General Introduction

to Structural Equation Modeling and Its Application

Outline

- General characteristics
- A short history
- The latent – manifest contrast
- The priority of theory
- The specificities of the model
- The need to be complete
- The step from the manifest to latent levels
- The graphical potential

General characteristics

A. Methodological background

- **Structural Equation Modeling** is a general approach for the statistical analysis of **social-science data** that highlights the use of **latent variables**

  (→ ***Latent variables modeling***)

- An important characteristic of this approach is the focus on **non-observable random variables** that represent theoretical **constructs**

- It incorporates **factor-analytic techniques** and **methods of regression analysis**

B. The denotation

- Modeling latent variables (also applies to the IRT and ML approaches)

- Structural equation modeling

- SEM (*S*tructural *e*quation *m*odeling)

- Confirmatory factor analysis

- CFA (*C*onfirmatory *f*actor *a*nalysis)

Outdated denotation:

- LISREL: *Li*near *s*tructural *rel*ationships

- LISREL als program package

C. The basic concepts

- a ***variable***:

….. a ***place holder*** that can take different values or levels or states

…. is something unknown

…. must be defined (for being psychologically useful)

… in psychological applications variables are usually restricted to real numbers or integers or categories

C. The basic concepts

- a ***variable***:

….. a ***place holder*** that can take different values or levels or states

…. it is something unknown

…. it must be defined (for being useful)

…. it is often used for representing something

- a ***construct***:

…. a theoretical concept / an idea

…. is a concept of science

…. is a concept that has been shaped as the result of conducting research

e.g. competency, extraversion, mathematical reasoning

C. The basic concepts

- *relationships according to **mathematical structures***
- an example:

… one of many possible mathematical structures of y, a, b …

$$y = a + b$$

variables

we can add meaning by defining variables!

C. The basic concepts

- *relationships according to* ***mathematical structures***
- an example:

$$y = a + b$$

Using ***constructs adds (psychological) meaning***

reasoning ability

numeric reasoning ability

logical reasoning ability

D. Characteristic features of SEM

- a multivariate method for data analysis (in contrast to multiple methods)

$$\left.\begin{array}{l} y_1 \\ y_2 \\ \cdots\cdot \\ y_p \end{array}\right\} \boxed{= \ldots}$$

D. Characteristic features of SEM

- a multivariate method for data analysis
- a confirmatory method (… explained in one of the following sections)

D. Characteristic features of SEM

- a multivariate method for data analysis
- a confirmatory method
- consideration of multiple indicators

e.g. *construct*: ~~reasoning ability~~ reasoning ability

indicator: ~~ability scale score~~ ability scale score 1 ability scale score 2

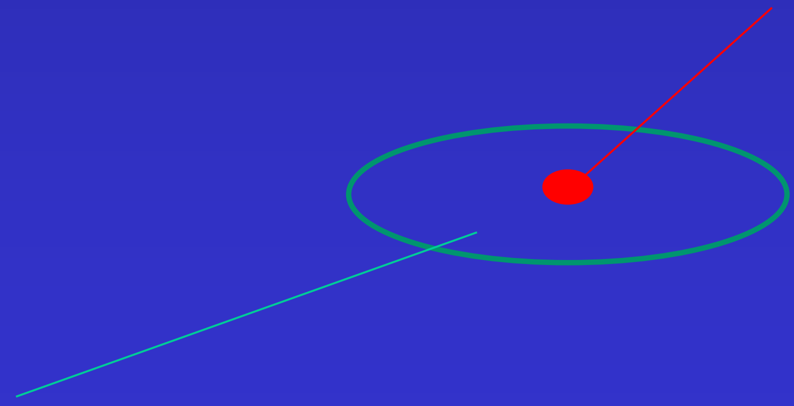
D. Characteristic features of SEM

- a multivariate method for data analysis

- a confirmatory method

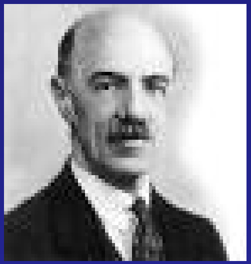
- consideration of multiple indicators

- consideration of errors of measurement



A short history

- **Spearman is credited with** the idea of a latent variable



- In **1904 Spearman** included the idea of a latent variable in his early concept of factor analysis (FA)

Latent source → Responses to items → **Factor** in FA

… represents the latent source as latent variable

► In about 1935 **Thurstone** introduced common factor analysis

… allows no comparison with alternative structures!

► In about **1935** **Thurstone** introduced common factor analysis

… allows no comparison with alternative structures:
no model check possible!

i.e. it cannot be excluded that the response is driven by another source (→ capitalization on chance)!

- **Confirmatory factor analysis** becomes available (**Jöreskog**, **1970, 1971**)

In CFA a latent variable is presented as part of a ***model*** *… allows* ***check of correctness of model*** *(i.e. it is possible to decide whether there is good model fit or model misfit)*

► **Confirmatory factor analysis** becomes available (**Jöreskog**, **1970, 1971**)

- *good model fit* ⟶ *confirmation of hypothesis (assumptions) incl. in model*

- *model misfit* ⟶ *rejection of hypothesis (assumptions) incl. in model*

- The further development consists in adapting the approach to …

  … specific research problems
  … data types
  … method effects
  …
  that makes it really work.

The Latent -

Manifest Contrast

The basic contrast: manifest - latent

- related to: theory of observational and theoretical languages, etc.

The basic contrast: manifest - latent

- related to: theory of observational and theoretical languages, etc.

i.e. discrimination of two types of language –

language of what is observable / language of ideas

… was developed by the so-called Vienna group

(z. B. Carnap)

The basic contrast: manifest - latent

- What do you see now (give a name)?

The basic contrast: ***manifest - latent***

- What do you see now (give a name)?

- What kind of experience do you have with it?

- Is it *manifest* or *latent*?

The basic contrast: *manifest - latent*

- related to: discrimination of two types of language …
- What is the manifest level? What does it mean?

A real burgler!

The basic contrast: manifest - latent

- related to: discrimination of two types of language …
- What is the manifest level? What does it mean?
- What is the latent level? What does it mean?

A unreal burgler!

The basic contrast: manifest - latent

… there is a specific person

(„**Max**“)

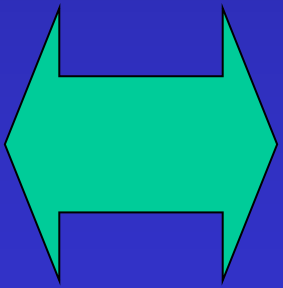
When we talk about it, we use the concept of what he is doing

(a **burgler**)

… because the concept is more general.

The basic contrast: manifest - latent

- related to: discrimination of two types of language …
- What is the manifest level? …
- What is the latent level? …
- How are the levels related to each other?



The basic contrast: manifest - latent

How is the contrast reflected in psychological statistics?

(*related statistical concepts*)

- Things of the manifest level: ⟹ ***manifest variable***
- Things of the latent level: ⟹ ***latent variable***

The basic contrast: manifest - latent

How is the contrast reflected in psychological statistics?

(*related statistical concepts*)

- Things of the manifest level: ⟹ ***manifest variable***
- Things of the latent level: ⟹ ***latent variable***

How are these levels related to each other? …by the model of measurement

The basic contrast: *manifest - latent*

The **model of measurement** :

it explains a manifest variable (e.g., X) by means of several latent variables (e.g., τ, .. and ε)

$$X \quad = \quad \tau + \ldots. + \varepsilon$$

(mostly by assuming linear relationships among the latent variables *but other relationships are also possible*)

The basic contrast: manifest - latent

The **model of measurement** :

it explains a manifest variable (e.g., *X*) by means of several latent variables (e.g., τ, .. and ε)

$$X \quad = \quad \tau + \ldots . + \varepsilon$$

$$\left\{ \begin{matrix} \text{manifest} \\ \text{part} \end{matrix} \right\} \left\{ \begin{matrix} \text{latent} \\ \text{part} \end{matrix} \right\}$$

(mostly by assuming linear relationships among the latent variables)

The priority

The priority of theory

- research starts with *a theory* or *detailed construct*
- data collection is designed according to theory
- data analysis is conducted according to theory

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Confirmatory approach of research

The priority of theory

- Confirmatory approach of research

means the *checking of hypotheses (…) regarding …*

The priority of theory

- Confirmatory approach of research

means the *checking of hypotheses (…) regarding …*

… e.g. food of parrots

The priority of theory

- Confirmatory approach of research

means the *checking of hypotheses (...) regarding ...*

The beak suggests that parrots eat nuts!

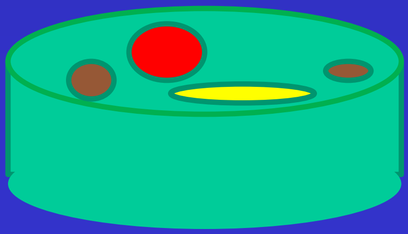
The priority of theory

- Confirmatory approach of research

means the *checking of hypotheses (…) regarding …*

Hypothesis: parrots eat **nuts**!

Search for supporting information



The priority of theory

- Confirmatory approach of research

  means the *checking of hypotheses regarding ...*

- Exploratory approach of research

  means *searching of something*

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- Confirmatory approach of research

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  means *searching of something*

- *Origin*: Empiricism

  → Research without assumptions (e.g. John Lock)

The priority of theory

- Confirmatory approach of research

  means the *checking of hypotheses regarding ...*

- Exploratory approach of research

  means *searching of something*

- *Origin*: Empiricism

  → Research without assumptions (e.g. John Lock)

  → Problems (perceptual errors, random influences, etc.)

The priority of theory

An important advantage of the confirmatory approach is that it is instrumental in dealing *with* the ***complexity*** of the empirical reality.

