# Introduction to Mathematical Psychology

Week 1



Music. Discrim. 0.63 Mathem. 0.66 Typical Forgetting Curve for Newly 1 0.57 English. 0.65 0.51 0.70 **First learned** 0.5I 0.67 0.54 French. 0.78 0.40 0.45 0.64 Classics. 0.67 0.83 0.88 0.89 0.84 0.87 0.40 0.45 0.64 Classics, 0.67 0.83 0.51 0.54 0.78 French, 0.67 0.5<sup>1</sup> English, 0.65 0.70 Mathem., 0.66 0.57 Discrim., 0.63 Music, 5 Days

#### Abductive theory of scientific method





#### Course

Learn the concept of a formal theoretical model, as an aid in understanding cognitive processes; and get familiar with three leading approaches, to understand the basic concepts of math. psychology.

## 4 weeks / 3 topics / 1 project



Week 1 Alexander Savi

Introduction & growth models in intelligence



Week 3 Han van der Maas

Catastrophe models in psychology



Week 2 Leendert van Maanen

Diffusion models in decision making



#### Schedule

#### In class

- Mo 4 Introduction & growth models (AS)
- Th 7 Tutorial growth models (AS)
- Mo 11 Lecture diffusion models (LvM)
- Th 14 Tutorial diffusion models (LvM)
- Mo 18 Lecture catastrophe models (HvdM)
- Th 21Tutorial catastrophe models (HvdM)
- Mo 25 Research project (you)
- Th 28 Research project (you)

Time 13:00-15:00; location JK B.26 *Time 12:00-14:00; location G S.08* 

#### At home

Assignment Assignment

Assignment Assignment

Assignment Assignment

Research project Research project

Slides on www.alexandersavi.nl/teaching/

## Grading

Assignments

- Various assignments for each topic
- Pass / fail

Research project

- Pick a topic from the assignments / tutorials
- Extend the topic with an idea of your own
- Write a report or research proposal about it
- Use about 2000 words
- <u>Upload</u> report (pdf) before June 29th, 18:00
- Graded (final grade)

## Growth models in intelligence #1

#### IOURNAI THE ROYAL SOCIETY Interface

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#### The Matthew effect in empirical data

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The Matthew effect describes the phenomenon that in societies, the rich tend to get richer and the potent even more powerful. It is closely related to the concept of preferential attachment in network science, where the more connected nodes are destined to acquire many more links in the future than the auxiliary nodes. Cumulative advantage and success-breads-success also both describe the fact that advantage tends to beget further advantage. The concept is behind the many power laws and scaling behaviour in empirical data, and it is at the heart of self-organization across social and natural sciences. Here, we review the methodology for measuring preferential attachment in empirical data, as well as the observations of the Matthew effect in patterns of scientific collaboration, socio-technical and biological networks, the propagation of citations, the emergence of scientific progress and impact, career longevity, the evolution of common English words and phrases, as well as in education and brain development. We also discuss whether the Matthew effect is due to chance or optimization, for example related to homophily in social systems or efficacy in technological systems, and we outline possible directions for future research.

## Pólya's urn





#### Explore

#### **Parameters**

What are they? What is their influence?

#### **Compensation effect**

#### What is it? Can you create it?

Do the smart get smarter? Development of fluid and crystallized intelligence in 3rd grade\*

Ulrich Schroeders <sup>a,\*</sup>, Stefan Schipolowski <sup>b</sup>, Ingo Zettler <sup>c</sup>, Jessika Golle <sup>d</sup>, Oliver Wilhelm <sup>e</sup>





CrossMark

### Next Thursday

Make groups of three

Identify a phenomenon

Identify the (type of) data that support the phenomenon

Identify a formal theory that explains the phenomenon

Identify the mechanisms that explain the phenomenon

Present it on Thursday

## Presentations

## Thinking in systems



comorbidity from a network perspective

## Thinking in systems

Warren Weaver

- simplicity
- disorganized complexity
- organized complexity



#### Levels of description



## Levels of analysis

David Marr & Tomaso Poggio

- learning level
- computational level
- algorithmic/representational level
- implementational/physical level



## "All models are wrong; some models are useful." - George Box



## Growth models in intelligence #2





Altogether, we have a uniformity that is very nearly perfect and far surpasses the conceivable limits of chance coincidence.

#### multiplier effect















### Idiographic theory





#### **Preferential attachment**



#### **Explore**

What patterns do you observe?

What is the mechanism?

What do the degree distributions tell you?

What is special about the degree distribution?

How does it relate to Pólya's urn?

Can it be used in our idiographic theory?



Abductive theory of scientific method Brian D. Haig / Jan-Willem Romeijn

Understanding modeling Joshua M. Epstein / David Marr & Tomaso Poggio / Warren Weaver / (Leo Breiman)

Software Loopy / <u>NetLogo</u> + <u>Tutorial</u>

Models

Pólya urn model / Mutualism model / Multiplier effect models / (Network models)

Learn about complexity science Complexity explorer / Herbert A. Simon

#### Comments / feedback

We're here to facilitate your learning experience

Any comments or feedback?

Tell us during the course

You can do so anonymously on www.alexandersavi.nl/teaching/

## Week 2

Diffusion models in decision making, with Leendert van Maanen

