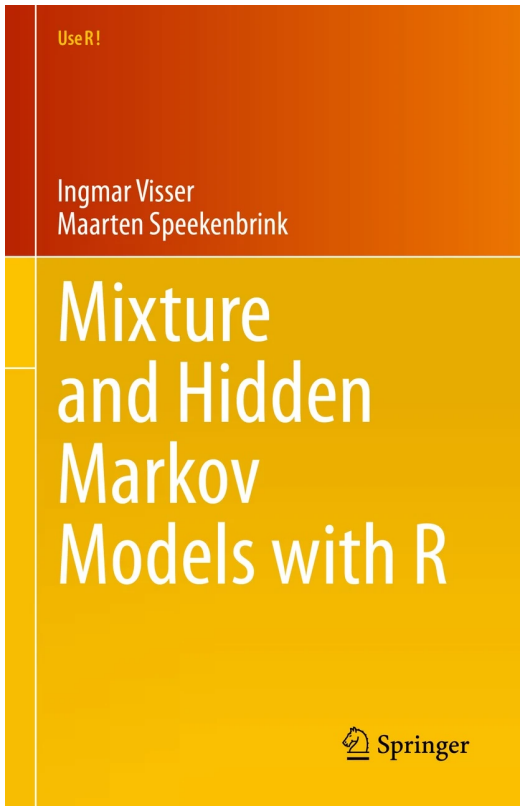
Detecting (categorical) individual differences in developmental data

Mixture models, latent class models and Markov models for studying change

Ingmar Visser

2023-08-22

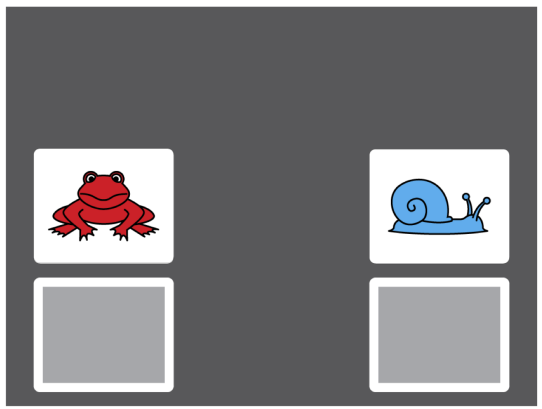
Joint work


UseR!
Ingmar Visser
Maarten Speekenbrink
Mixture and Hidden Markov Models with R
Springer

Workshop outline

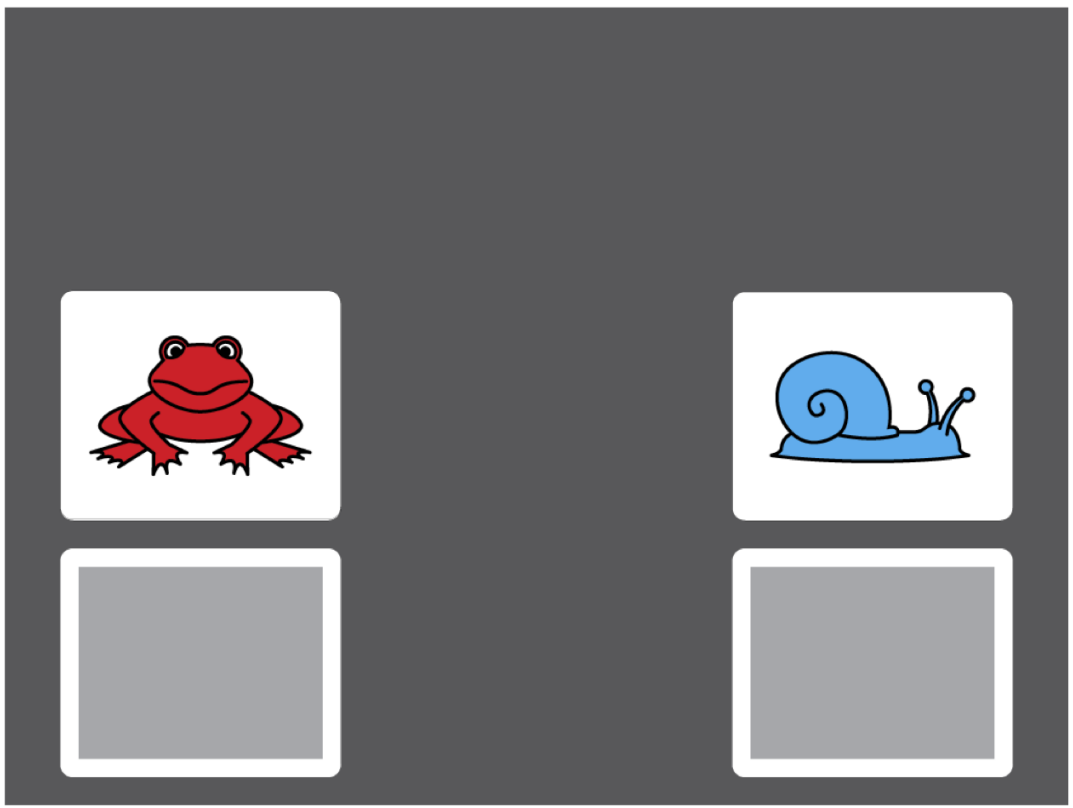
1. Introduction and examples (45 min)
2. Individual differences: mixture & latent class models (60)
3. Examples & hands-on exercises (45)
4. Break, lunch, 12.30-14.00
5. Hidden Markov models: modelling change over time (60)
6. Examples & hands-on exercises (60)
7. Questions & discussion (30)

