FROM GENES TO BIOLOGY-INFORMED COGNITIVE TESTING: MAPPING THE GENETIC ARCHITECTURES OF COGNITIVE FUNCTIONING

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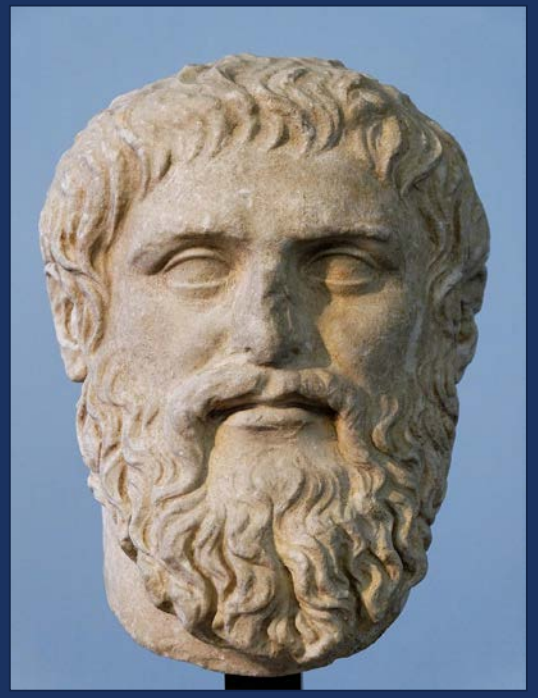
THE NATURE OF INTELLIGENCE

INTELLIGENCE AND THE ASSESSMENT OF COGNITIVE PROCESSES

EARLY IDEAS ABOUT THE NATURE OF INTELLIGENCE

PLATO
427 BC – 347 BC

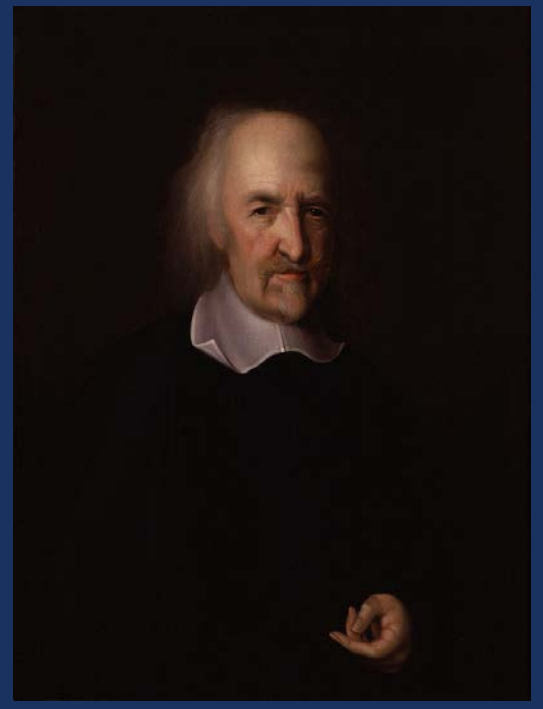


The love of learning –
and the love of truth

ST.AUGUSTINE
354 – 430

Superior intelligence might lead people away from God

THOMAS HOBBES
1588 - 1679



Superior intelligence is the ability to see similarities between different things, and differences between similar things (*Leviathan)*

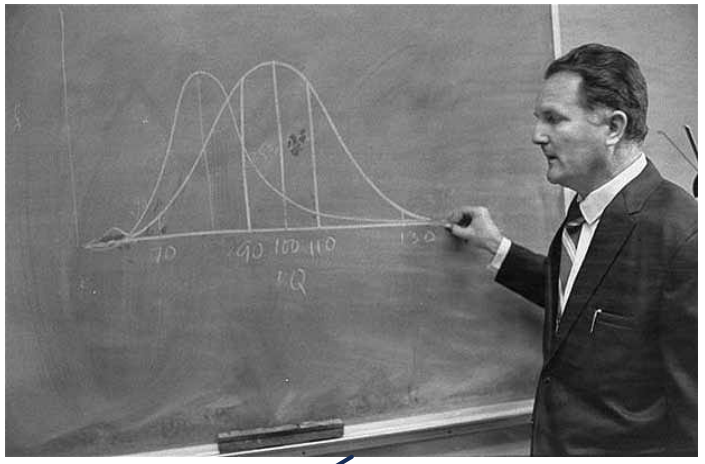
ORIGINS OF MODERN UNDERSTANDING OF INTELLIGENCE

Charles Spearman

Alfred Binet
1857 - 1911

Louis Thurstone
1887 - 1955

Arthur Jensen
1923 - 2012



Hans Eysenck
1916 - 1997

g, general intelligence | Mental energy | Mental speed | Multiplicity of higher mental processes

HOW WE DEFINE INTELLIGENCE TODAY?

