



UNIVERSITY OF GOTHENBURG

Cognitive abilities and academic achievement as predictors of success in higher education: The Encapsulation model

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Main approaches to selection to higher education

- Two major approaches:
 - *Achievement or assessment of acquired knowledge*: Focus on measures or indicators of attained knowledge and skill (e. g., domain specific knowledge, reading and writing skills, grades)
 - *Aptitude or capacity for learning*: Focus on measures or indicators of ability to acquire knowledge and skills (e. g., measures of scholastic aptitude or general cognitive ability).
- Both these approaches claim success:
 - Reviews by Hunter/Schmidt conclude that general cognitive ability (G) is the best predictor of occupational and educational success.
 - Reviews by Atkinson, among many others, conclude that measures of achievement, and grades in particular, are the best predictors of educational success.





But can the two approaches be separated in practice?

- “In public controversies about tests, disputants have failed to recognize that virtually every bit of evidence obtained with IQs would be approximately duplicated if the same study were carried out with a comprehensive measure of achievement.” (Cronbach, 1976).
- “. ... *a valid school achievement test will reflect differences in scholastic capacities (especially among the pupils of one school) to a much greater degree than a general intelligence test can reflect differences in the same or any other intellectual capacities.* Insofar as general intellectual capacity affects school achievement, individual differences in this capacity can be inferred better from a valid general school achievement test than they can from a general intelligence test.” (Cureton, 1951, pp. 649-650; italics in original).



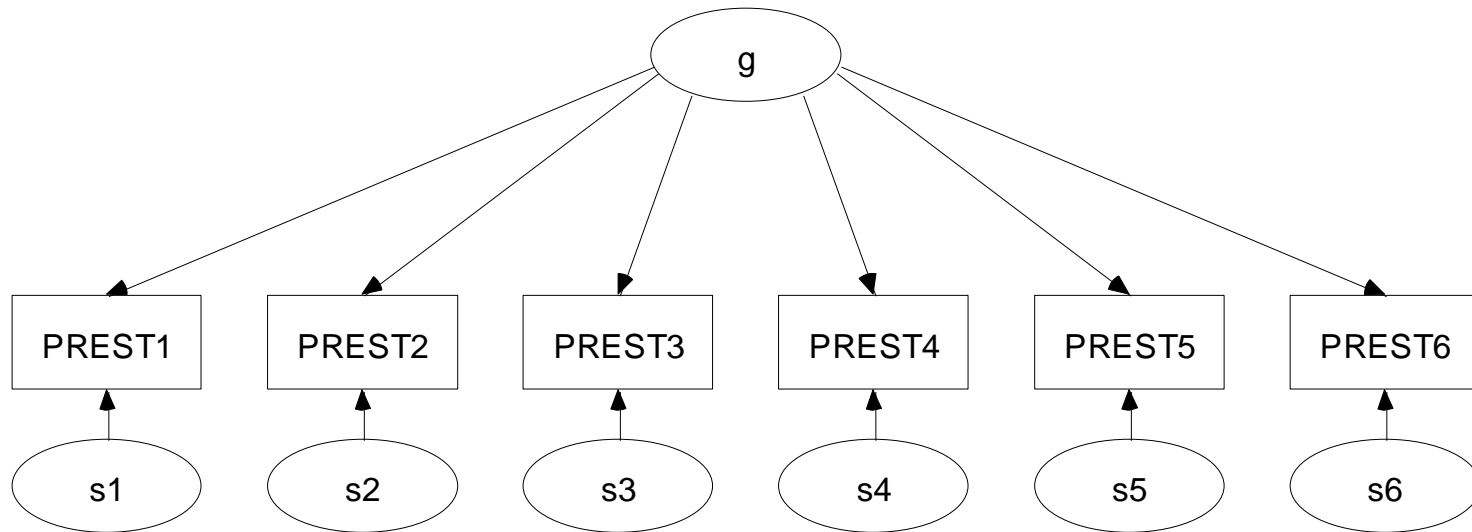


Purposes

- Clarify the achievement-aptitude distinction theoretically and empirically within the framework of a model of the structure of cognitive abilities.
- Elaborate implications of this model for conceptualization of measurement and prediction.
- Test the implications empirically.
- Discuss theoretical and practical consequences.



