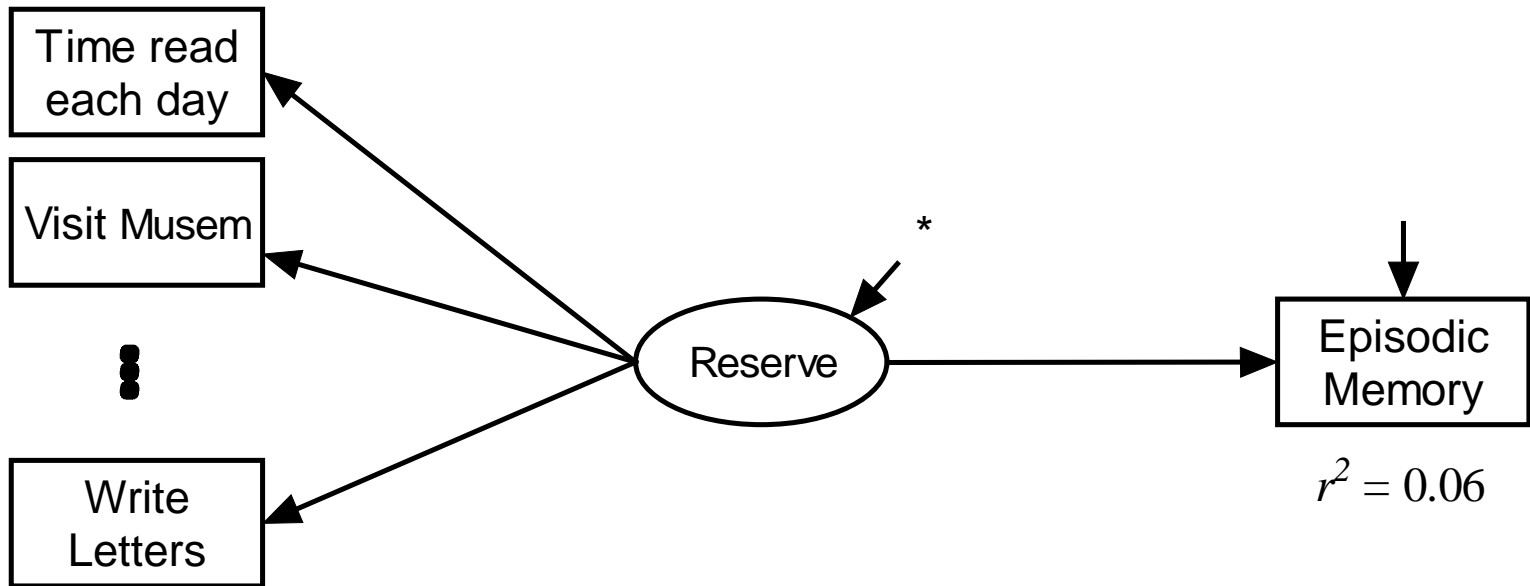
Memory and Aging Project

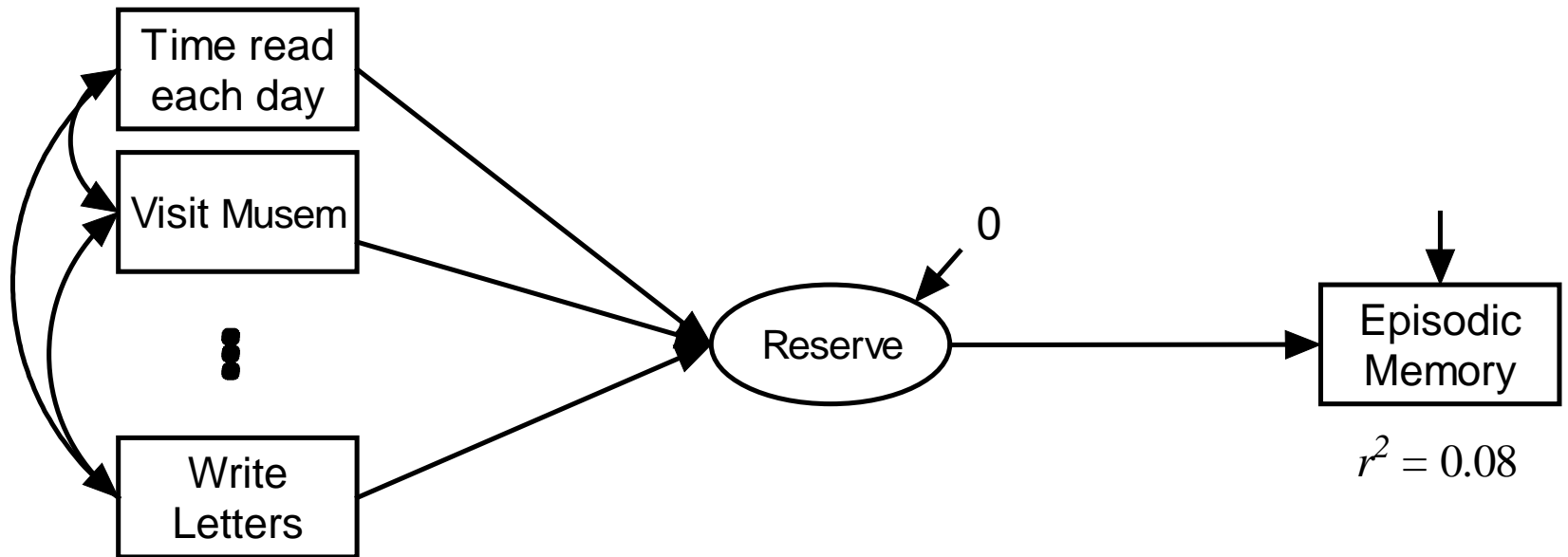
Bennett, Schneider et al., 2005