AMERICAN PSYCHOLOGICAL ASSOCIATION

intelligence

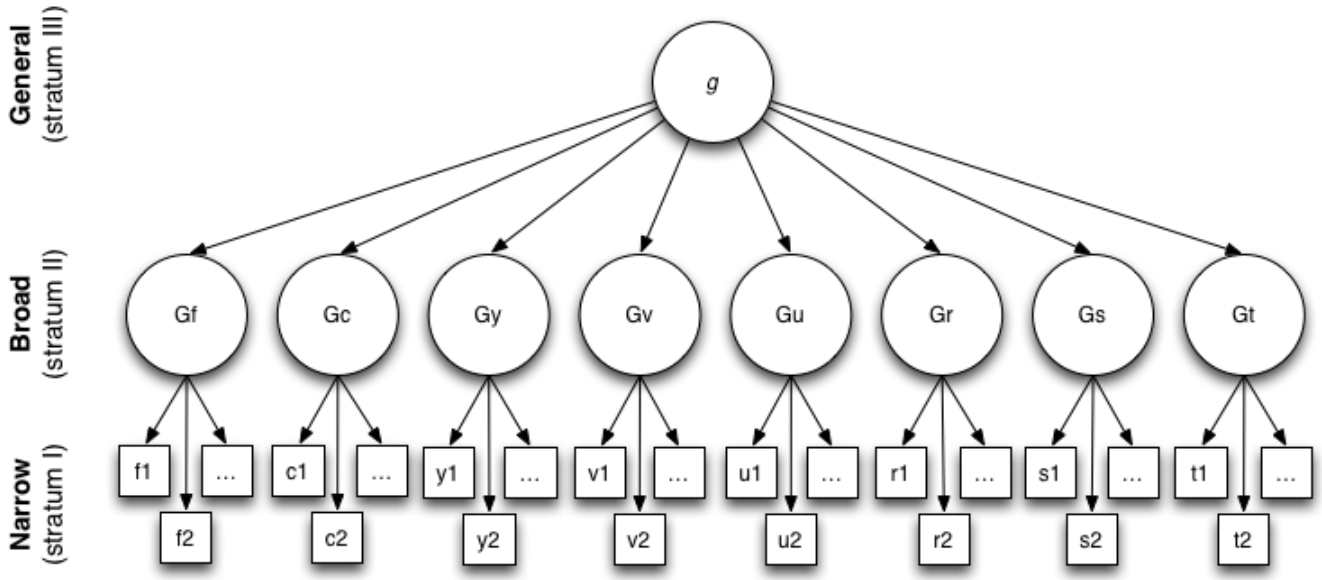
n. the ability to derive information, learn from experience, adapt to the environment, understand, and correctly utilize thought and reason.

cognition

n.

1. all forms of knowing and awareness, such as perceiving, conceiving, remembering, reasoning, judging, imagining, and problem solving. Along with affect and conation, it is one of the three traditionally identified components of mind.
2. an individual percept, idea, memory, or the like.