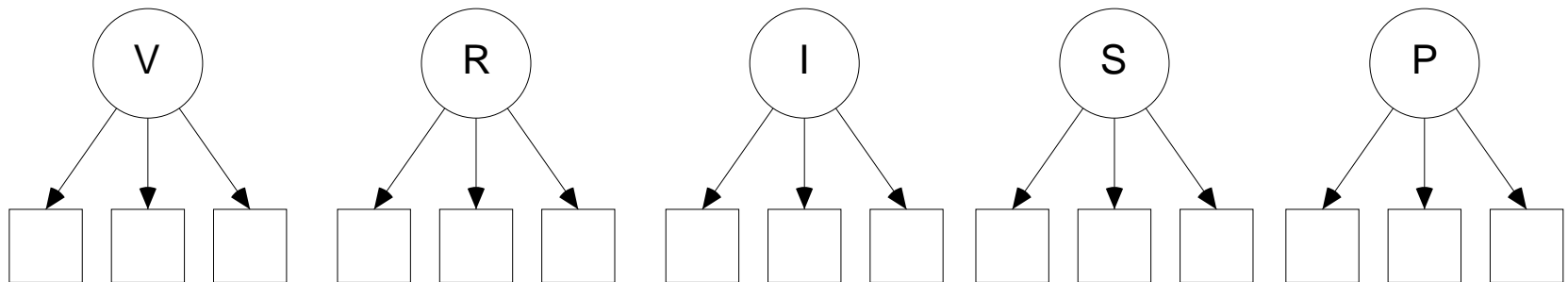
Spearman's Two-factor Theory



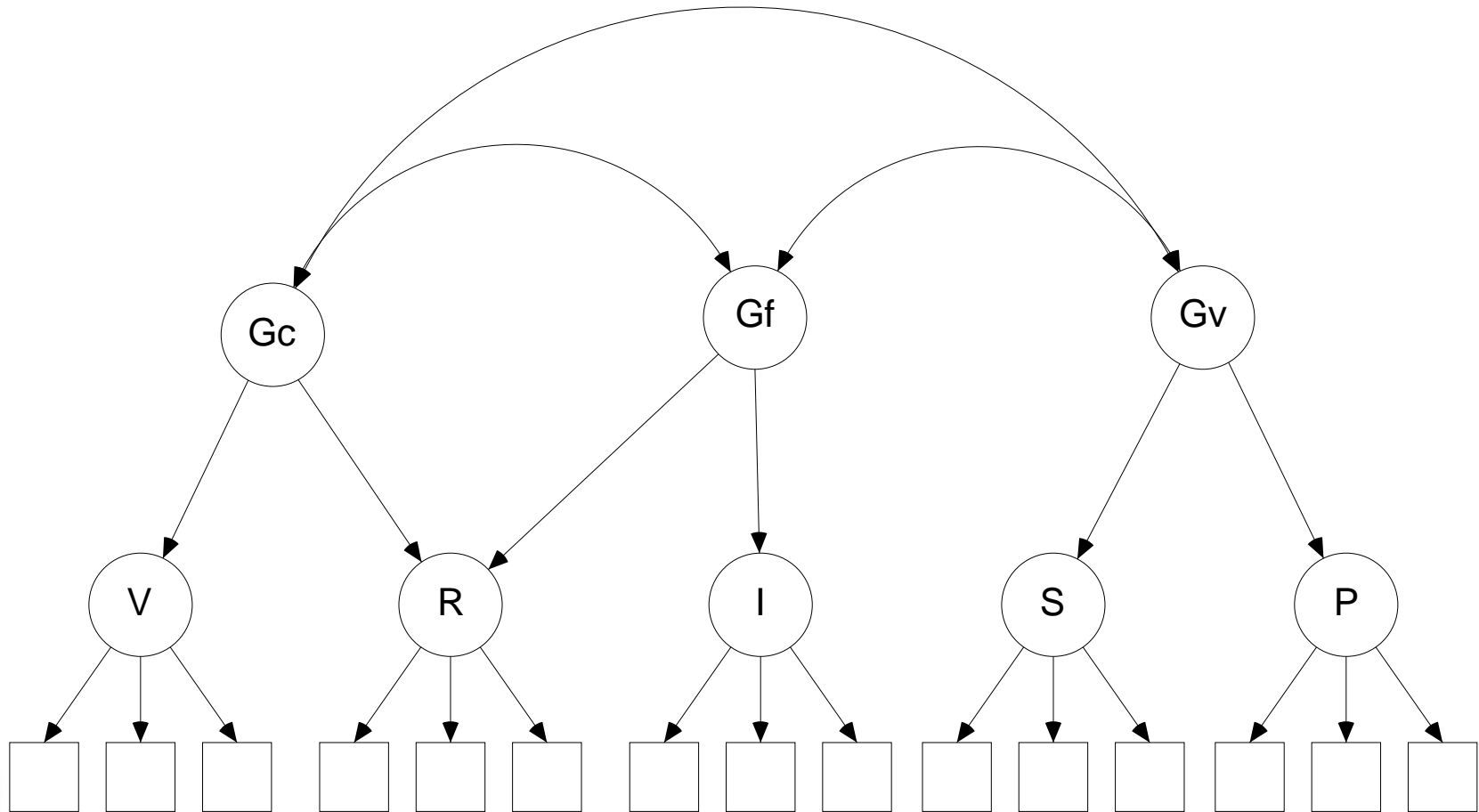
g: "education of relations and correlates"

The Two-factor Theory has been rejected, but not the *g*-factor.