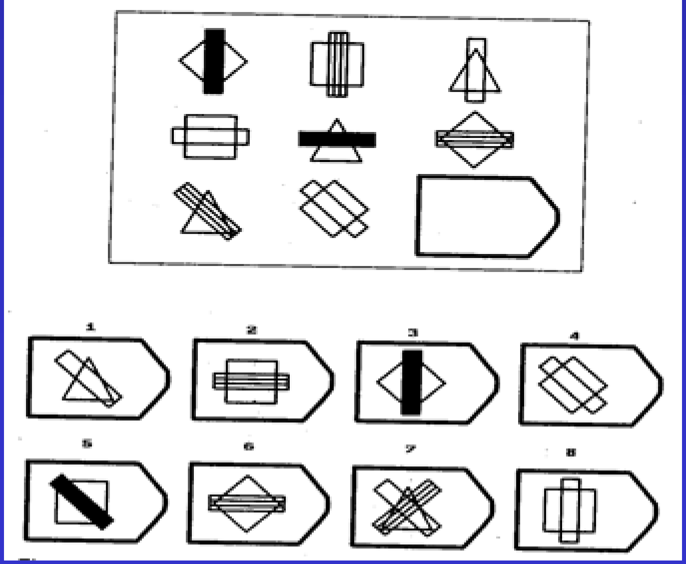
An example is provided to demonstrate this advantage!

The priority of theory as coping with complexity

The priority of theory as coping with complexity

Example: investigation of the *validity of a scale* - APM

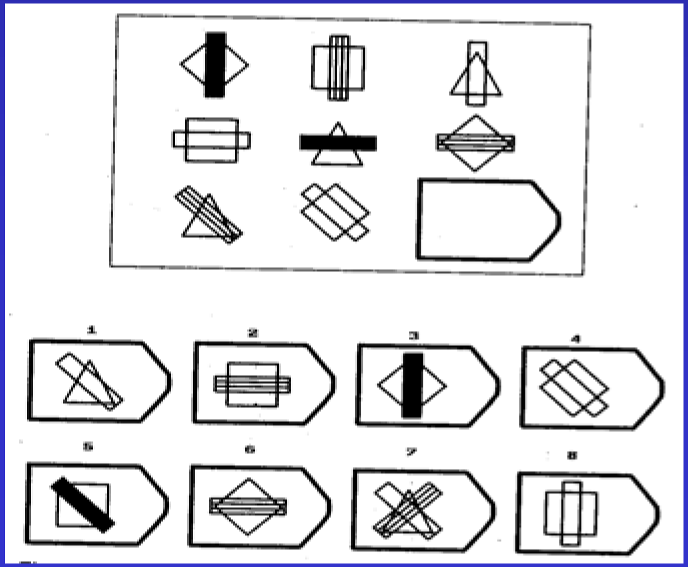
Figure: APM item



The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

- ... is id valid as scale of fluid reasoning?
- ... is id valid as scale of spatial ability?



The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

A popular way of ***investigating validity*** is to <u>*relate*</u> the scale to be validated (APM) to other scales that are expected to measure the same construct.

This means that APM is to be related to

- a scale measuring *fluid reasoning*
- a scale measuring *spatial ability*

The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

Spatial ability

Mentale Rotation (mR)

Visualization (V)

Closure (C)

The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

Spatial ability	*Mentale Rotation* (mR)
	Visualization (V)
	Closure (C)
Reasoning	*Numerical reasoning* (nR)

The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

Scales used to collect the available data

APM

Mentale Rotation (mR)

Visualization (V)

Closure (C)

Numerical reasoning (nR)

The priority of theory
as coping with complexity

Example: investigation of the validity of a scale, APM

Next step: statistical investigation using ….

- *exploratory approach*: estimation of the weights w
- *confirmatory approach*: use of already available knowledge for theory-guided estimation the weights w

The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

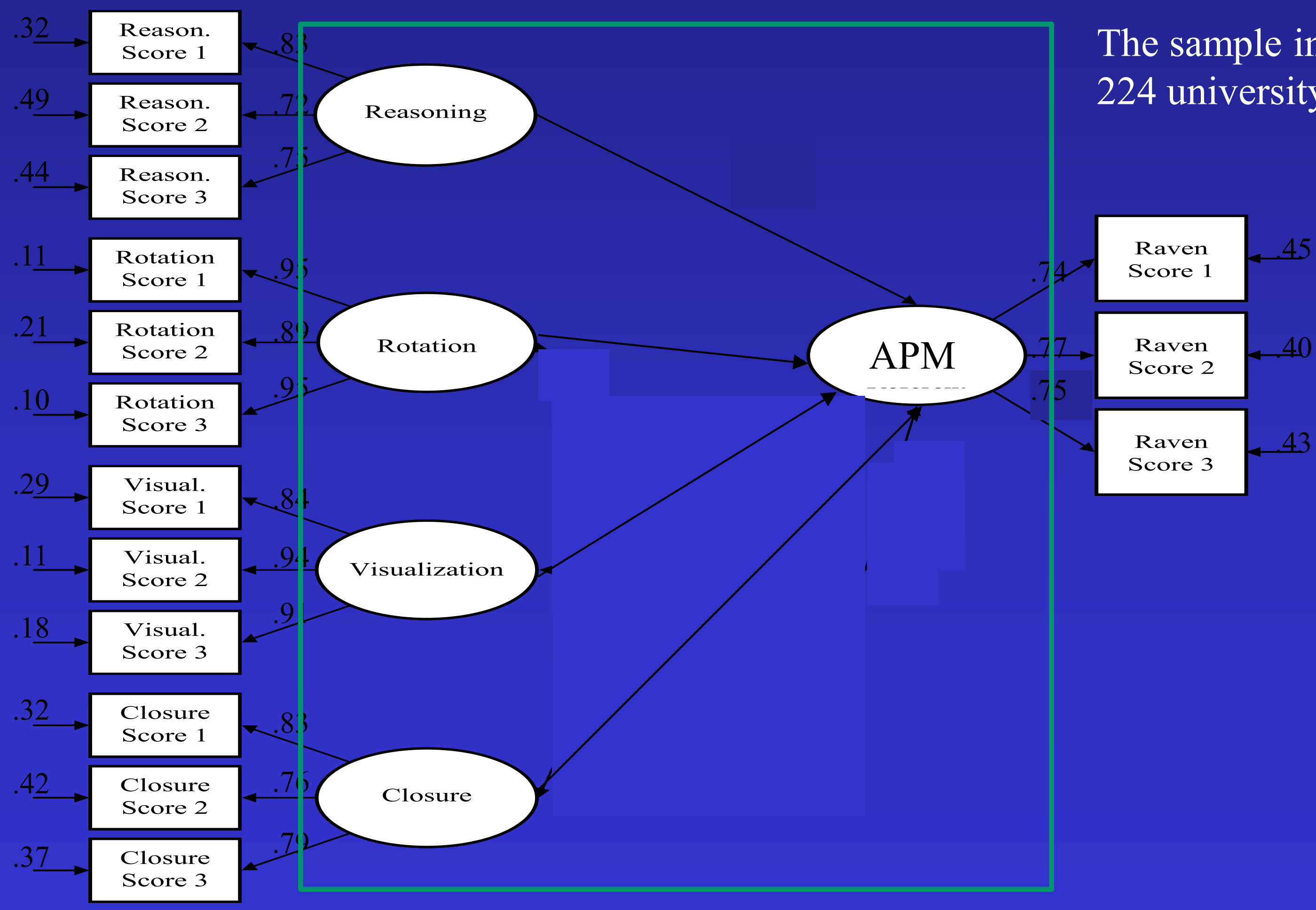
Next step using the …

- *exploratory approach*: estimation of the weights w

$$\boxed{\text{Exploratory: } \mathbf{Y_{APM} = k + wX_{mR} + wX_{V} + wX_{C} + wX_{nR} + e}}$$

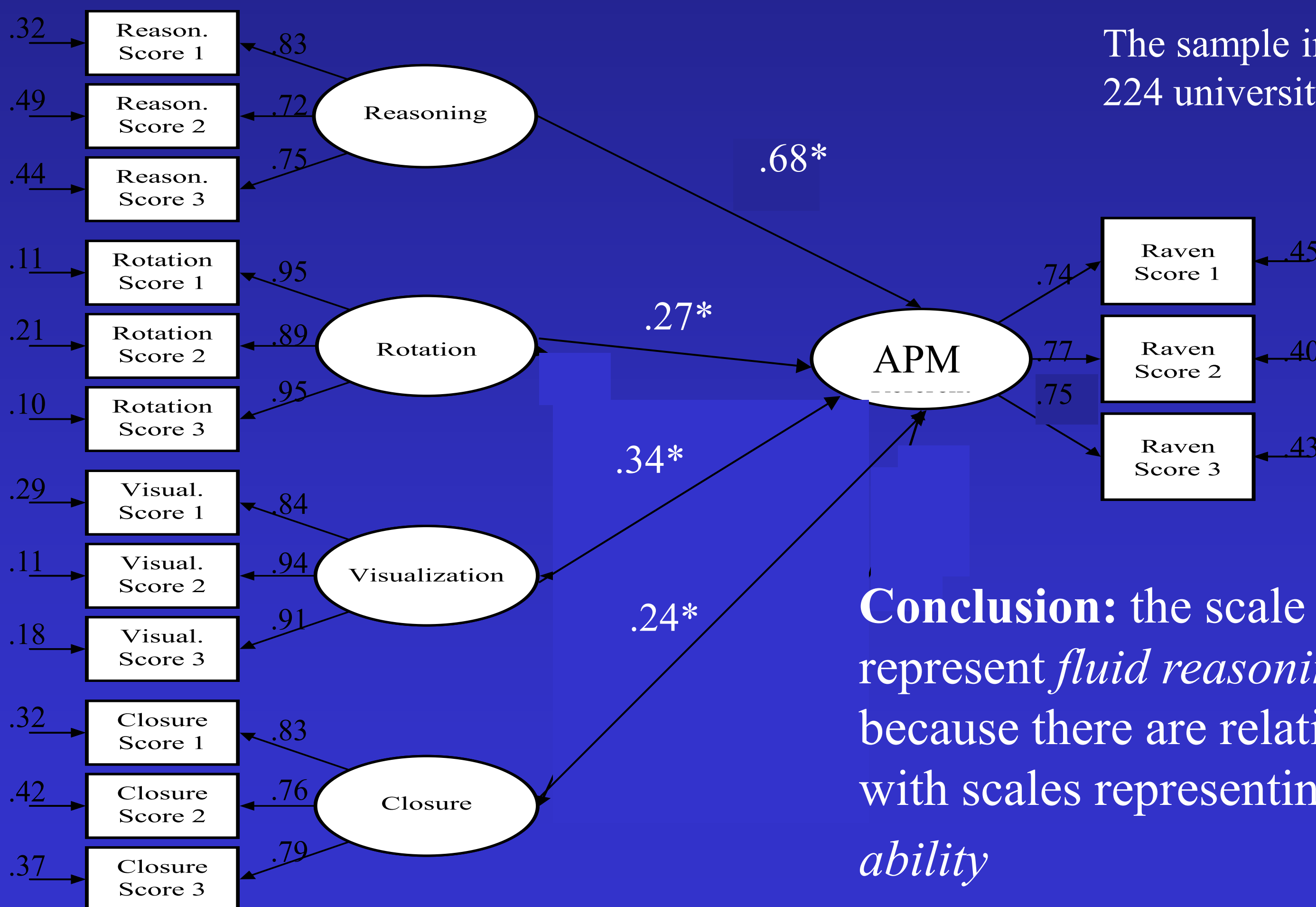
The estimates of the weights have to show
which scale contributes to the scale that is to be validated !