DCCS: the task



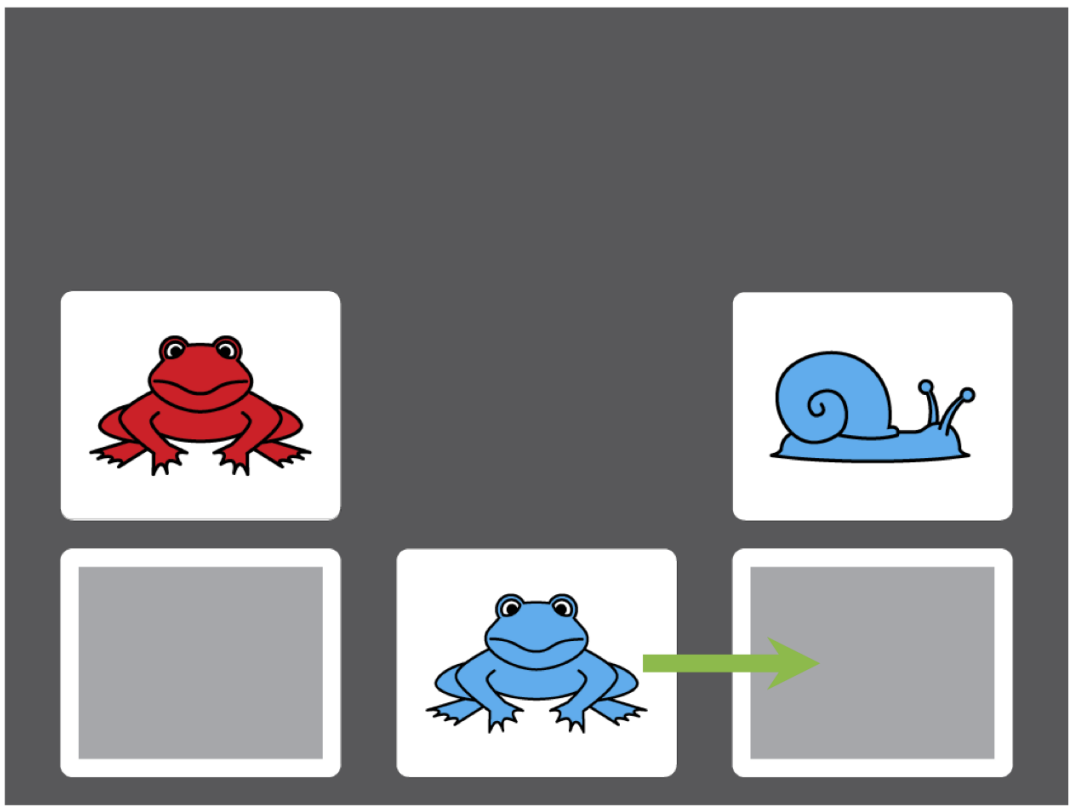
DCCS: the task

pre-switch phase: target cards



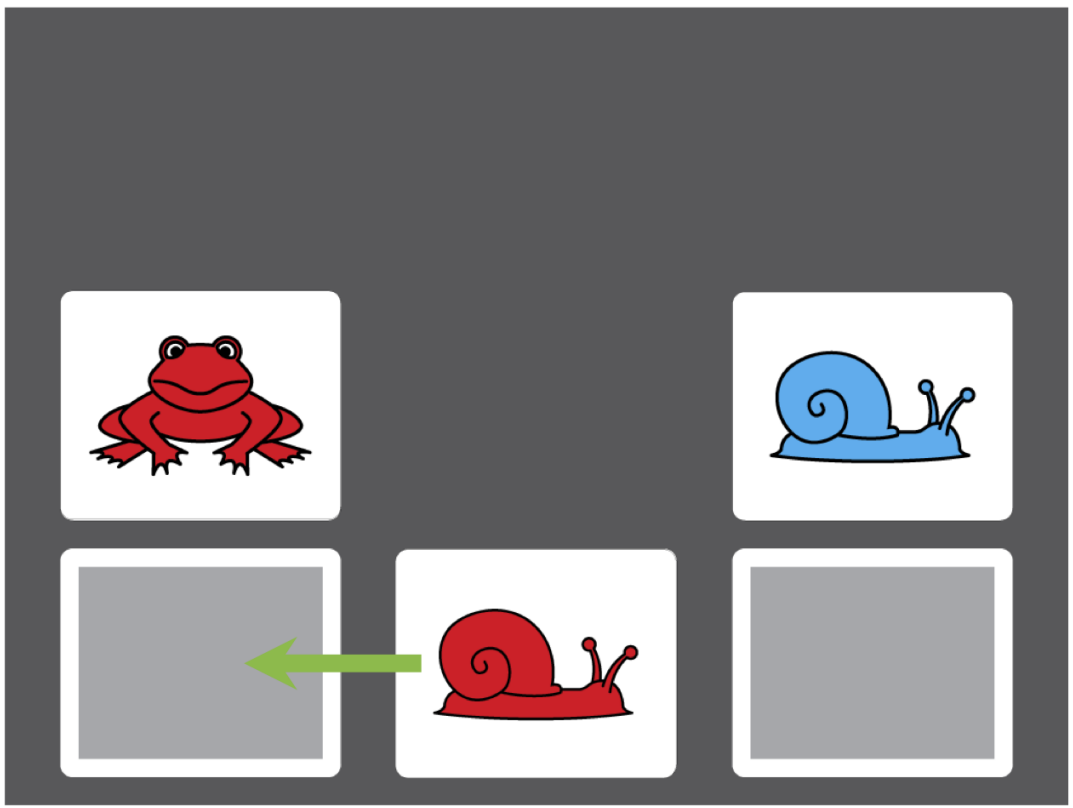
DCCS: the task

pre-switch phase: sort on color



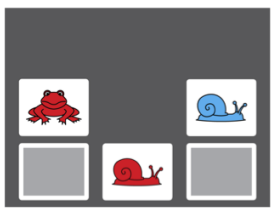
DCCS: the task

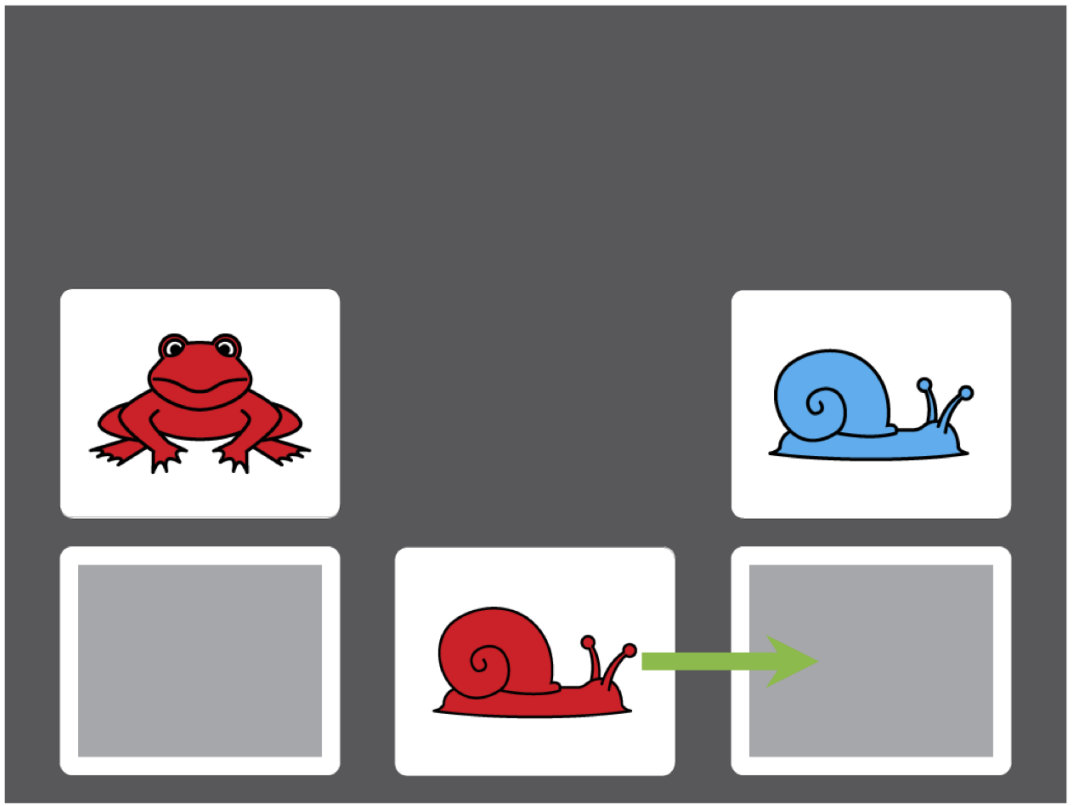
pre-switch phase: sort on color



DCCS: the task

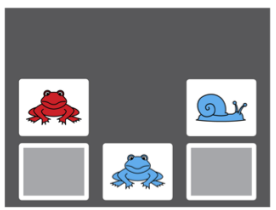