THE CATTELL-HORN-CARROLL (CHC) THEORY



- Performance on a test as a function of multiple domain-general and domain-specific abilities
- Widely accepted as the most comprehensive and empirically supported theory of cognitive abilities, informing a substantial body of research
- Kovacs and Conway (2019) have proposed Process Overlap Theory (POT) which describes overall performance on a test as a function of multiple domain-general and domain-specific abilities

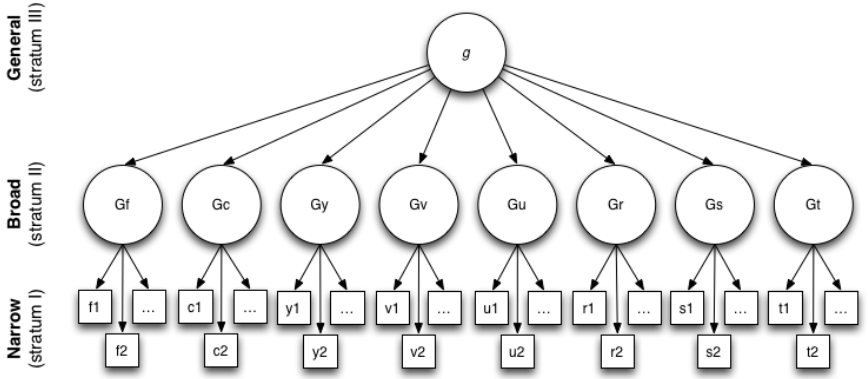
All cognitive theories and measurement instruments have been developed without taking biological bases of cognitive behaviour into consideration!

SETTING THE STAGE: ARE SPECIFIC COGNITIVE ABILITIES GENETICALLY SEPARABLE FROM G?

WHAT DO WE KNOW ABOUT GENETIC ARCHITECTURE OF COGNITION

WHAT DO WE KNOW ABOUT GENETICS OF COGNITION?

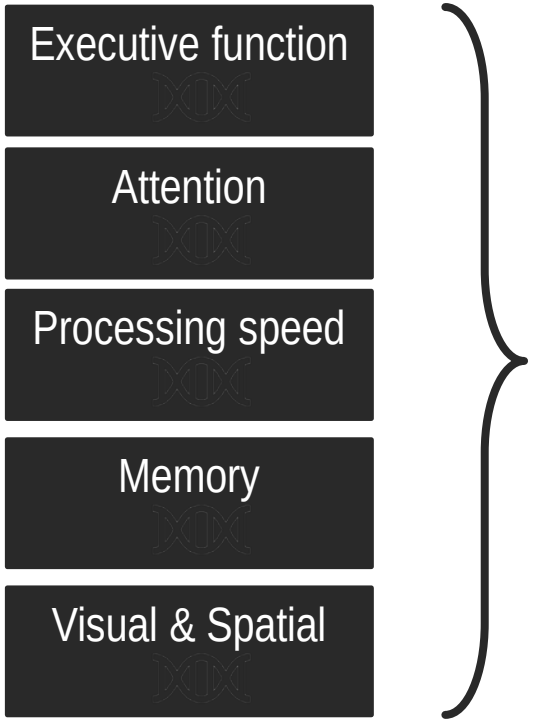
- General intelligence, g



- Arrived at by factor analysis of results of multiple tests
- Claims a general component to intelligence, supplemented by specific components
- Over 1,000 genetic variants identified across 12 studies at $p<5x10^{-8}$

- **Limited translation due to lack of specificity**

- Specific cognitive abilities



- **Limited understanding of genetics of specific cognitive abilities**
- **Not clear whether specific cognitive abilities are genetically separable from g**

- **Are specific cognitive abilities, such as EF, genetically separable from g?**

IS **EF** GENETICALLY SEPARABLE FROM ***G***?

1 Literature search & SNPs identification

GWAS Catalog
The NHGRI-EBI Catalog of published genome-wide association studies

2 In-silico functional characterisation and pathway analyses

SNPnexus

3 Is there genetic and/or pathways overlap between *g* and EF?

Studies of interest:

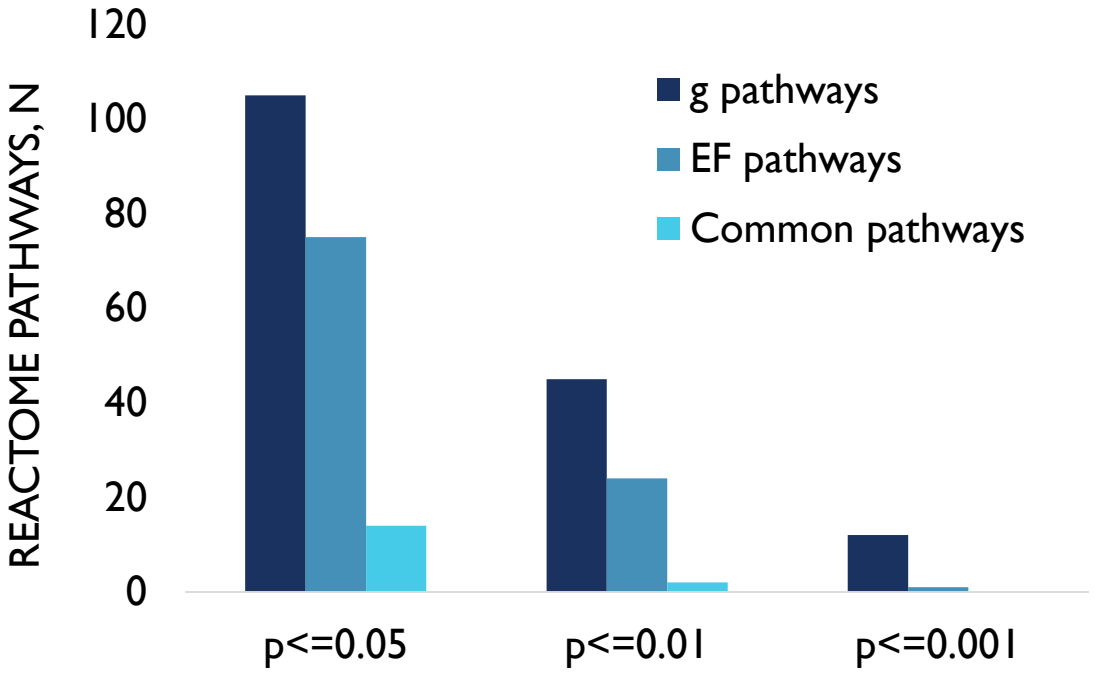
- 12 studies on general intelligence, g
- 5 studies on executive function

Index SNPs:

- 1,372 g SNPs at $p<5x10^{-6}$
- 300 EF SNP $p<5x10^{-6}$

Proxy SNPs (LD, R^2 >0.8):

- 37,547 g SNPs
- 8,493 EF SNPs



RESULTS

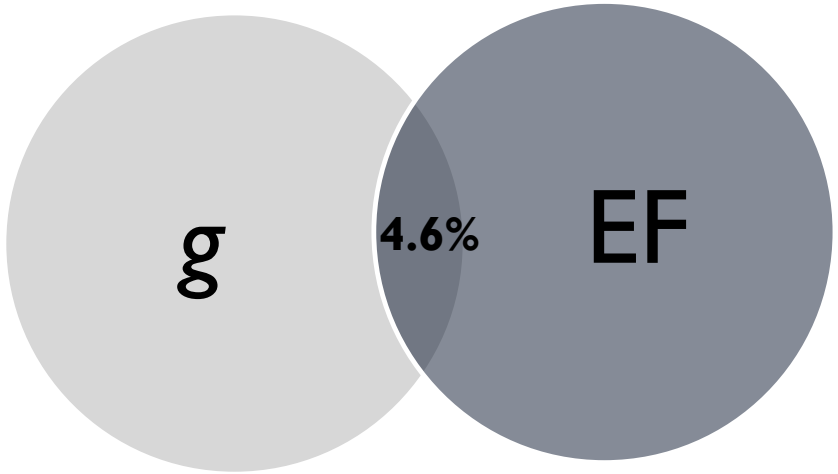
- Minimal LD-based genetic overlap between g & EF (4.6%)
- Small pathway overlap between g & EF (7.8%)

CONCLUSION

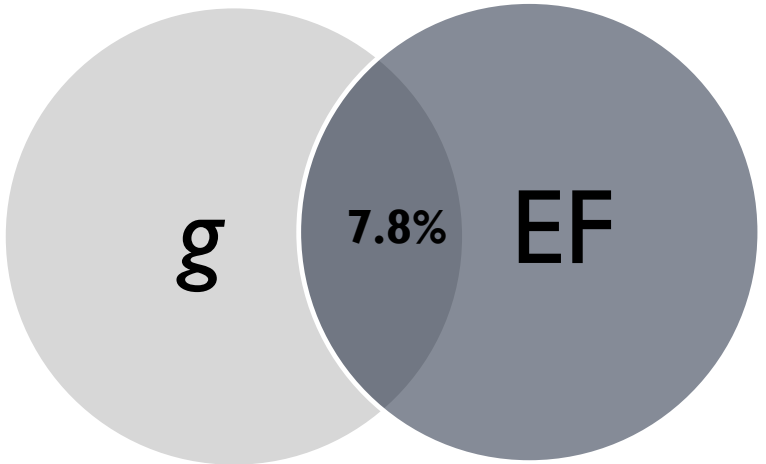
EF appear to be separable from g at the molecular level