The priority of theory as coping with complexity



The sample included 224 university students.

The priority of theory as coping with complexity



The sample included 224 university students.

Conclusion: the scale does not represent *fluid reasoning* well because there are relationships with scales representing *spacial ability*

The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

Next step using the …

- *confirmatory approach*: use of already available knowledge for *theory-guided* estimation the weights w

What we know is that mental rotation (mR), visualization (V) and closure (C) are integrated into spacial ability!

The priority of theory as coping with complexity

Example: investigation of the validity of a scale, APM

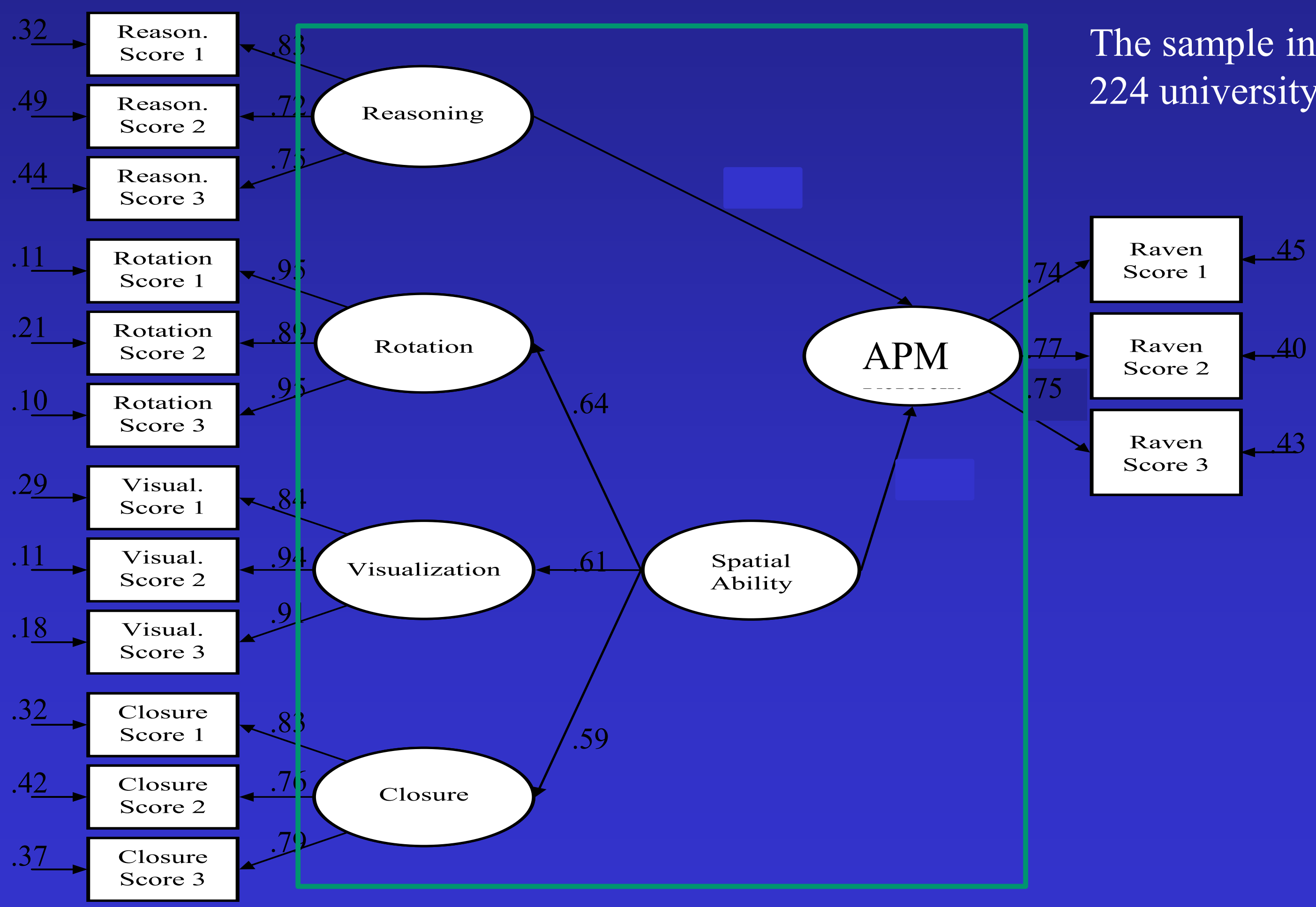
Next step using the .....

- *confirmatory approach*: use of already available knowledge for *theory-guided* estimation the weights w

Therefore, $wX_{mR} + wX_{V} + wX_{C}$ needs to be integrated into one component: $\mathbf{wX_{V\_mR\_C}}$

so that $\boxed{\mathbf{Y_{APM} = k + wX_{V\_mR\_C} + wX_{nR} + e}}$

The priority of theory as coping with complexity



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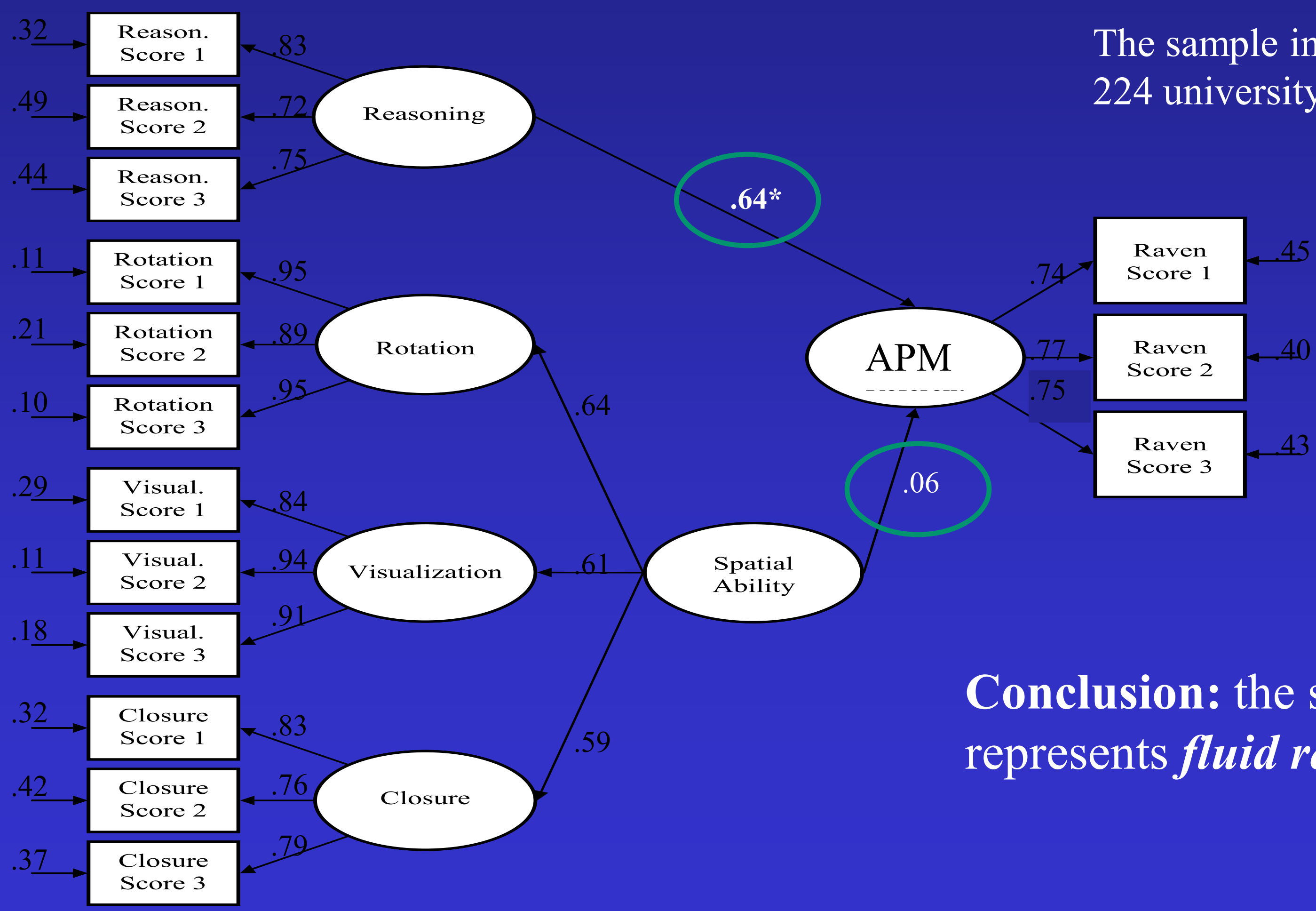
The priority of theory as coping with complexity



The sample included 224 university students.