post-switch phase: sort on shape

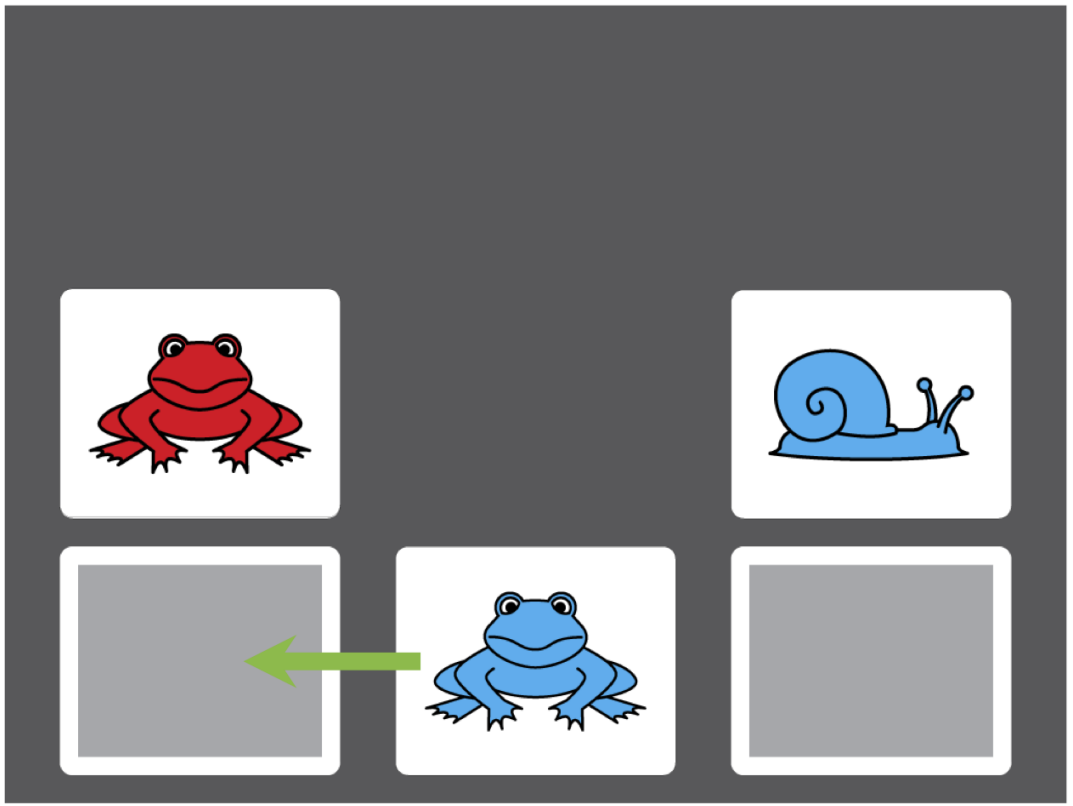




DCCS: the task

post-switch phase: sort on shape



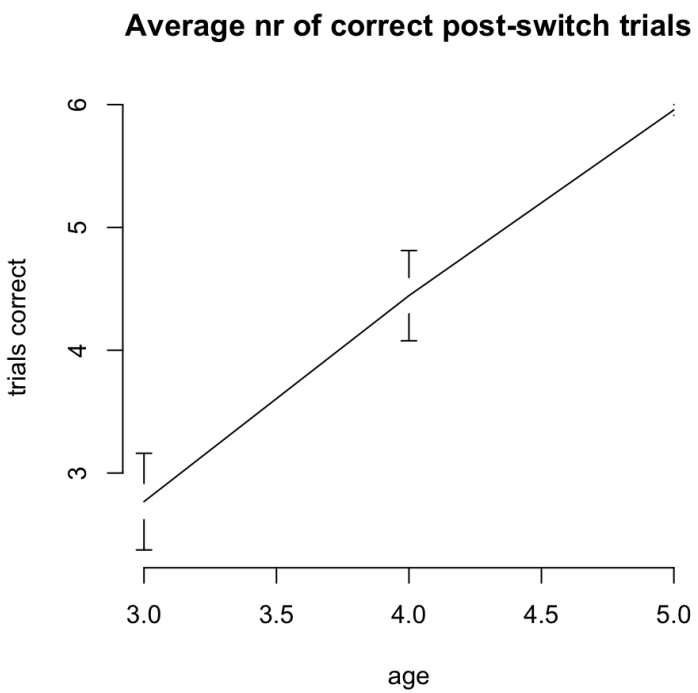


DCCS: research questions

1. When do children develop the ability to switch?
2. Which processes/knowledge are involved? How do those support switching?
3. Are there individual differences in this developmental pathway?