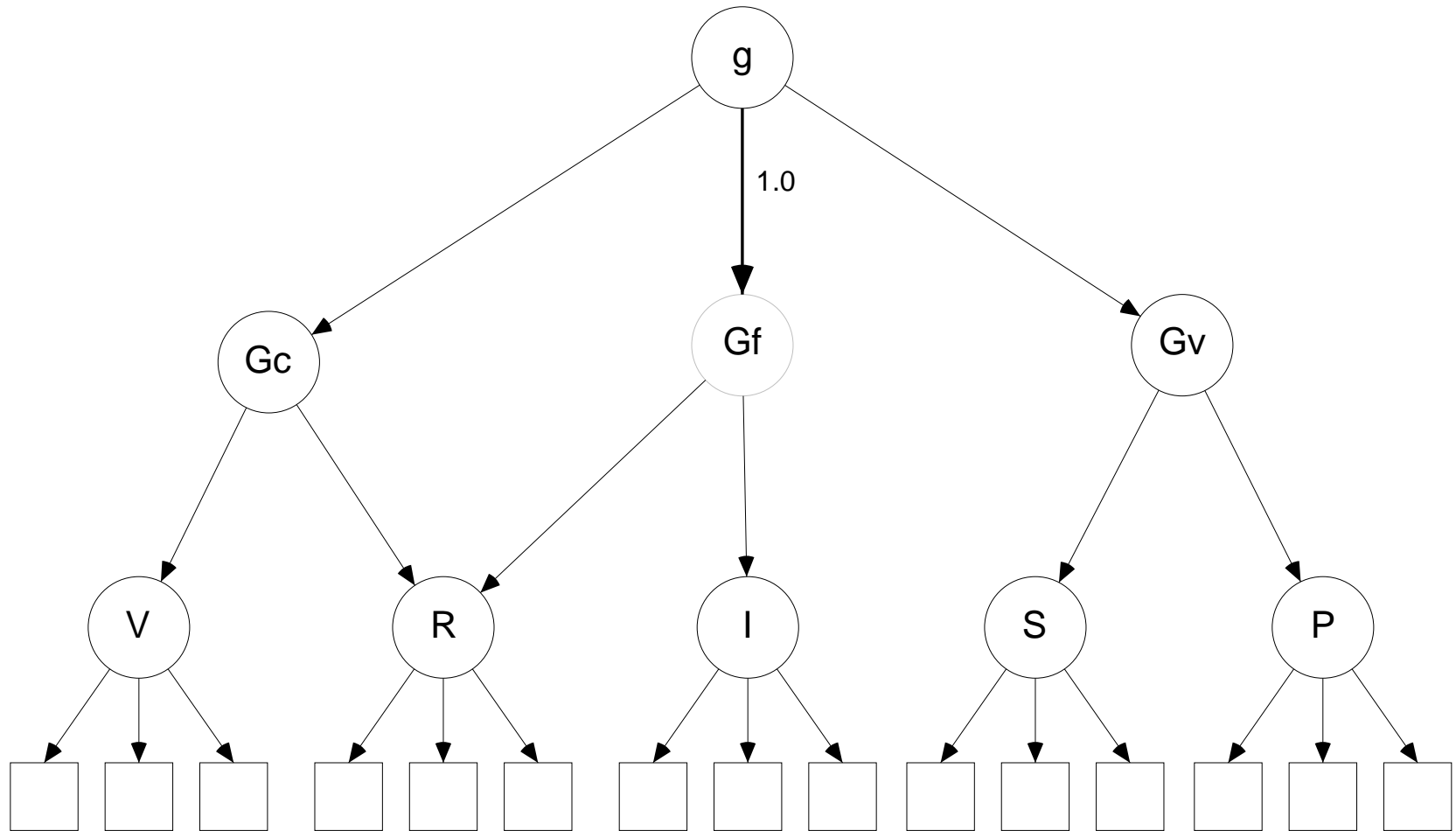
Thurstone



Cattell-Horn



"The unifying model"





Is $g = Gf$?

- Yes, according to Gustafsson (1984), Undheim & Gustafsson (1987) and a large number of other studies there is a perfect relation between g and Gf .
- No, according to Carroll (1993) and a number of other studies the relation between g and Gf is not perfect, even though it is strong.





Why does it matter if $g = Gf$?

- The G-factor is not invariant over test-batteries with different compositions.
- If $g = Gf$ this carries theoretical and practical implications.



$g = G_f$ in homogeneous groups

Measures of G_f , G_c , G_v and G_s in three groups:

- Persons born in Sweden ($N = 2358$)
- Immigrants from European countries ($N = 620$), and
- Immigrants from non-European countries ($N = 591$)

Loadings on g	
Factor	All
G_f	0.83
G_c	0.80
G_v	0.55
G_s	0.61

Loadings on g			
Factor	Swedish non-imm	European imm	Non-European imm
G_f	0.98	0.99	0.98
G_c	0.80	0.67	0.63
G_v	0.37	0.49	0.38
G_s	0.58	0.56	0.44



Why is $g = Gf$?