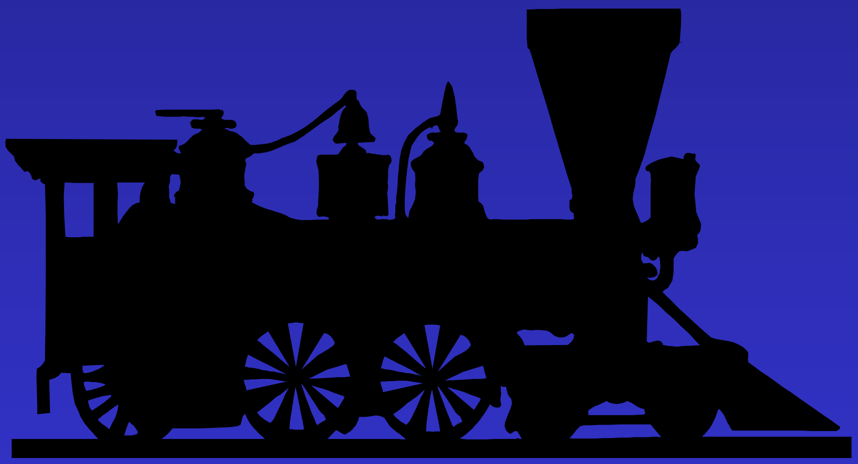
Conclusion: the scale represents ***fluid reasoning***

TheSpecificities

The Specificities

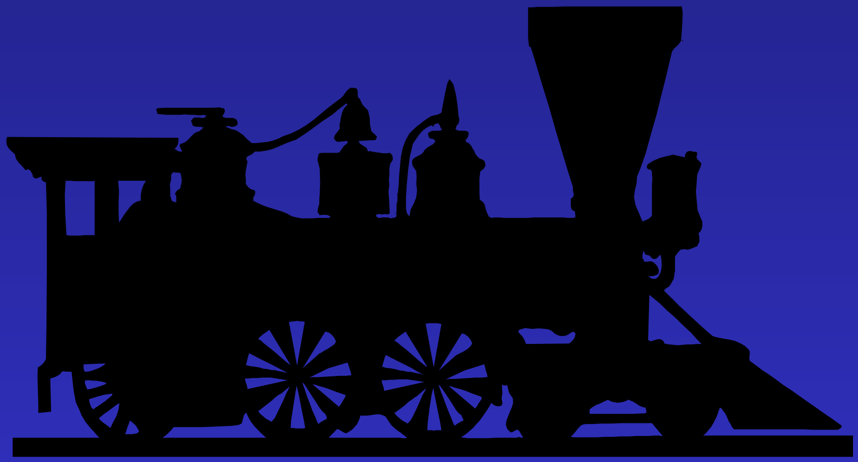
… concerning the question: Why is the focus on the model and not on the theory?

.... *an analogy*



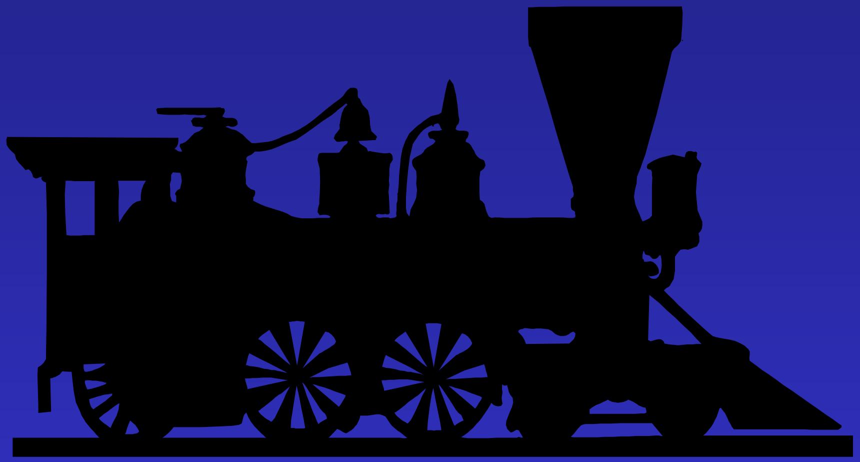
…. *an analogy*

…. *an analogy*



The train-engine theory

…. *an analogy*



The train-engine theory

The train-engine model

The model

.... is a <u>construction</u> that serves the picturing of reality.

.... is to a small degree an abstraction of reality.

The theory

.... is also a <u>construction</u>.

.... is focused on what is essential

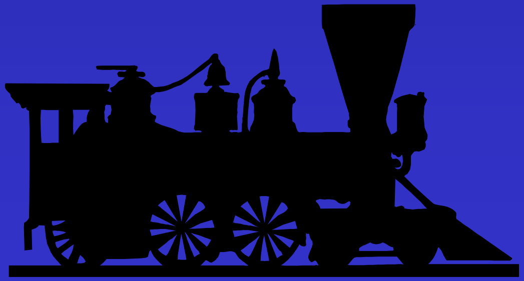
A major differerence: the details

- a model is usually rather specific (many details)

  e.g. it may say „the train engine
  has **eight** wheels for rails“

- a theory is usually rather general

  e.g. it may say „the train engine
  has wheels“



The consequences of specificity

- there is one theory (e.g. of the train engine)
- there are various models (e.g. of specific train engines)
- but both of them refer to the same reality

The consequences of specificity

Advantages of models:

♦ they are so specific that they **turn out as wrong** when related to observations

♦ different models can be compared with each other with respect to observations

♦ the best model can be identified

All this means that models are especially useful for investigating <u>properties of …</u>!

The consequences of specificity

Disadvantage of theory:

♦ they can hardly fail (*some researchers even argue that it is impossible to disprove a theory*)

♦ progress in science is hardly possible

An example

An example from ***cognitive load theory***

- Theory of cognitive load says … a too large ***load*** in cognitive processing leads to errors!

  … it implies that increasing the <u>difficulty</u> (=<u>load</u>) of arithmetic tasks leads to more errors.

  ……………………………. the difficulty (=load) by integrating <u>more rules to be processed</u> into the arithmetic tasks leads to more errors.

An example

Models for investigating properties: *an example from **cognitive load theory***

- Theory of cognitive load says … a too large ***load*** in cognitive processing leads to errors!

  …………

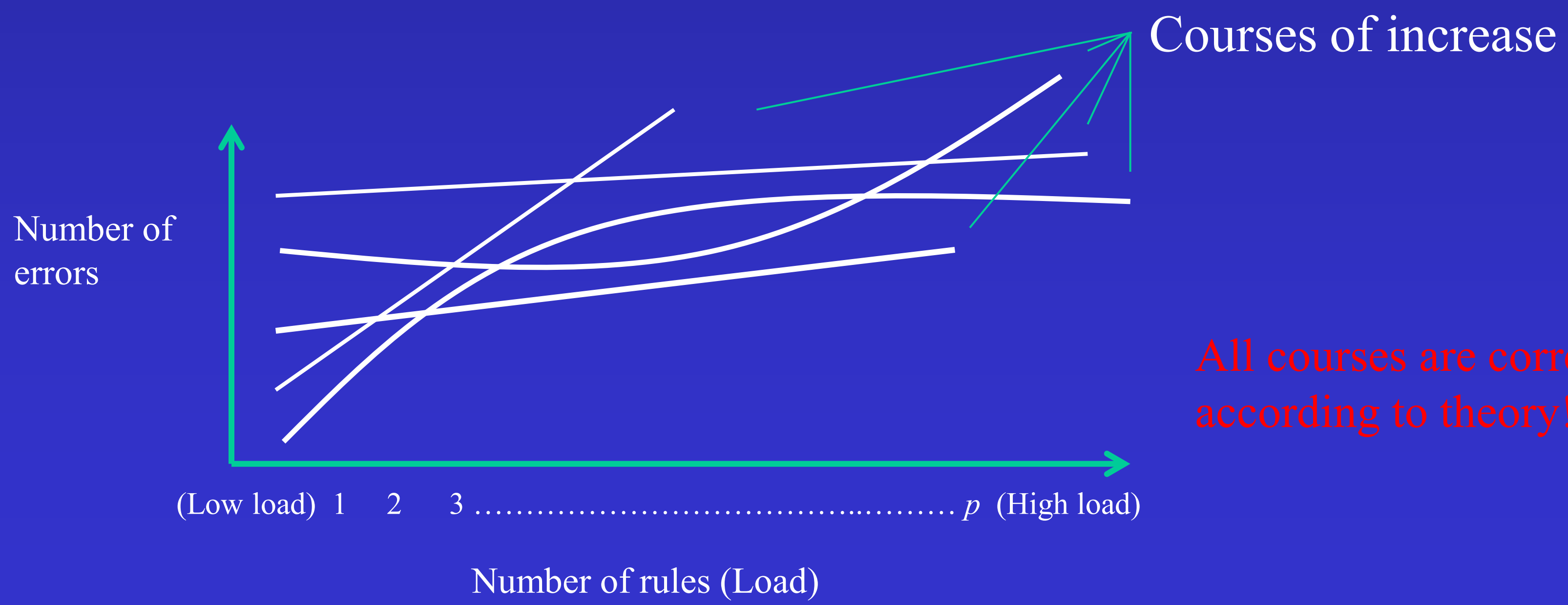
- But, cognitive theory is imprecise regarding the relationship of load and errors

  \- it only suggests: *the more rules (that means more difficult, a higher load), the more errors*.

An example

Models for investigating properties: *an example from* ***cognitive load theory***

Ways of modeling ……. „the *more rules (...), the more errors „* can mean …….