YES, **EF** APPEAR TO BE GENETICALLY SEPARABLE FROM ***G***

Genetic overlap



Molecular pathways overlap



EF & g showing minimal overlap at genetic variant and biological pathways levels, suggesting that EF is genetically separable from *g*

Ciobanu et al. 2021. "General intelligence and executive functioning are overlapping but separable at genetic and molecular pathway levels: an analytical review of existing GWAS findings". Under review

A NOVEL FRAMEWORK FOR DERIVING BIOLOGY-INFORMED STRUCTURE OF COGNITION

A NETWORK-BASED APPROACH

A UNIFIED MODEL OF GENERAL INTELLIGENCE

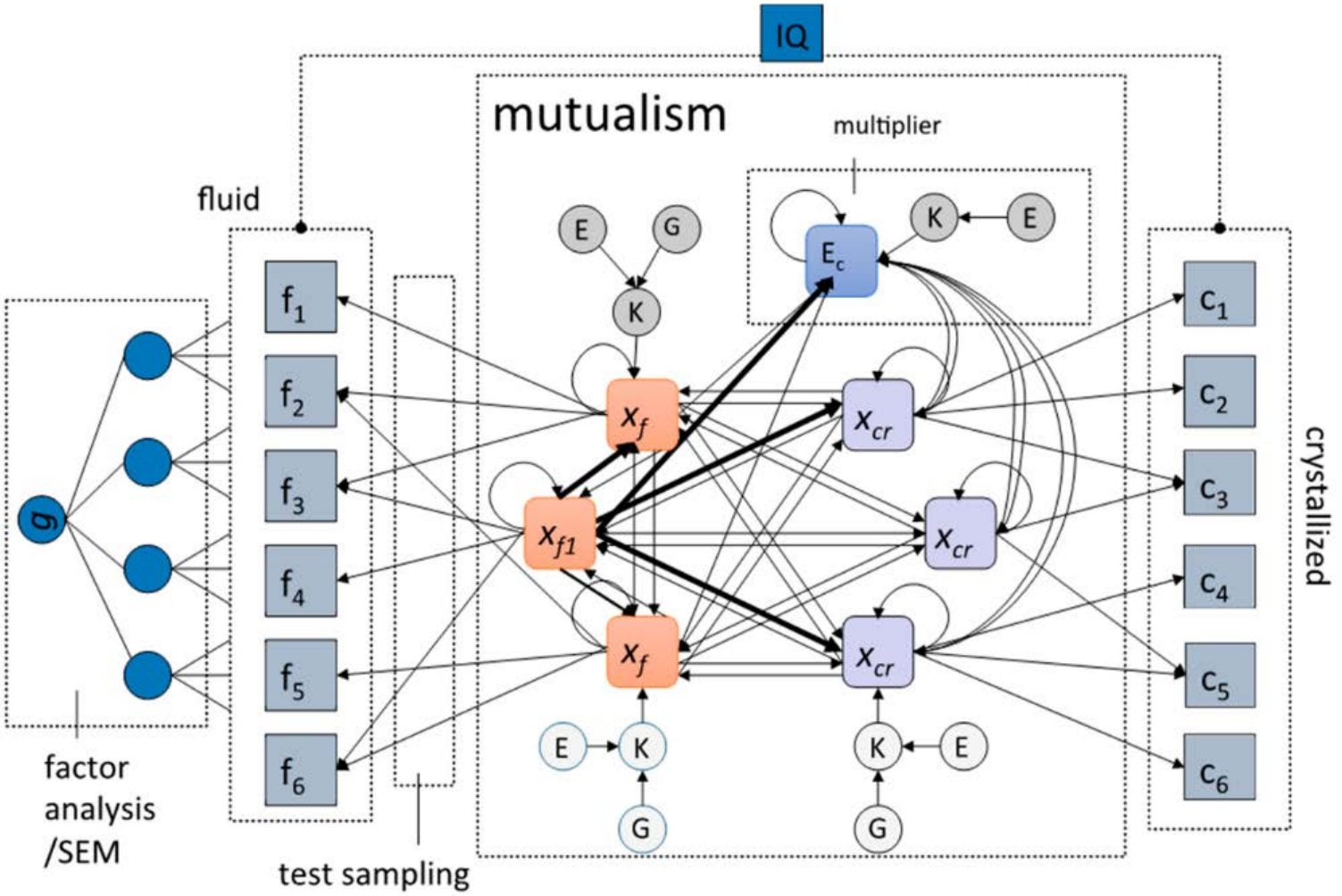