DCCS: the data

DCCS: the data



1. Pre-switch data: Almost all children answer all items correct, if not data are discarded
2. Post-switch data:

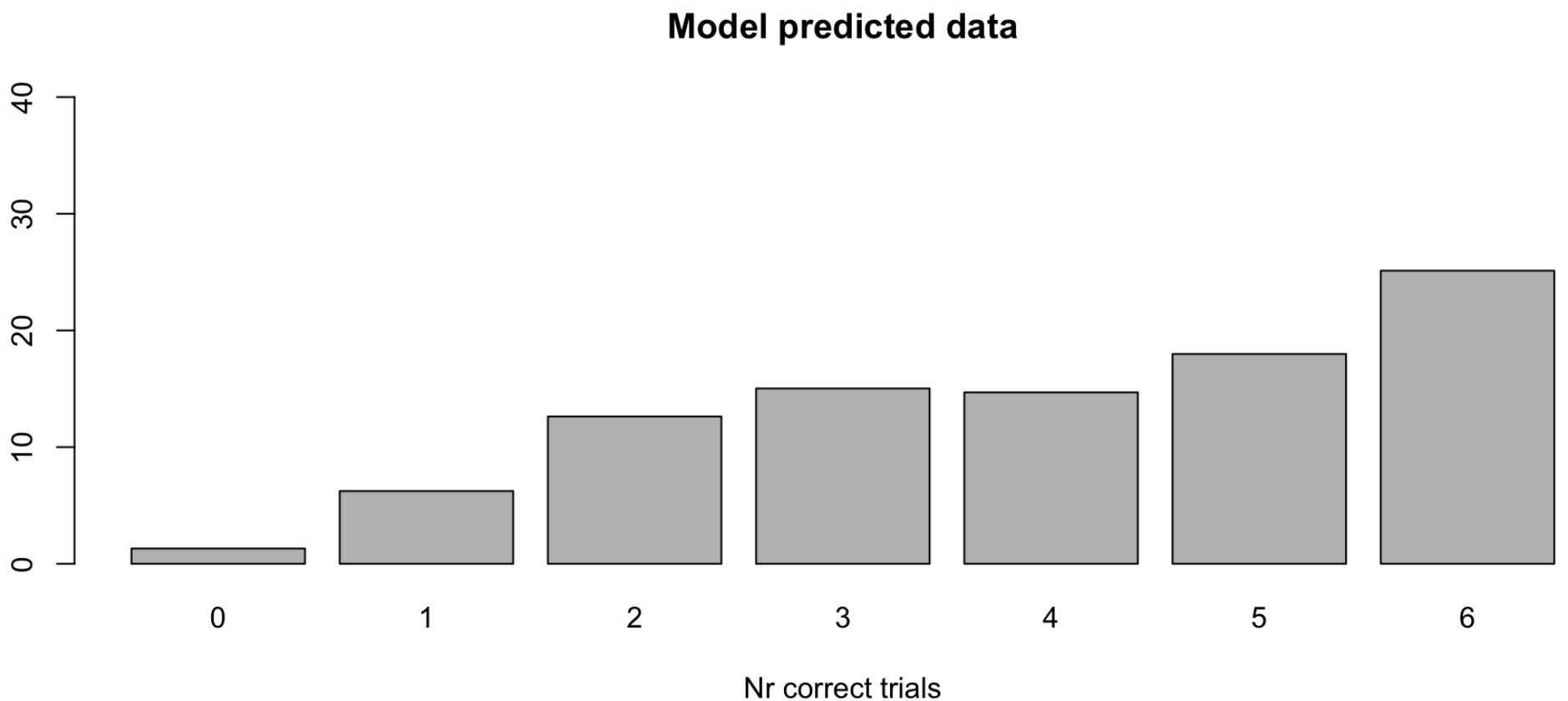
- What is the relationship between age and switching ability?
- How to test this?

1. DCCS: age and switching ability

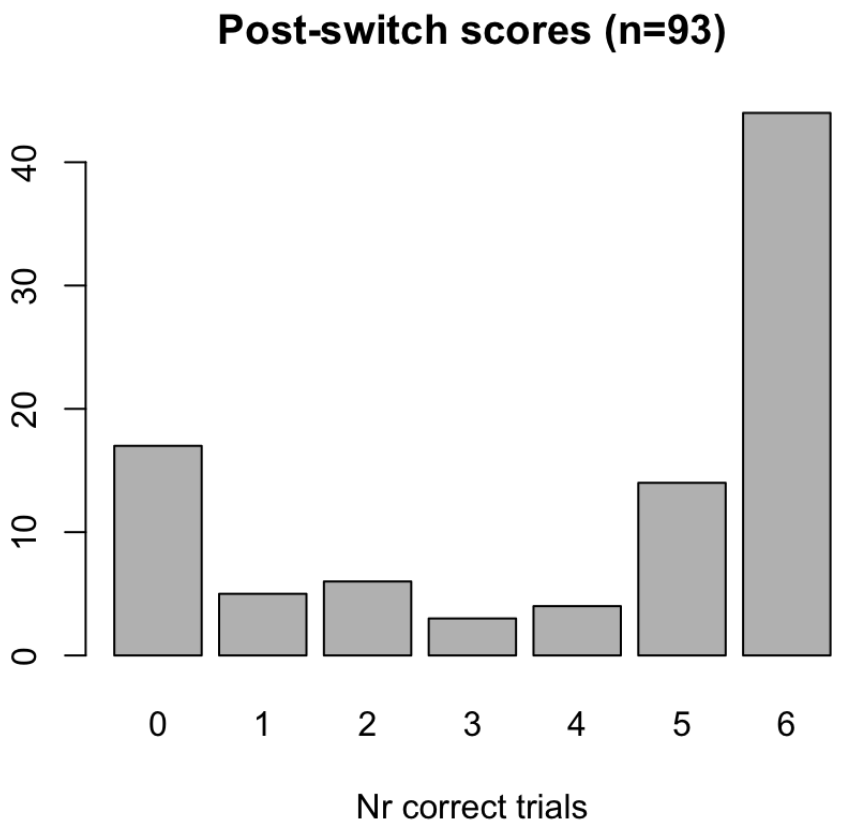
Testing this by a logistic regression with age:

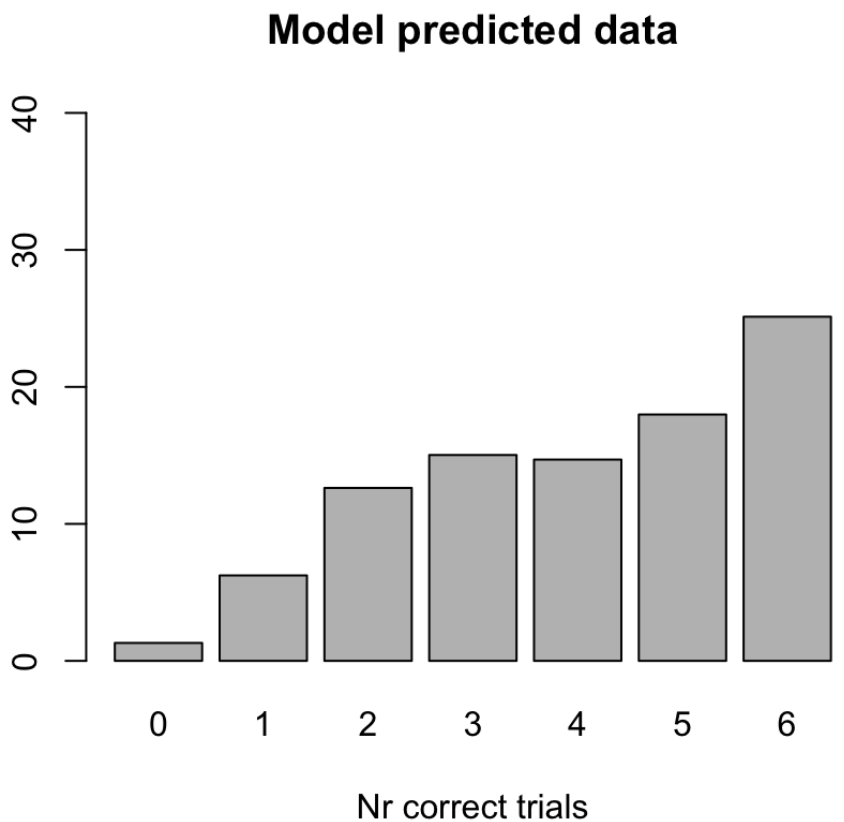
```
Call:
glm(formula = cbind(nCorPost, 6 - nCorPost) ~ ageY, family = "binomial",
    data = dc)

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -5.186      0.587   -8.83   <2e-16 ***
ageY           1.650      0.170    9.68   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 500.61  on 92  degrees of freedom
Residual deviance: 360.49  on 91  degrees of freedom
AIC: 428.3

Number of Fisher Scoring iterations: 3
```

Logistic regression: model check



Logistic regression: model check





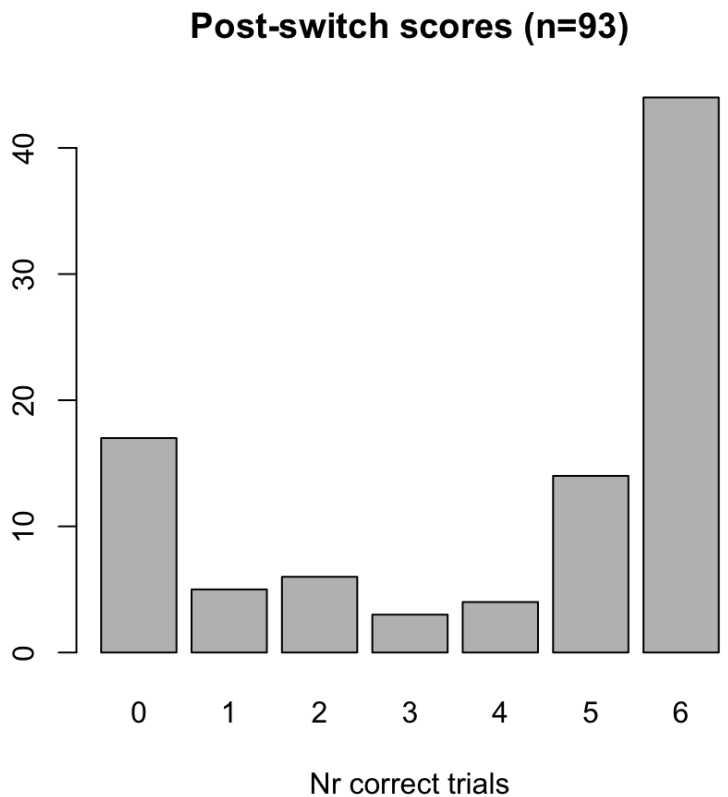
- Model does not describe the data very well…

Two ways to look at development and individual differences

1. Correlation/regression model with age (IQ, personality, …)
2. Study the distribution of the data

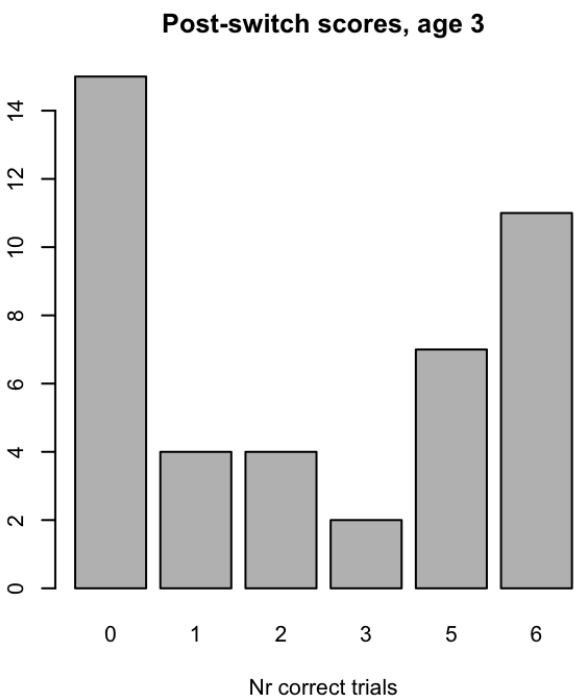
2. DCCS: data distribution (1)