All courses are correct according to theory!

An example

Models for investigating properties: *an example from* ***cognitive load theory***

…….

Models must be specific!

e.g. model 1: assumes a linear increase
e.g. model 2: assumes a quadratic increase
e.g. model 3: assumes an increase within a specific range
….

This way models are likely to improve our knowledge

On specificities – final comments

- Models are expected to account for observed data either well or not at all.
- One aim of research is to identify the best model out of the set of all reasonable models
- Further research aims at designing models that provide a *good account of reality*.
- There is agreement that all models are *wrong* but *useful*.

The Need

to be complete

The need to be complete

- The statistical evaluation of models is conducted by means of

Goodness-of-fit tests

… this means a „high“ error probability is desirable

… compare inferential statistics: a „small“ error probability is desirable

The need to be complete

- The statistical evaluation of models is conducted by means of

Goodness-of-fit tests

i.e. it is checked whether the data in general are explained by the model

The need to be complete

- The statistical evaluation of models is conducted by means of

  Goodness-of-fit tests

The <u>general problem with goodness-of-fit testing</u> is …

… that all systematic sources of responding must be represented in the model

… otherwise „good model fit“ is not reachable

The need to be complete

An example:

The investigation of the structural/factorial validity of a reasoning scale

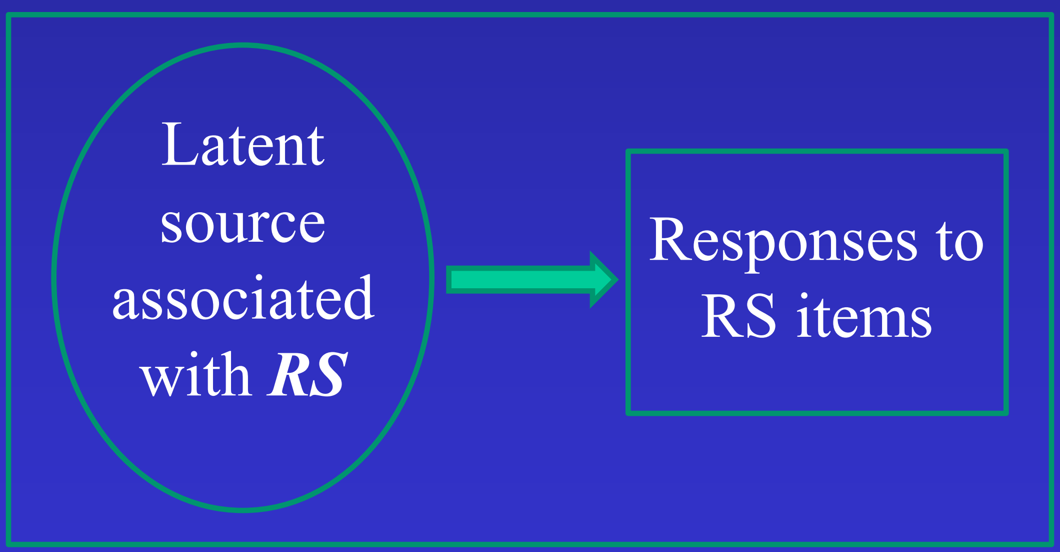
i.e. it is to be investigated whether the items of the scale - are *homogeneous*
- are *unidimensional*

The need to be complete

A specific example:

.... data collection by a reasoning scale (RS)

.... investigation of the data by the following rational:



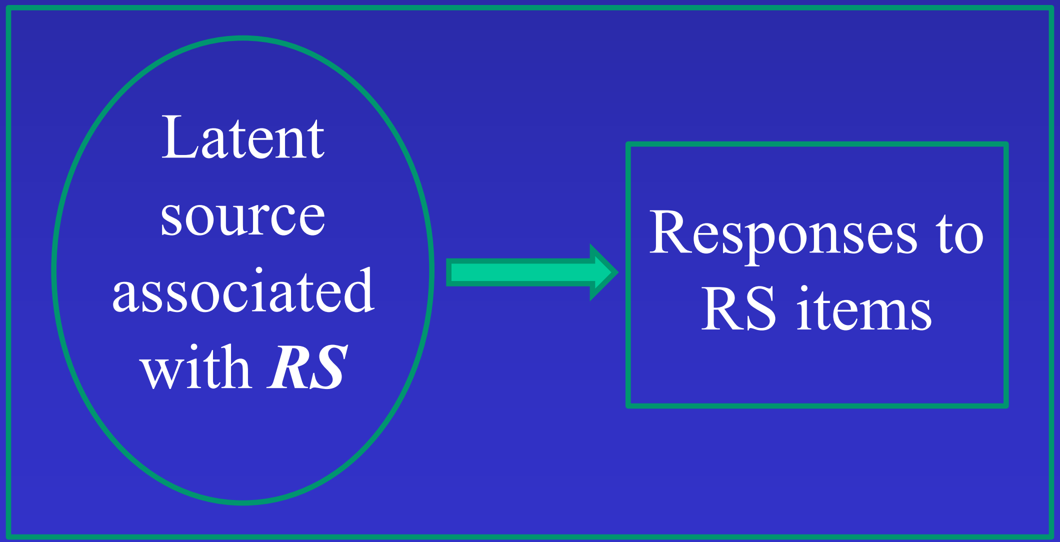
If there is no other source of responding, the corresponding model is likely to yield ***good model fit***

The need to be complete

A specific example:

.... data collection by a reasoning scale (RS)

.... investigation of the data by the following rational:



But, if there is another source of responding …

The need to be complete

A specific example:

… for demonstrating the „need to be complete“, we assumed that

something went wrong in data collection:

… the participants did *not* get enough time to complete all items.

…………

The consequence: the statistical investigation indicates a failure; i.e. model misfit.

The need to be complete

A specific example:

…..

The consequence: the statistical investigation indicates model misfit.

What does this mean?

… the outcome seems to suggest that

either

➡ model does not fit to data

or

➡ the hypothesis is incorrect

… the true reason for failure is <u>incompleteness</u> (… *not* an incorrect hypothesis)

The need to be complete

A specific example:

… „the participants did *not* get enough time to complete all items“ ...

means that the participants‘ processing speed influenced results.

There were two sources of responding instead of one.

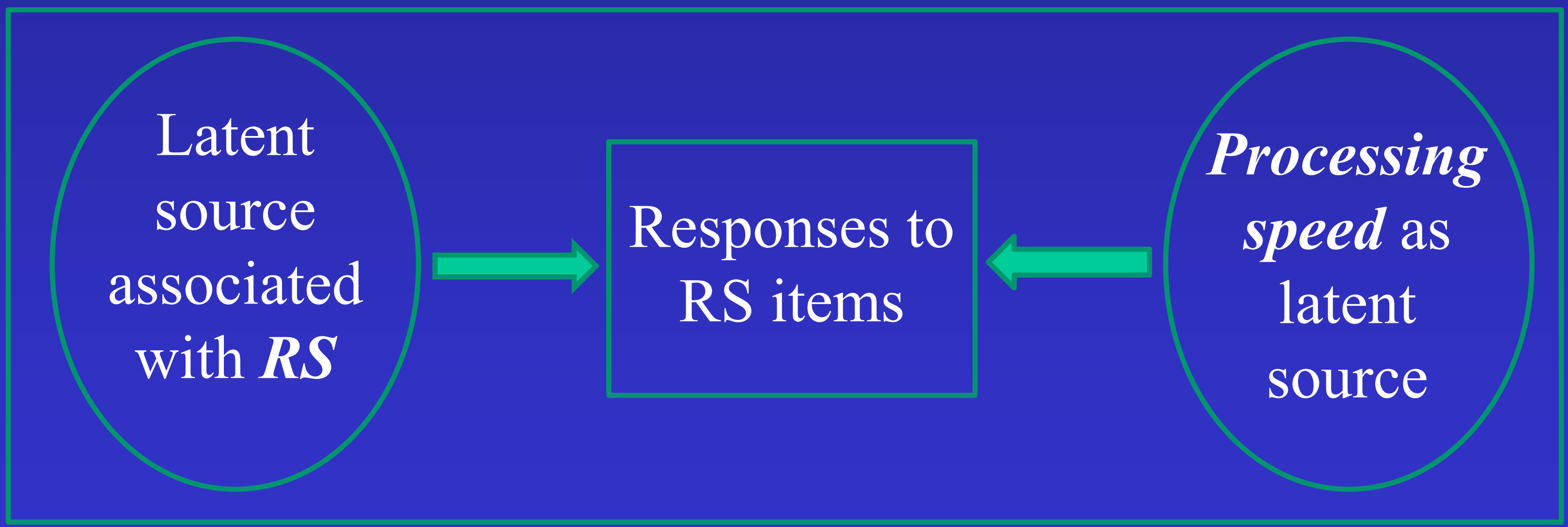
Therefore, the model must consider ***two*** sources in order to account for the data - or - sufficient time must be made available.

The need to be complete

A specific example:

… „the participants did *not* get enough time to complete all items“ …

means that the participants‘ processing speed influenced results.



The need to be complete

In sum

The *need to be complete* creates the following situation:

all important sources of performance must be integrated into the model that is investigated .... to achieve good model fit.

..... although the researcher may be interested in only one of them.

The need to be complete

In sum

.....

If the model is incomplete, it is likely to fail! (… although the investigated hypothesis may be correct)

The M-L step

The step from the manifest to latent levels

…. This section is on the consequences of latent variable modeling for the results of investigating the relationship between two constructs!

It demonstrates an advantage of modeling latent variables because the statistical investigation is conducted ***at the latent level*** (not the manifest level)

The step from the manifest to latent levels

- customary investigations are conducted at the manifest level
- investigations using modeling latent variables are conducted at the latent level.

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *natural-science competency* (*n-competency*)

The data:

- Intelligence data: APM, WAIS
- N-competency data: chemestry and physics grades

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency*

Empirical results for estimating the relationship from student sample:

- correlation *APM – chemistry grade*: .3
- correlation *APM – physics grade*: .4
- correlation *WAIS – chemistry grade:* .3
- correlation *WAIS – physics grade:* .2

What is an estimate of the true relationship?