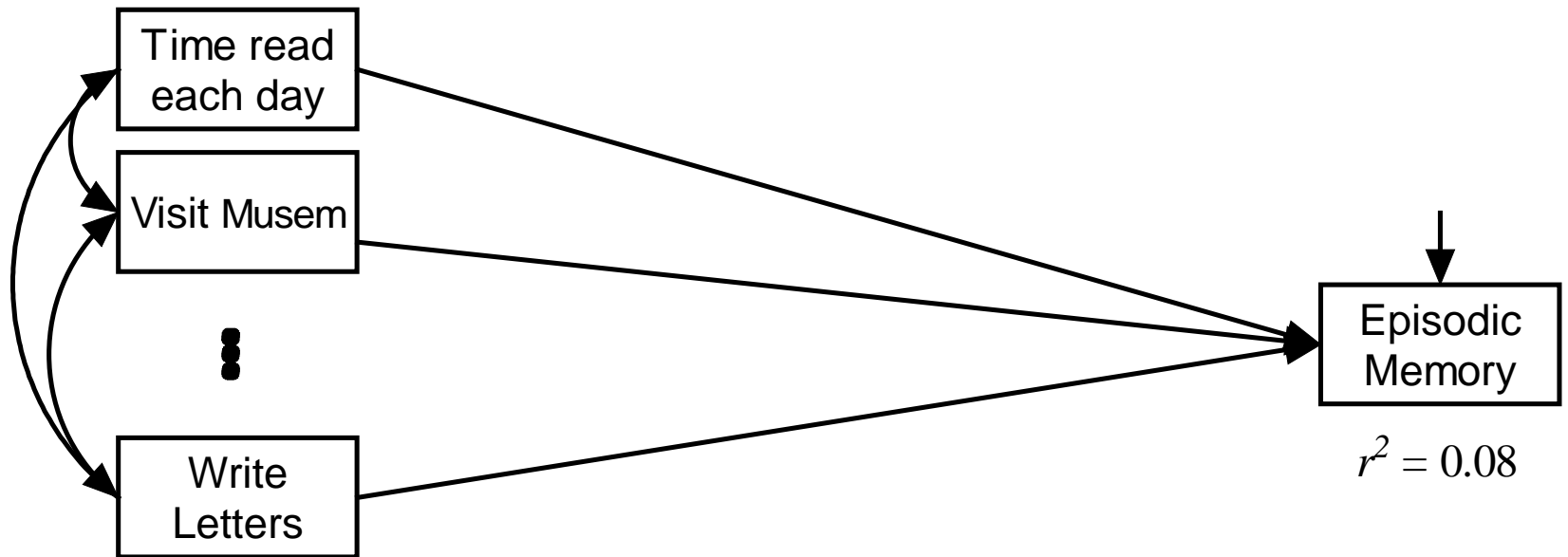
Neuroepidemiol **25**:163-75

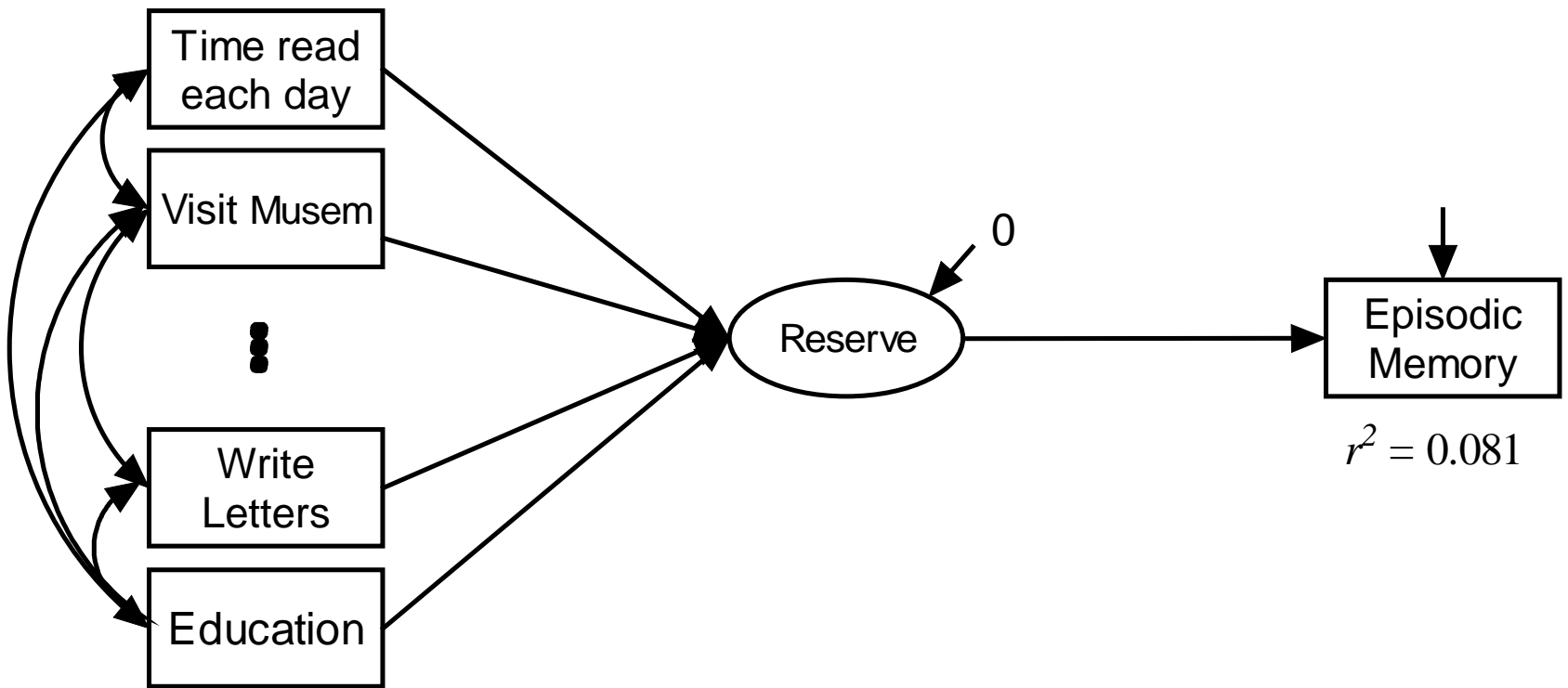
Memory and Aging Project