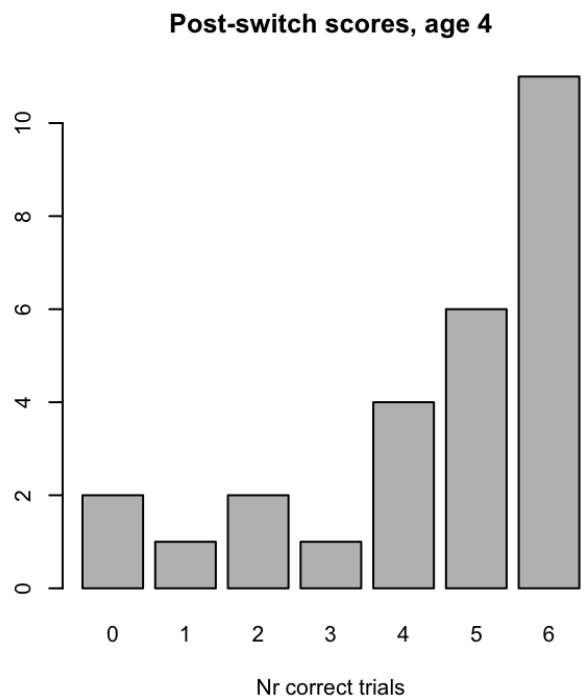
Instead of correlations with other variables: study the full distribution first

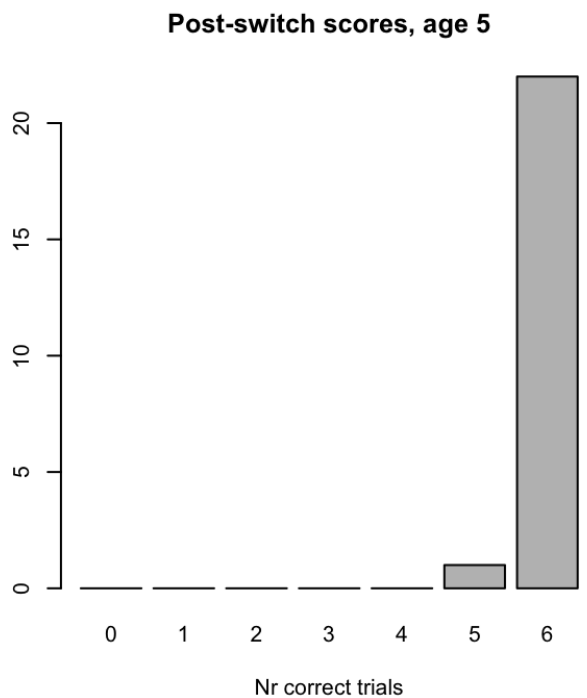


2. DCCS: data distribution (2)

Instead of correlations with other variables: study the full distribution



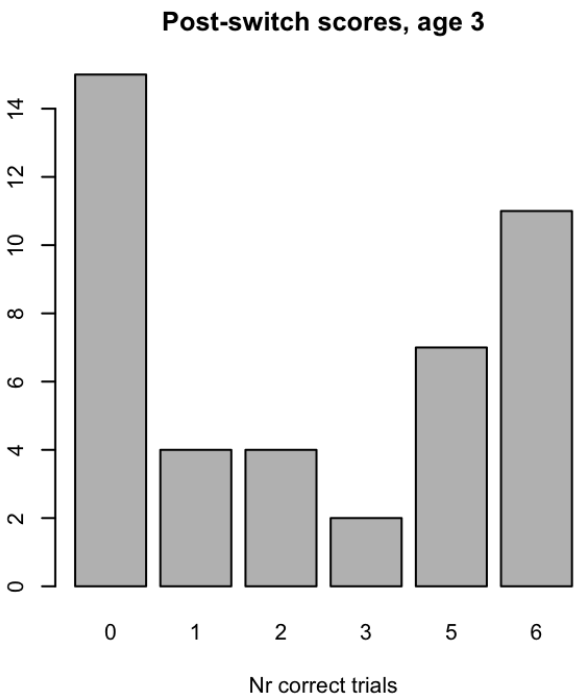


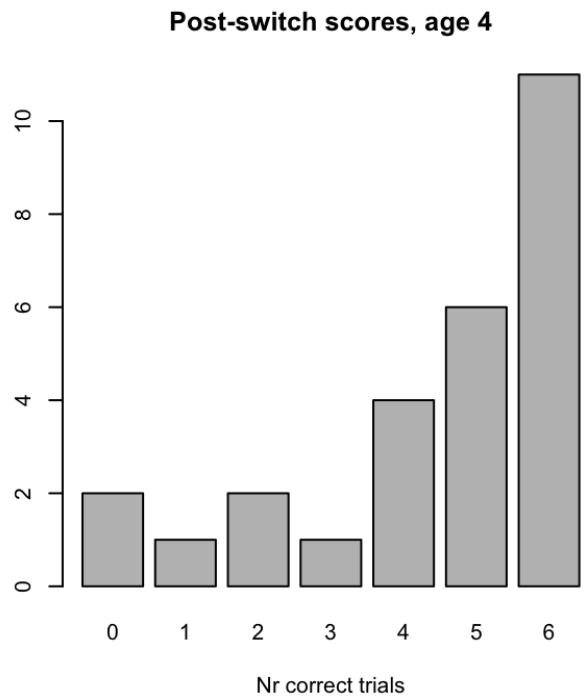


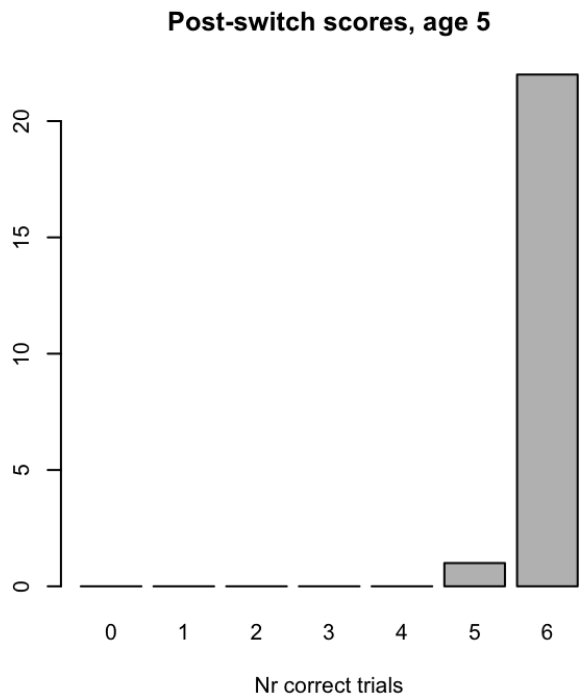
What to do with this?