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency*

Result of averaging: correlation *intelligence Ø – grade Ø* : **.3**

Result is true for the manifest level only

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency*

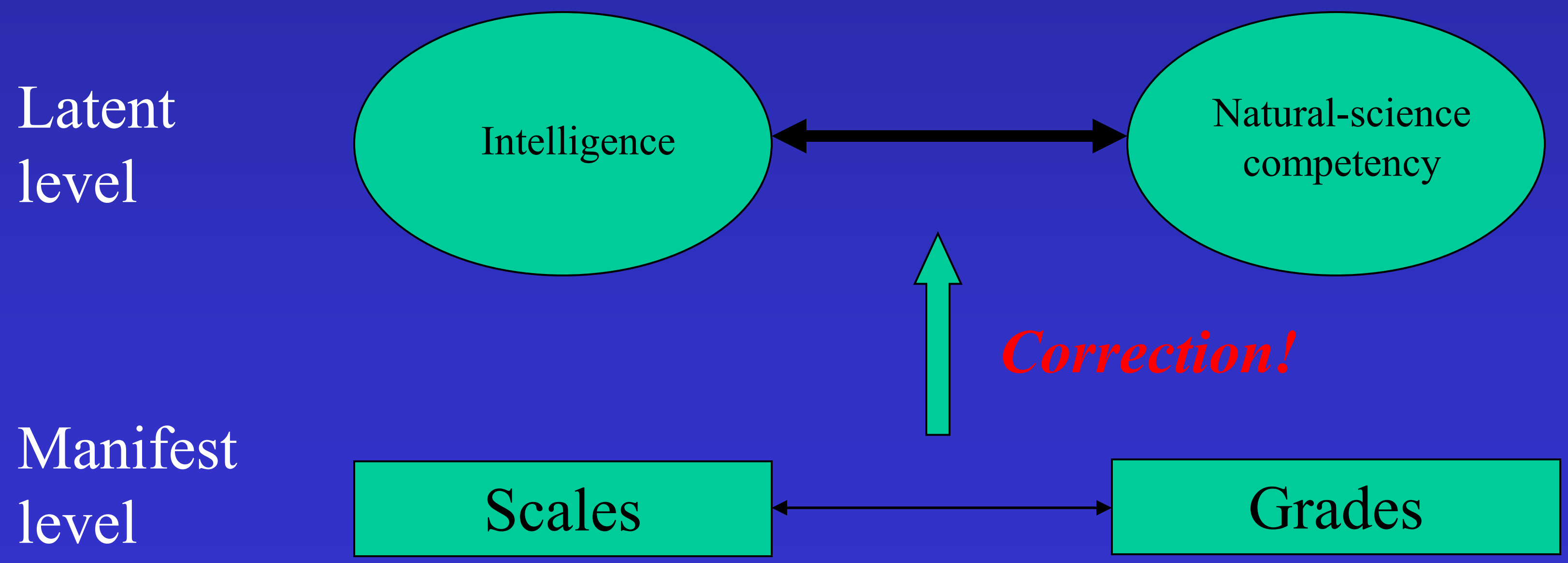
with the transfer to the latent level

The idea is:
the correlation at the manifest level is impaired by the influence of error.
Therefore, the elimination of error means the transfer to the latent level

The transfer is accomplished by a correction procedure that eliminates the influence of error

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency* with the transfer to the latent level



The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency* with the transfer to the latent level

The outset:

$$\text{correlation} = \frac{\text{covarianz on manifest level}}{\text{SDs}}$$

Note. SD means standard deviation

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency* with the transfer to the latent level

A correction procedure eliminates the influence of error!

$$\text{correlation}_{\text{intelligence-nc…}} = \frac{\text{covarianz on manifest level}}{\text{true part of SDs}}$$

Note. SD means standard deviation

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency*

with the transfer to the latent level

Auxiliary estimates of the relative amount of true variation included in the standard deviation are provided by correlations of the indicators of the same construct !

- Correlation *WAIS* – *APM* : .77
- Correlation c*hemistry grade* – *physics grade*: .77

$\left.\begin{matrix} .77 \\ .77 \end{matrix}\right\} = c_{\text{true part}}$

(Reliability)

(+ assumption of equal standard deviation)

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency* with the transfer to the latent level

A correction procedure eliminates the influence of error!

$$\text{correlation}_{\text{intelligence - n-c...}} = \frac{\text{covarianz on manifest level}}{\textbf{true part}\text{ of SDs}}$$

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency* with the transfer to the latent level

A correction procedure eliminates the influence of error!

$$\text{correlation}_{\text{intelligence-nc…}} = \frac{\text{covarianz on manifest level}}{c_{\text{true\_intelligence}} SD_{\text{intelligence}} \times c_{\text{true\_n-competency}} SD_{\text{n-competency}}}$$

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency*

with the transfer to the latent level

A correction procedure eliminates the influence of error!

… for $c_{true\_intelligence} = c_{true\_n\text{-}competency}$: c_{true}

$$\text{correlation}_{\text{intelligence-nc…}} = \frac{\text{covarianz on manifest level}}{c_{true}^{2}\, SD_{intelligence} \times SD_{n\text{-}competency}}$$

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency*

with the transfer to the latent level

A correction procedure eliminates the influence of error!

$$\text{correlation}_{\text{intelligence-nc...}} = \frac{\text{correlation} \times \cancel{SD}_{\text{intelligence}} \times \cancel{SD}_{\text{n-competency}}}{c_{\text{true}}^{2}\ \cancel{SD}_{\text{intelligence}} \times \cancel{SD}_{\text{n-competency}}}$$

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency* with the transfer to the latent level

A correction procedure eliminates the influence of error!

$$\text{correlation}_{\text{intelligence-nc}\ldots} = \frac{\text{correlation}}{c_{\text{true}}^{2}}$$

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency*

with the transfer to the latent level

A correction procedure eliminates the influence of error!

Average correlation
on manifest level

$$\text{correlation}_{\text{intelligence-nc...}} = \frac{\text{correlation}}{c_{\text{true}}^{2}} = \frac{.30}{.77^{2}}$$

Average proportion
of true variance

The step from the manifest to latent levels

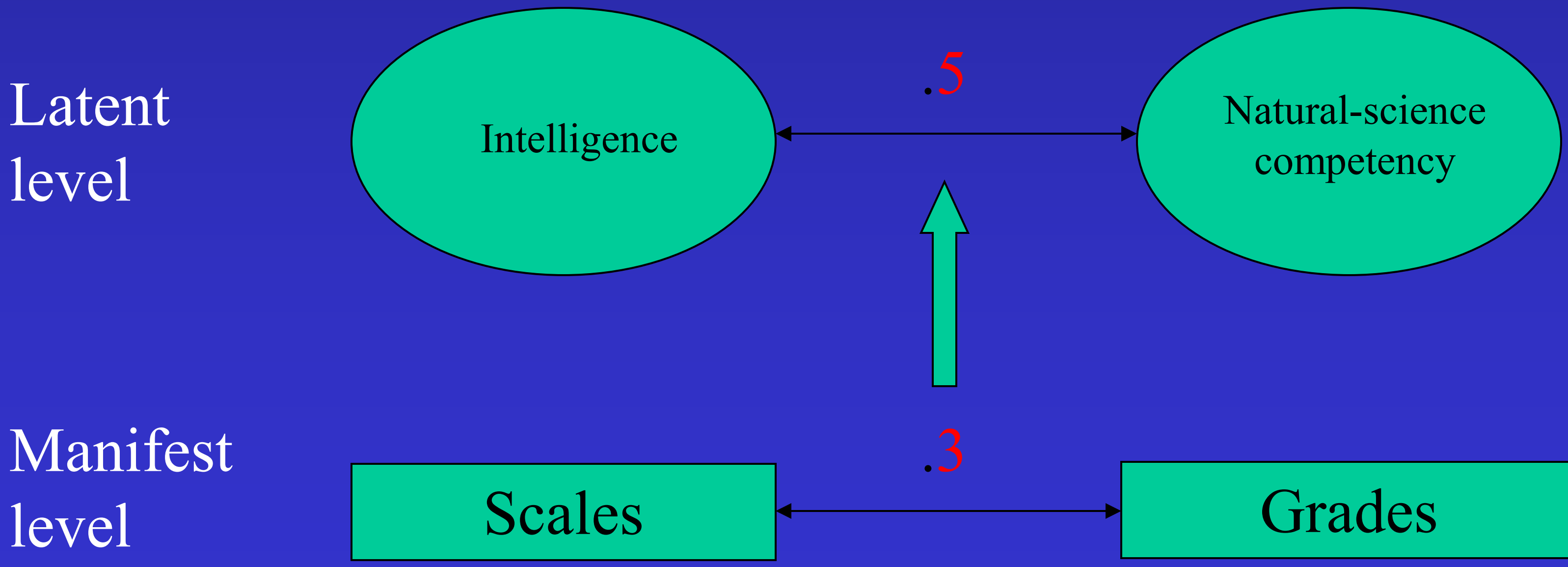
An example: the relationship between *intelligence* and *n-competency*
with the transfer to the latent level

A correction procedure eliminates the influence of error!

$$\text{correlation}_{\text{intelligence-nc…}} = \frac{\text{correlation}}{c_{\text{true}}^{2}} = \frac{.30}{.77^{2}} = .506$$

The step from the manifest to latent levels

An example: the relationship between *intelligence* and *n-competency* with the transfer to the latent level



Practice

The step from the manifest to latent levels

Investigate the relationship between optimismus and extraversion on the latent level when you have only data from the manifest level!