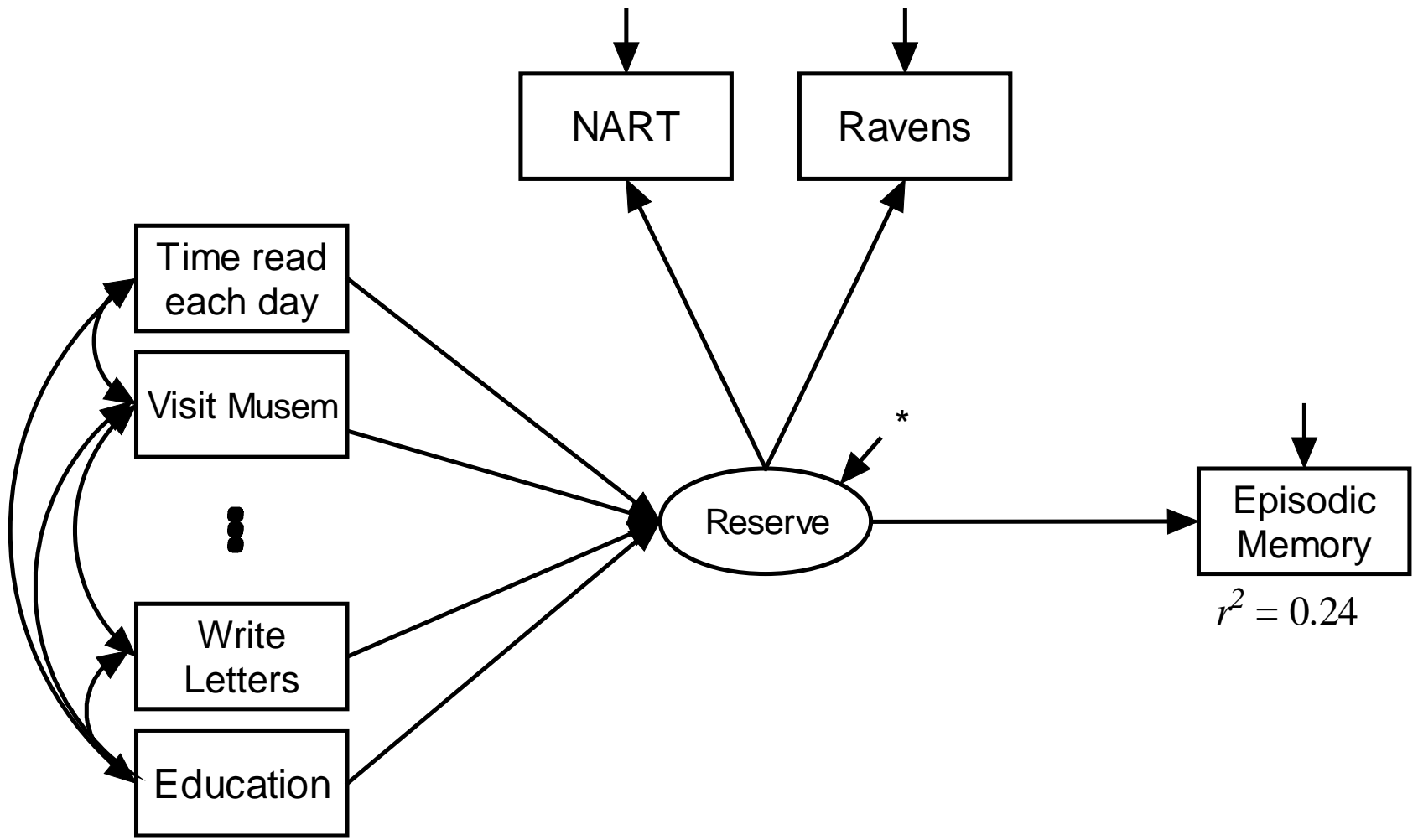
- Longitudinal study of cognitive aging and dementia among Chicago area older adults (N>1000)
- Among many other things, measures of
 - Neuropsychological functioning
 - Lifetime participation in cognitive activities
 - Sociodemographics
 - Neuropathology at autopsy