- According to Cattell's "Investment theory" Gf causes development of Gc through investment of time and effort in learning activities
- If Gf is of importance for development of knowledge and skills in all areas, it will become a general factor
 - Gf is an ability to deal with new and complex information, and in initial phases of learning the information is always new.
 - Gf is an inductive ability, and in many areas learning involves synthesis of partial information from different sources (e. g., vocabulary acquisition).
- The Gf -factor becomes a general factor only when everyone has the same opportunity to learn. If there are systematic differences between different subgroups when it comes to opportunity to learn this will reduce the importance of Gf as a source of variation.



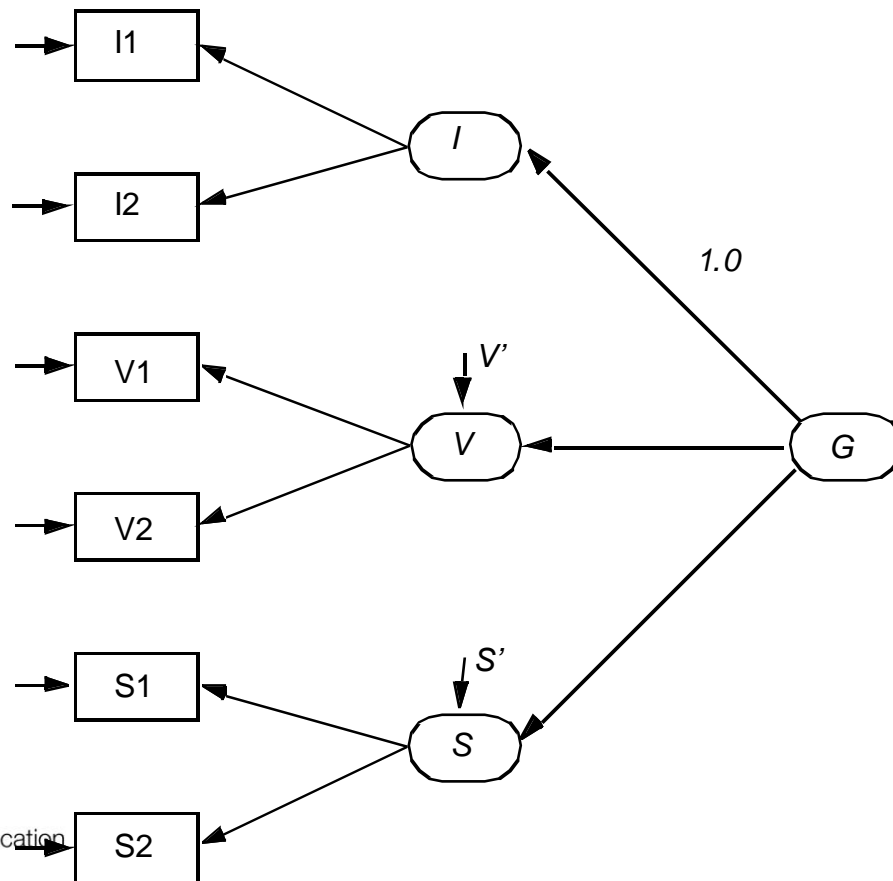


Measurement implications of the hierarchical model

- The hierarchical model of the structure of abilities includes latent variables of different degrees of generality
 - The g factor influences, directly or indirectly, all the observed variables.
 - The broad factors (e.g. Gc and Gv) influence broad categories of observed variables.
 - The narrow factors in the Thurstone tradition influence narrow categories of observed variables.
- The latent variables have different degrees of 'referent generality', from general to narrow.
- Models with latent variables of different degrees of referent generality have implications for how we should think of measurement.