The step from the manifest to latent levels

The data:
-Optimism data: RS (Rosenberg scale), PO (POSO scale)
-Extraversion data: E-EPI, E-BF (Big FIVE questionnaire)

The correlations:
-RS – E-EPI: .25
-RS – E-BF: .4
-PO – E-EPI: .2
-PO – E-BF: .35

RS – PO (c_{true}): .8

E-EPI – E-BF (c_{true}): .6

The correction formula:

$$\text{correlation}_{\text{optimism-extraversion}} = \frac{\overline{\text{correlation}} \times SD \times SD}{c_{true} \times c_{true} \times SD \times SD}$$

The step from the manifest to latent levels

The data:
-Optimism data: RS (Rosenberg scale), PO (POSO scale)
-Extraversion data: E-EPI, E-BF (Big FIVE questionnaire)

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The step from the manifest to latent levels

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The Formula:

$$\text{correlation}_{\text{optimism-extraversion}} = \frac{.30 \times SD \times SD}{c_{true} \times c_{true} \times SD \times SD}$$

The step from the manifest to latent levels

What is the result?

- .450
- .506
- .625
- .705

The step from the manifest to latent levels

Supplement: abuse in IQ research !

How can there be abuse?

* *using unreliable tests*

The step from the manifest to latent levels

Supplement: abuse in IQ research !

Previous example:	Reliability	Improvement in correlation
	.77	.30 → .50

The step from the manifest to latent levels

Supplement: abuse in IQ research !

	Reliability	Improvement in correlation
Previous example:	.77	.30 → .50
Other example:	.60	.30 → .83

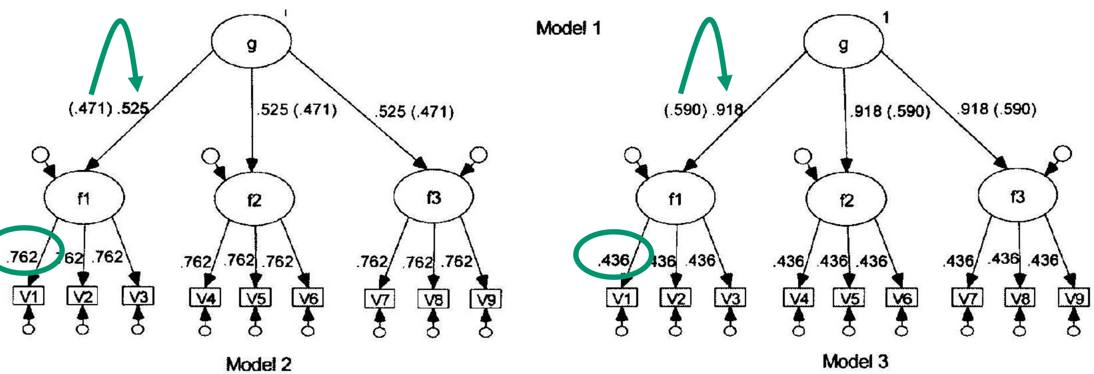
The step from the manifest to latent levels

Consequently:

The worse the reliability of the scale is, the larger the improvement due to correction.

Not good – leads to results that are not replicable

Demonstration of abuse due to unreliability by Gignac using artificial data



Reliable scores!

*Un*reliable scores!

G. E. Gignac

Figure 1:
Model 1 = higher-order model with phantom variables and corresponding constraints applied for the purposes of identification/scaling; Models 2 and 3 = high reliability/low reliability higher-order models with completely standardized maximum likelihood estimation parameter estimates (attenuated parameter estimates within parentheses).

The graphical potential

The graphical potential

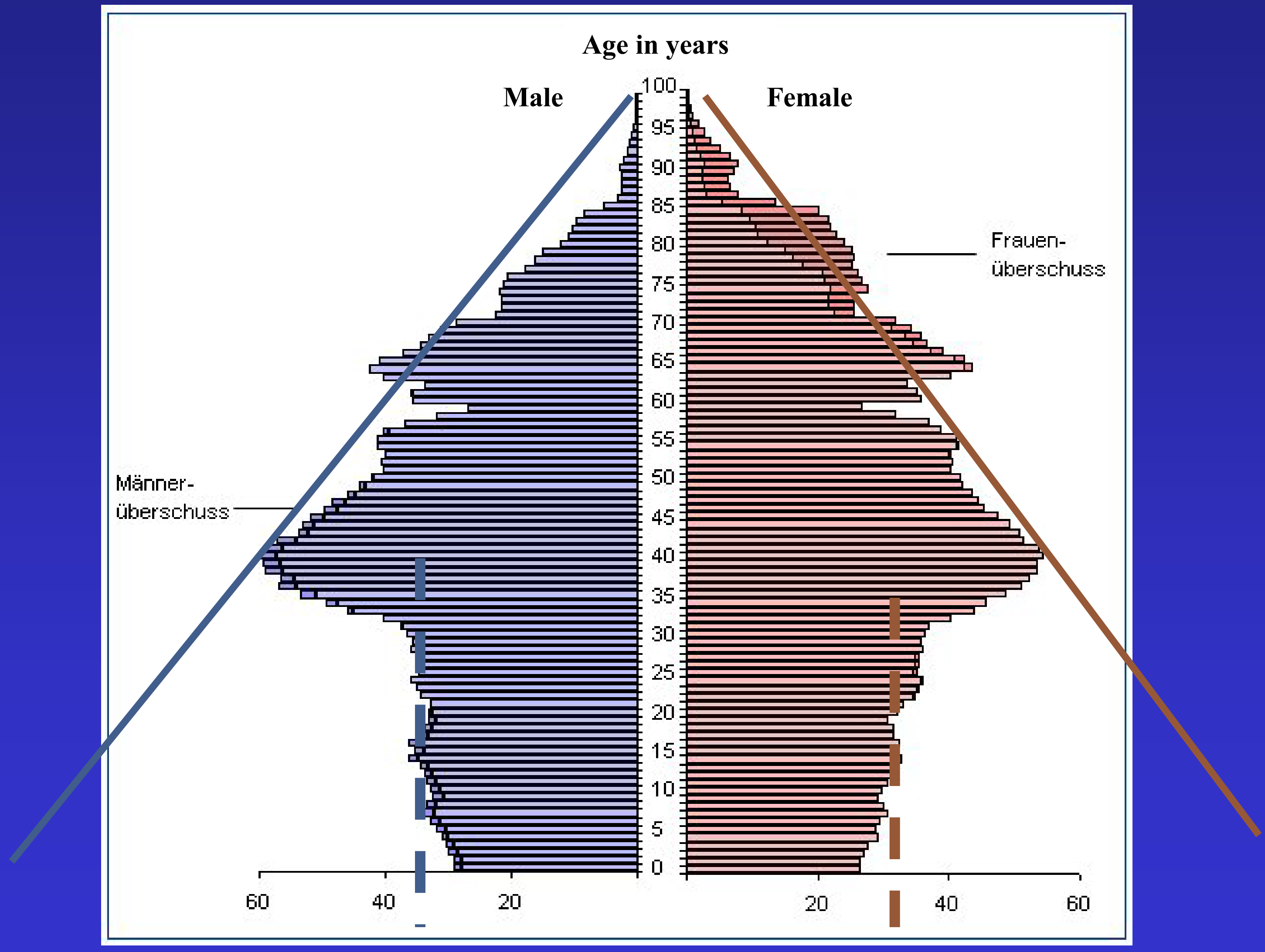
- Structural equation modeling heavily uses graphical illustration
  - for communicating structural features of models
  - for communicating important results

The graphical potential

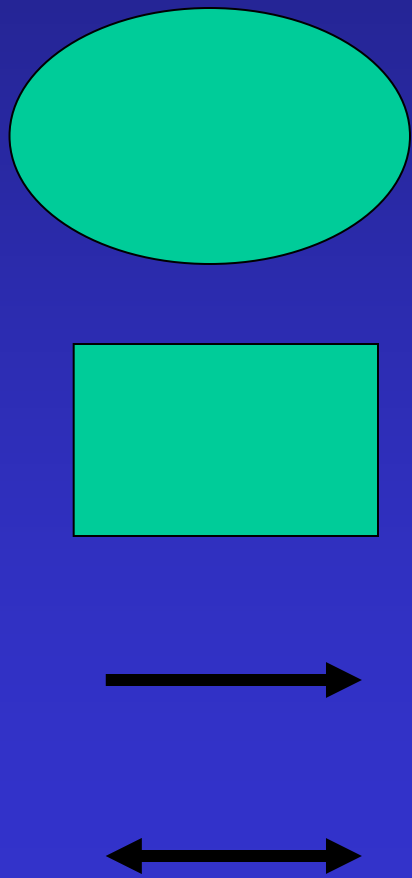
- latent variable modeling within the factor-analytic approach heavily uses graphical illustration
  - for communicating structural features of models
  - for communicating important results