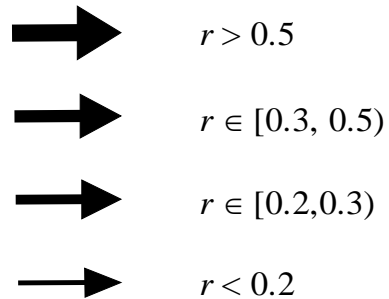
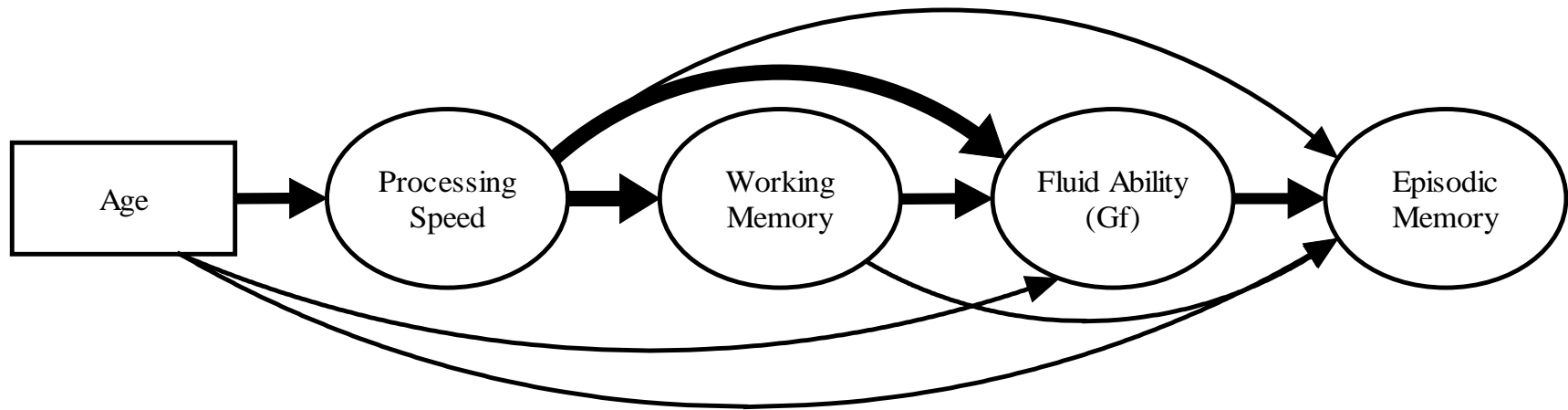
Future Directions

- Clarify theory of cognitive reserve
 - Formalize ontological argument
 - Does CR exist?
 - How is CR measured?
 - How does CR produce variance in reflective measures?
 - Set forth testable hypotheses

Future Directions

- Clarify theory of cognitive reserve in the context of observational studies
- **Embed theory of reserve in a developmental psychology framework**

Processing Resource Model for age differences in cognitive performance



See

Salthouse, 1996 *Psychol Rev* 103:403-27

Verhaeghen and Salthouse, 1997 *Psychol Bull* 122:231-49

Hertzog, in New frontiers in cognitive aging Dixon et al., Eds. 2004, pp. 41-64.

Boyle, Wilson et al., 2008 *Neurology* 70:1534

Future Directions

- Clarify theory of cognitive reserve in the context of observational and experimental studies
- Embed theory of reserve in a developmental psychology framework
- Incorporate future advances in neuroimaging (especially generally available *in vivo* measures of neuropathology)

Cognitive Reserve Research

- Does CR exist?
- How can it be measured?
- How are the concepts of reserve connected to its measures?
- How does reserve produce its reflective measures?