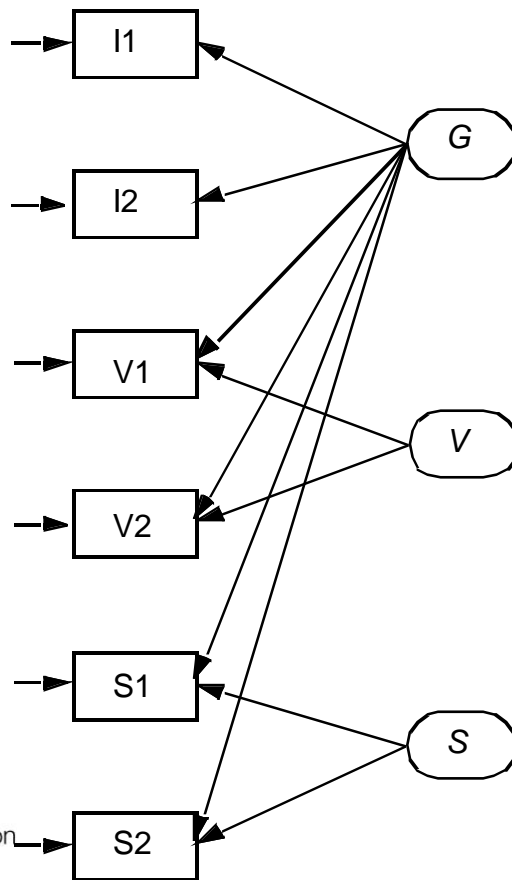


A higher-order model with three first-order and one second-order factors



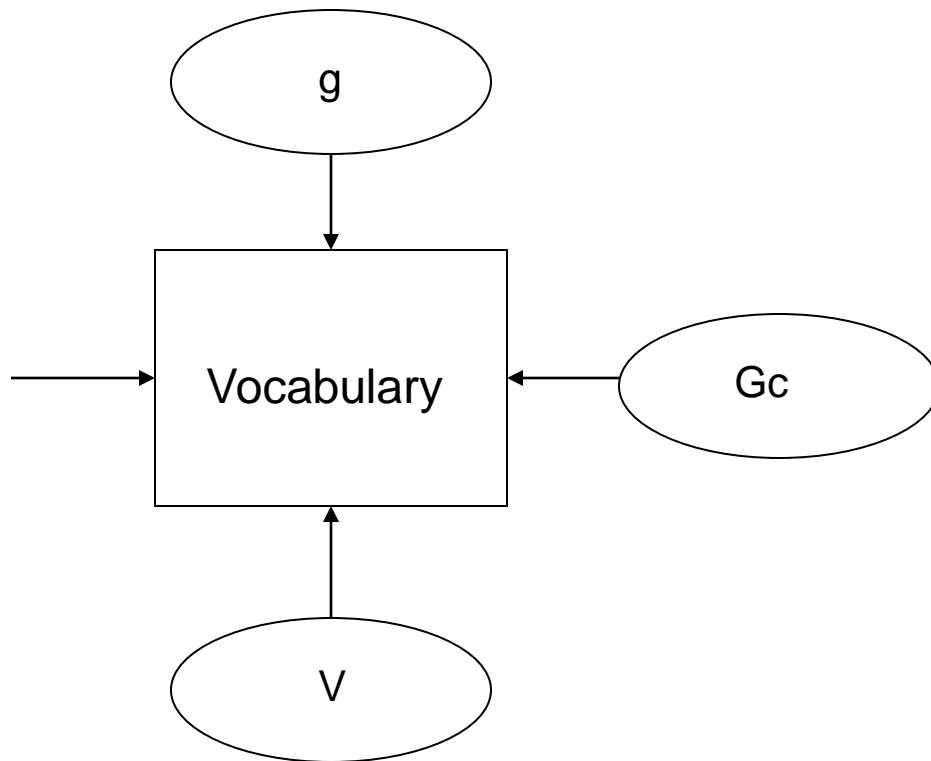
- In this model the observed measures are factorially simple, each being influenced by one latent variable only.
- The second-order factor is more distant from the observed variables than are the first-order factors.

A nested-factor model with one general and two specific factors



- In this model the observed measures are factorially complex, four of them being influenced by two latent variables.
- The general factor directly influences the observed variables and is no more distant than are the specific factors.

Complex measures



From the hierarchical model it follows that observed variables are factorially complex, in that they reflect variance from factors of different degrees of generality.