  Advantage:
  - it uses the high capacity for processing visual informantion

The graphical potential



The graphical potential



latent variable

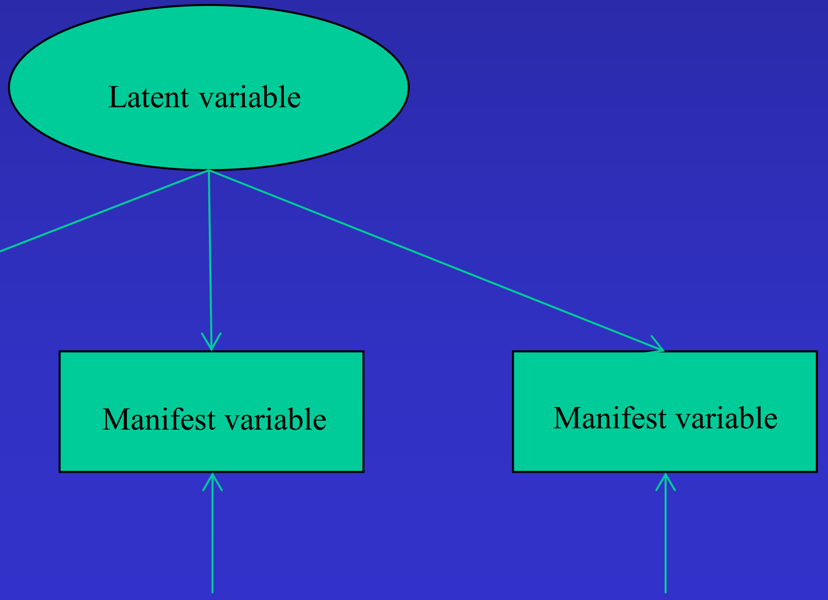
manifest variable

directed relationship

non-directed relationship / correlation

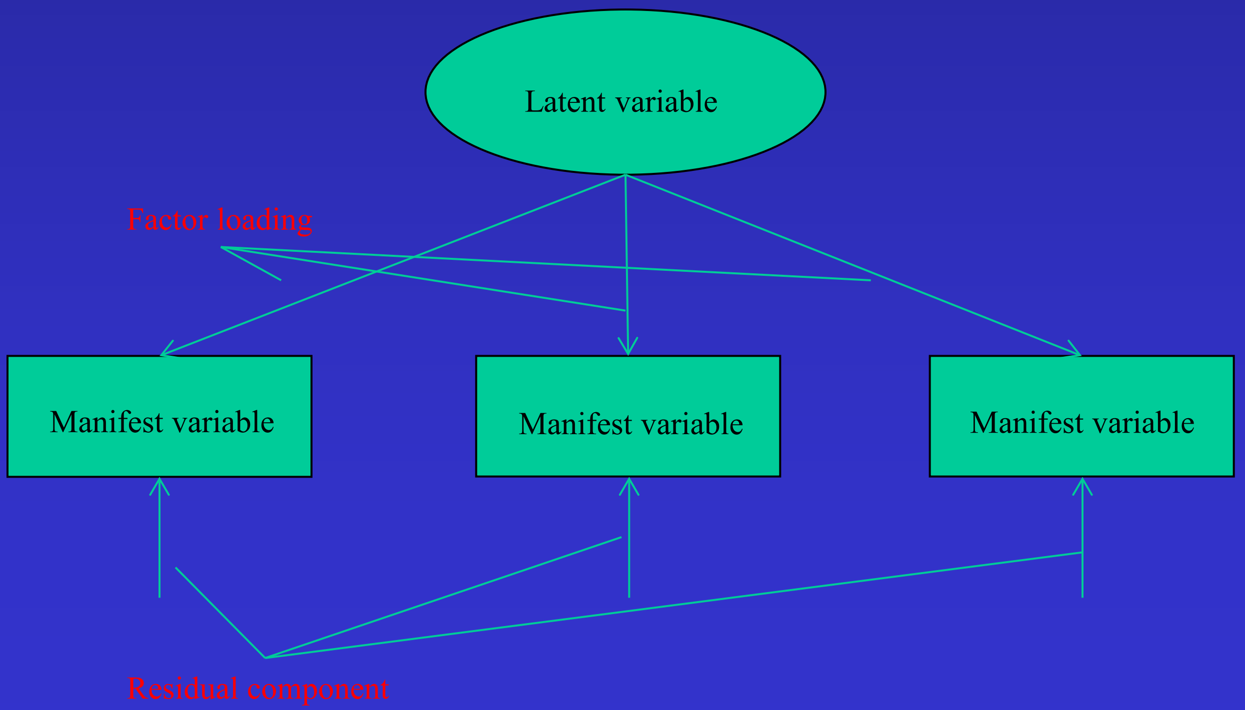
The graphical potential

An example: *the graphical representation of a model of measurement*



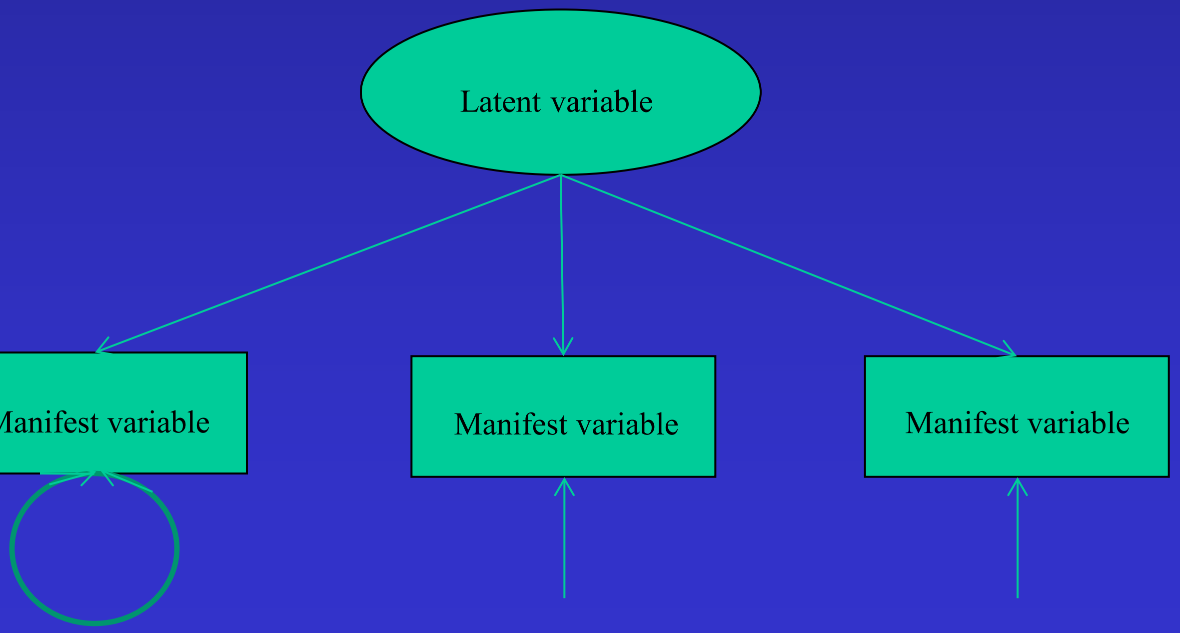
The graphical potential

An example: *the graphical representation of a model of measurement*



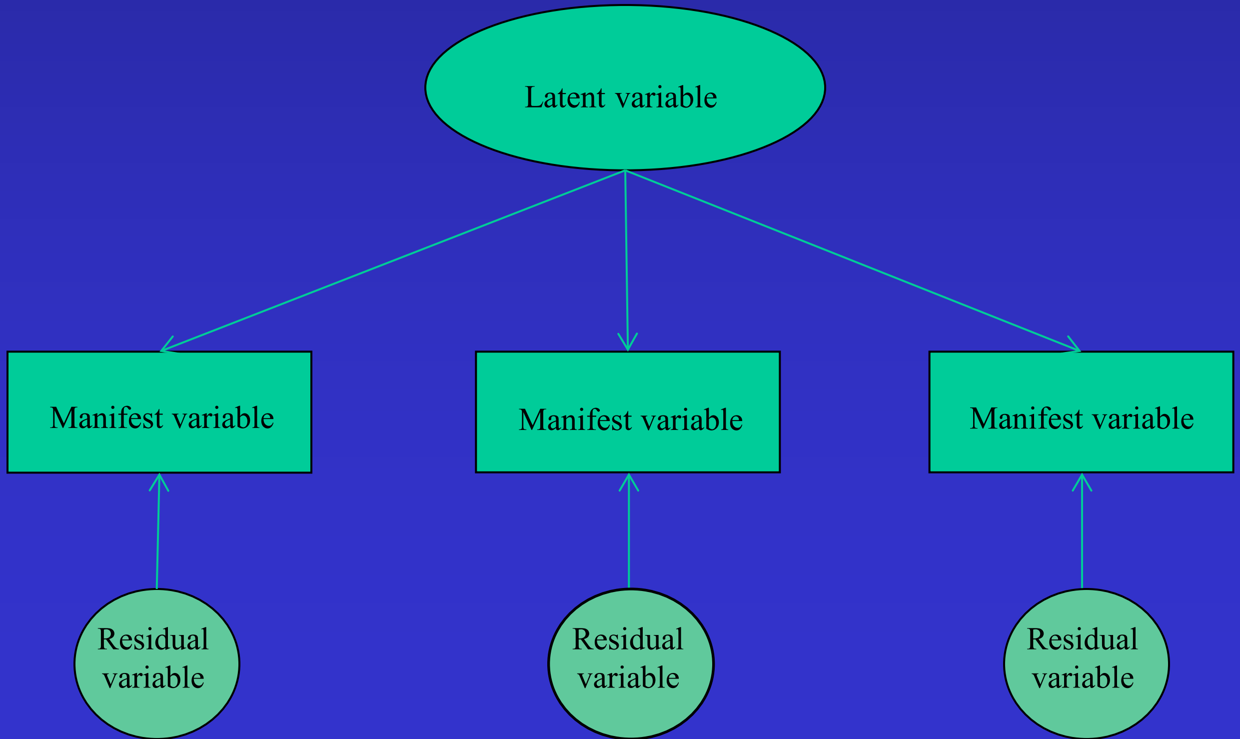
The graphical potential

An example: *the graphical representation of a model of measurement*



The graphical potential

An example: *the graphical representation of a model of measurement*



Summary and brush up:

What is a variable / a construct ?

- Some basics

… a placeholder / a scientifically elaborated idea

- A short history -

- The latent – manifest contrast … observable / not observable

- The priority of theory … it is a confirmatory approach

- The specificities of the model … models are more detailed than theories

- The need to be complete … testing extends to the complete model

- The step from the manifest to latent levels

- The graphical potential

Summary and brush up:

- Some basics
- A short history
- The latent – manifest contrast
- The priority of theory
- The specificities of the model
- The need to be complete
- The step from the manifest to latent levels
- The graphical potential

The gain due to LVM?

… estimates free of error

… use of figures and diagrams

Questions regarding the first unit:

- What is a construct?
- What distinguishes manifest from latent?
- What is the meaning of confirmatory?

End