What to do with this?

Use mixture models!







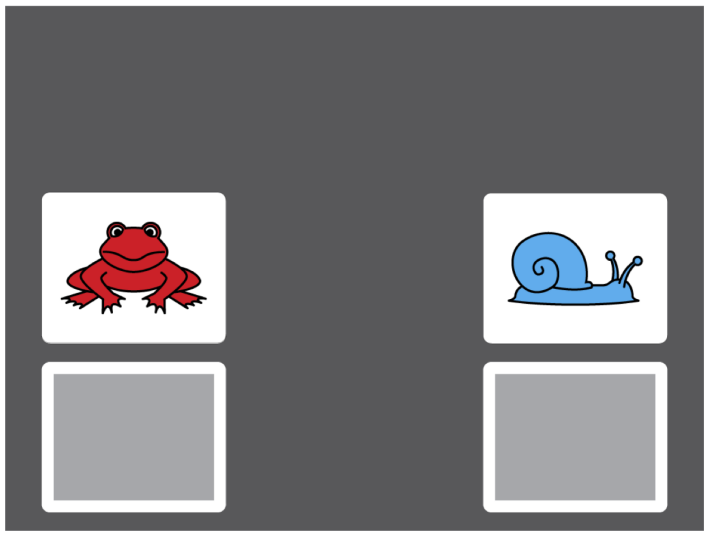
Mixture and hidden Markov models: why do we need them?

Some motivating examples and data

1. Developmental psychology
2. Cognition and learning
3. Others: finance & climate

Developmental psychology

Dimensional change card sorting task



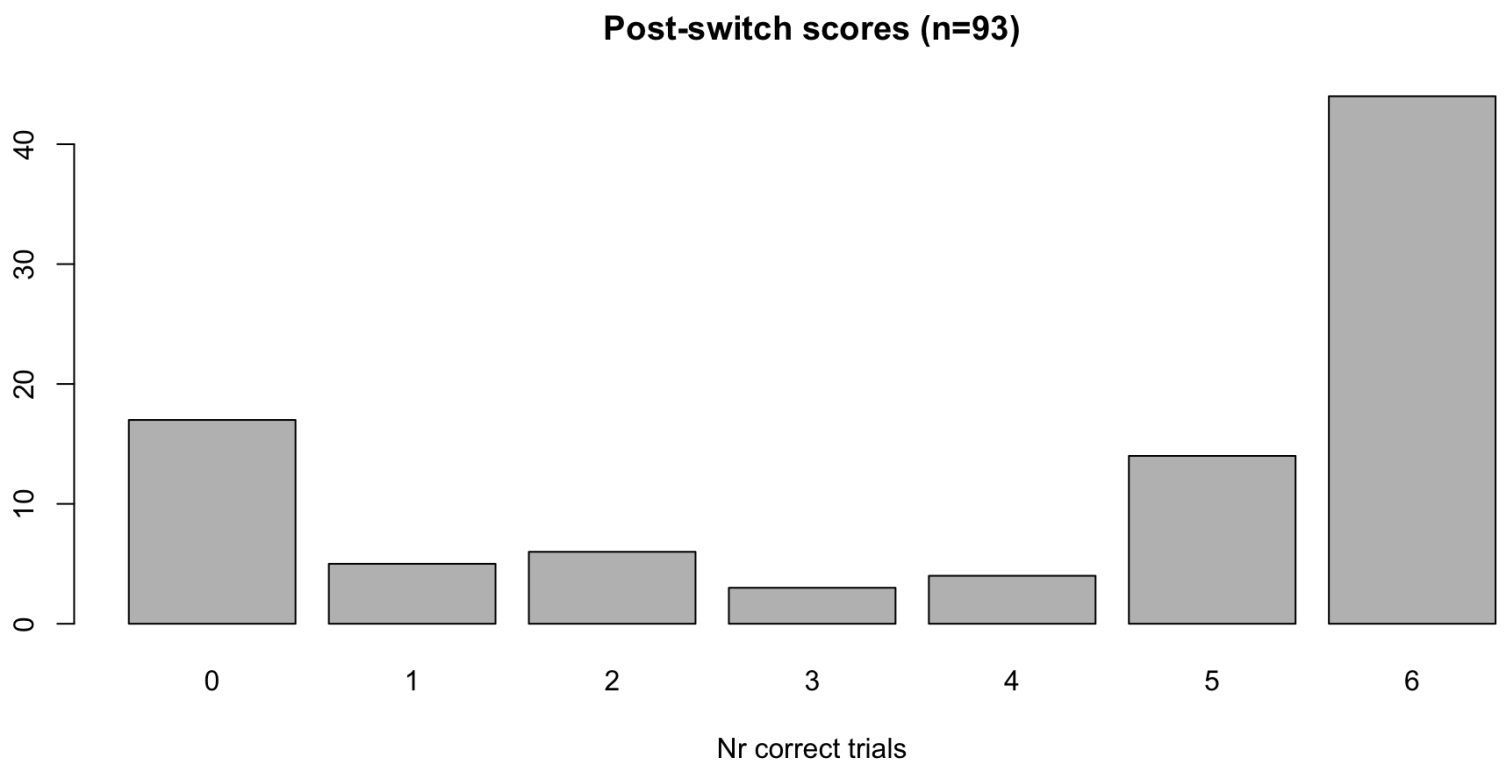
1. Sort cards by color (or shape)
2. Switch to sorting by shape (or vice versa)
3. Measures cognitive flexibility in 3-4 year olds

Image from the task by Bianca van Bers (Van Bers et al., 2013)