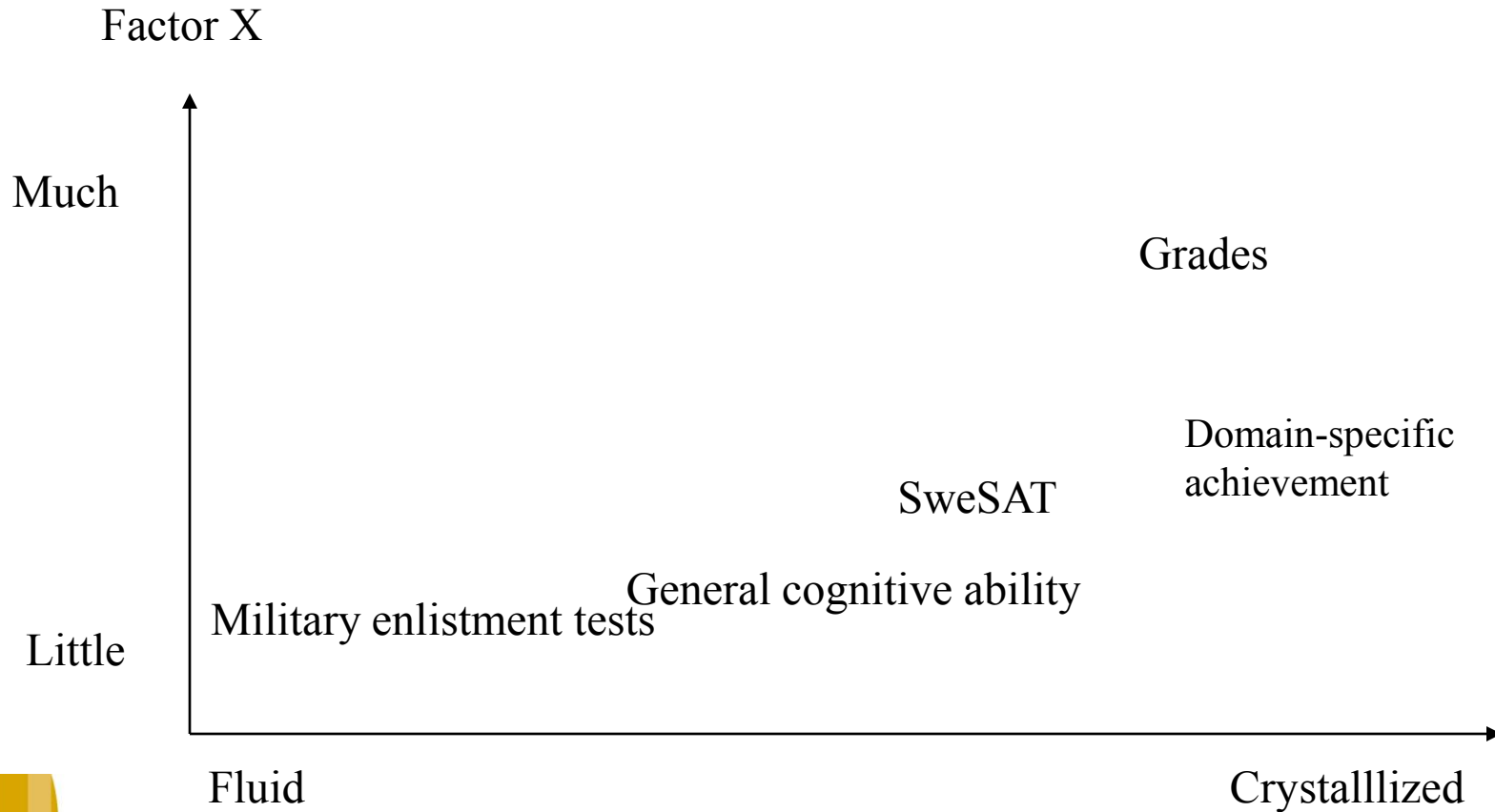
What predicts achievement in higher education?

- g, or the ability to "educe relations and correlates".
- Gc, or measures of developed abilities (achievement):
 - reading ability, vocabulary
 - general knowledge
 - mathematical knowledge and problem-solving abilities.
 - domain specific knowledge and skill
- Grades:
 - knowledge and skills
 - motivation, effort, industriousness, interests, social and communication skills (Factor X).