Figure from (Van Der Maas, Kan et al. 2017)

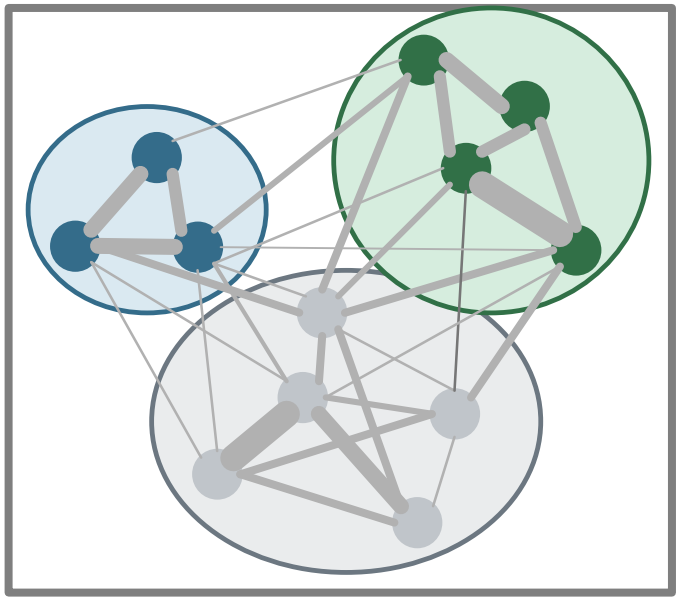
A NOVEL NETWORK-BASED FRAMEWORK

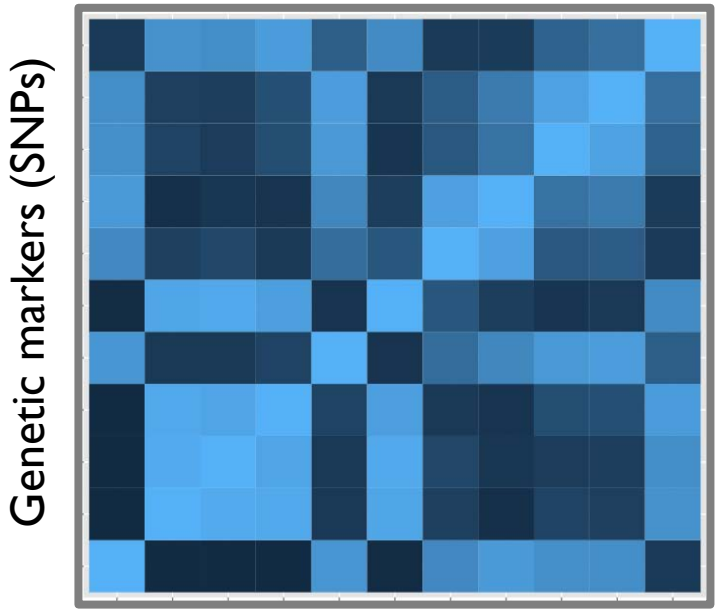
biobank uk
Enabling scientific discoveries that improve human health

Network modeling of cognitive behaviour

Genetic markers of basic units of cognitive behaviour

Biology-informed assessments





- **Biology-informed structure of cognitive functioning**
- **Better understanding of molecular mechanisms involved**
- **Biology-informed cognitive assessment battery**

ACKNOWLEDGEMENTS

Cognitive Genomics Research Group

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