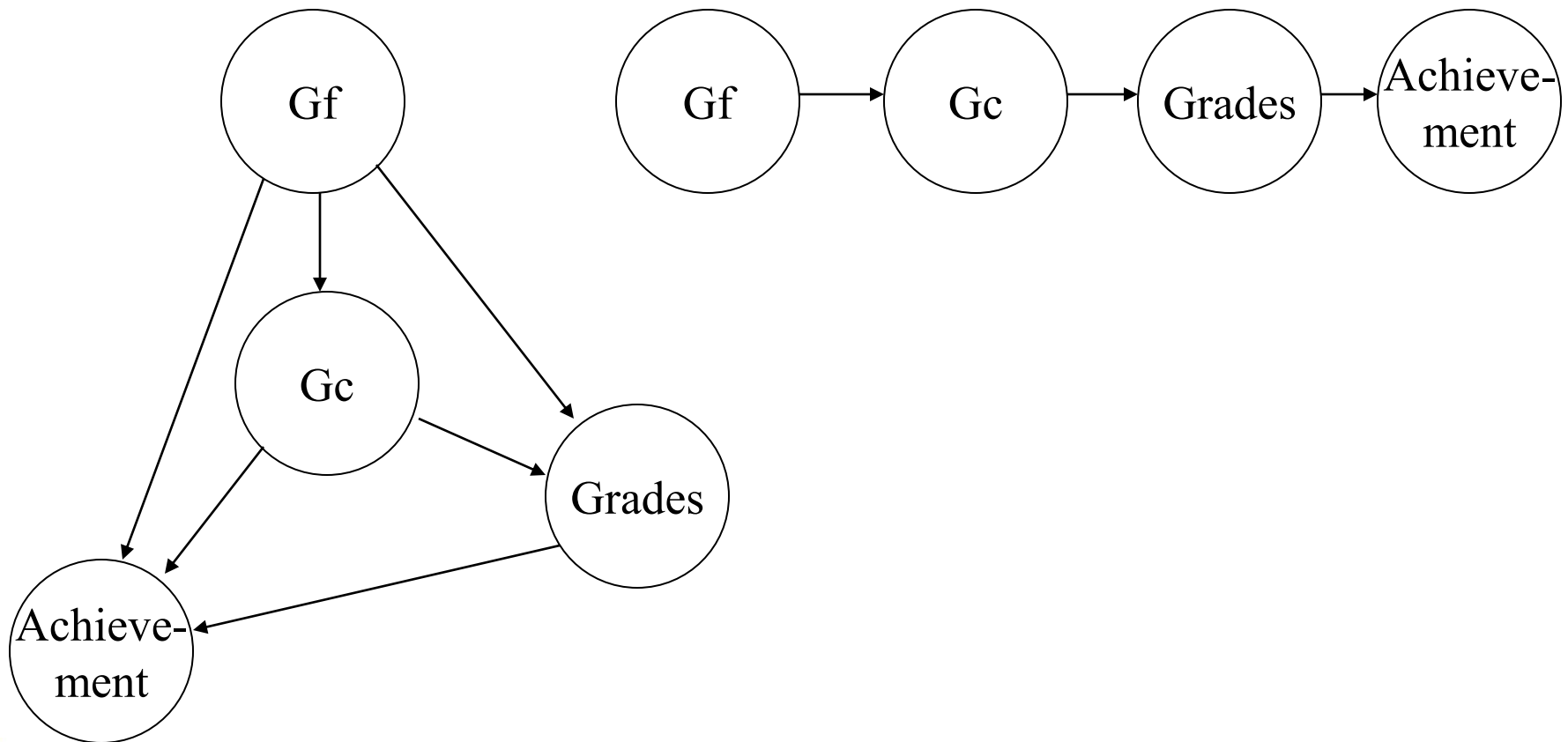




Hypothesized involvement of crystallized abilities and X in different selection instruments



Aptitudes, grades and achievement in higher education: Possible relations





An empirical study

- Swedish Enlistment Battery (*SEB*): 10 subtests measuring Gf (non-verbal problem solving), Gv (manipulation of figural information), and Gc (vocabulary).
- *SweSAT*: 5 subtests (English and Swedish reading comprehension, vocabulary, numerical reasoning, problem solving with information in diagrams, tables and maps)
- Average *grades* (norm-referenced) from upper secondary school
- *Credit points* earned during the first year of the graduate engineering program.





Data and Analytical techniques

- Sample of 9 539 men born in 1977 eligible for graduate engineering programs:
 - 3 089 were admitted to graduate engineering programs 1996 to 2000
 - 7 438 had CAT-SEB test data
 - 6 616 had SweSAT data
 - 9 379 had grades from upper secondary school.
- Latent variable models fitted with LISREL
- Missing data modeling to allow generalization to the group of eligible students.



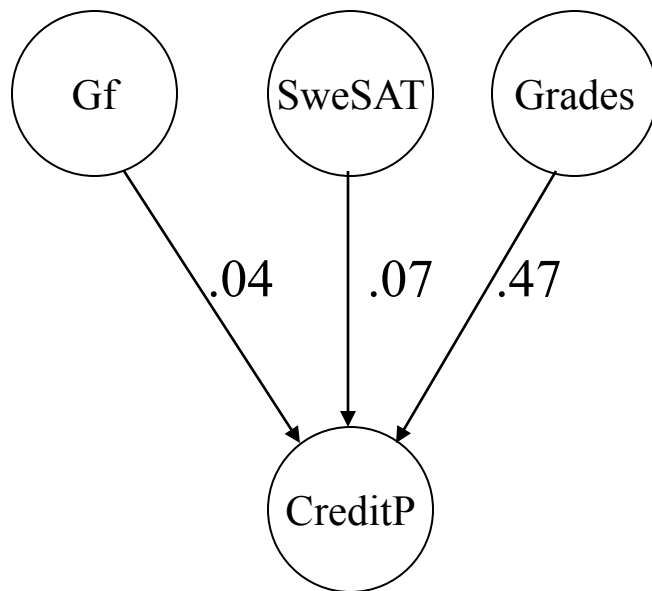


Correlations among the variables

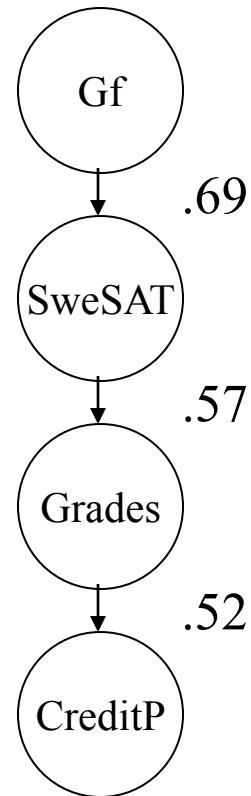
	Gf	SweSAT	Grades	Credit Points
Gf	1.00			
SweSAT	.69	1.00		
Grades	.40	.57	1.00	
Credit Points	.27	.36	.52	1.00



Two alternative models



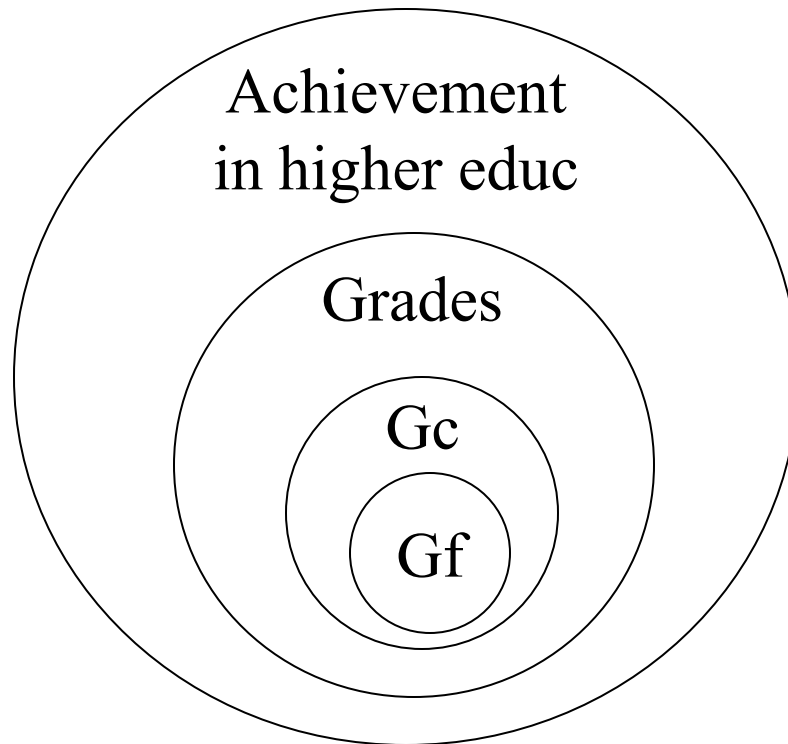
$$R^2 = .277$$



$$R^2 = .270$$

$$\chi^2 (9) = 142.00, \\ RMSEA = .039$$

The Encapsulation model



- Measures of Gc contain all information about Gf
- Grades contain all information about Gc and Gf, along with X.



When may Gf add to prediction?

- Variability in access to education, and in quality of education, causes Gc to imperfectly reflect differences in Gf. In these situations Gf may be expected to contribute to prediction.
- If the content of the educational program does not build upon previously acquired knowledge and skills, Gf may be expected to be important. But higher education does build upon previously acquired knowledge and skills, and probably more so now than before, as curricula expand.



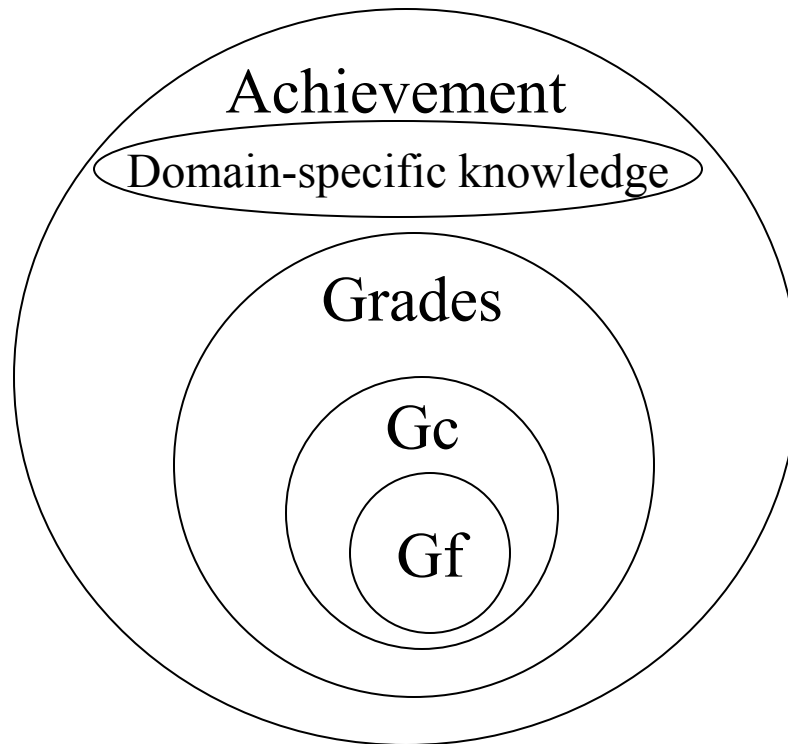


When may Gc add to prediction?

- When grades suffer from lack of comparability and/or low reliability.
- When grades are corrupted to reflect something else than knowledge and skills.



When may domain-specific knowledge add to prediction?



- Domain-specific knowledge is not well represented by grades or scholastic aptitude tests.
- When the educational program builds upon previously acquired knowledge and skills in different domains, measures of domain-specific knowledge should add to prediction.



Conclusions

- Theoretically a meaningful distinction can be made between aptitude and achievement within the framework of psychometric models of cognitive abilities.
- Practically, these models imply that measures of achievement have better predictive validity than have measures of aptitude.
- Grades have good predictive validity, partly because they capture a wider range of achievement than tests, and partly because they reflect non-cognitive skills.