Developmental psychology

Dimensional change card sorting task

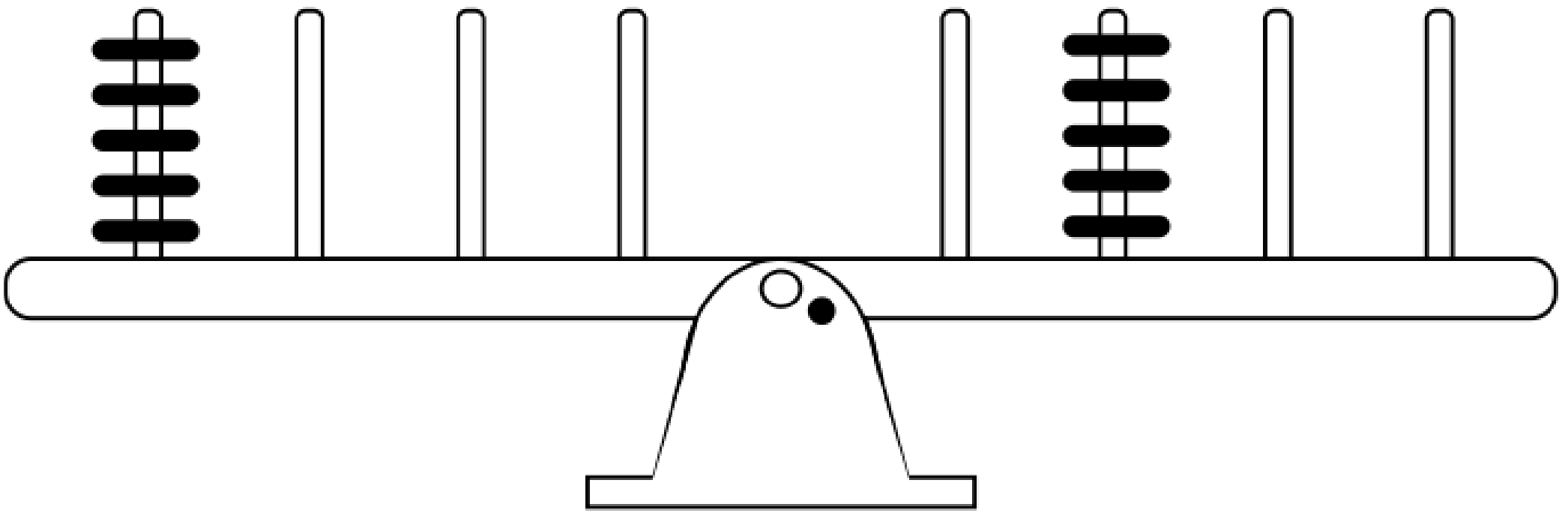
Children either pass or fail the task



Developmental psychology

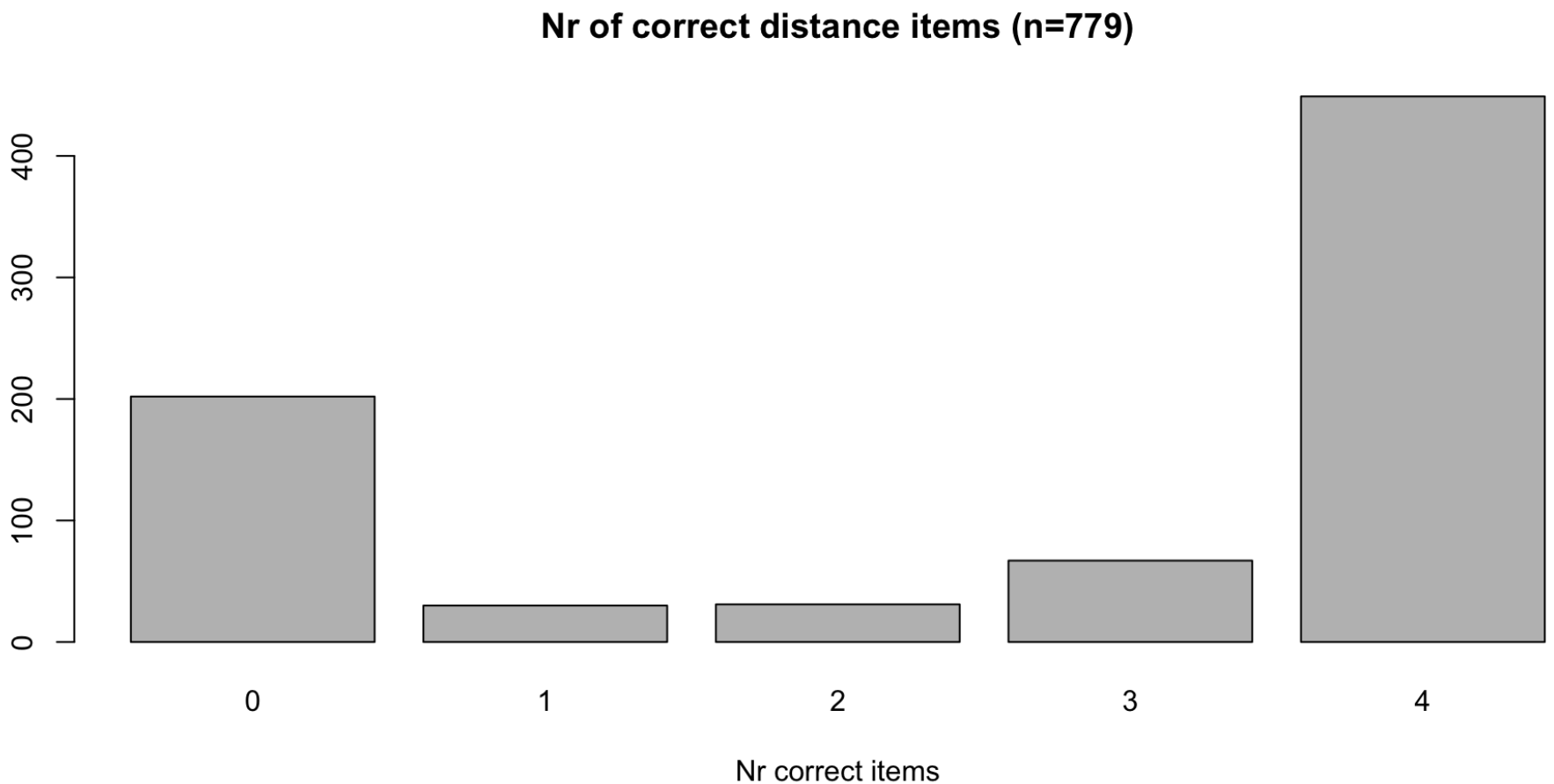
Balance scale task

Which side of the balance beam goes down?



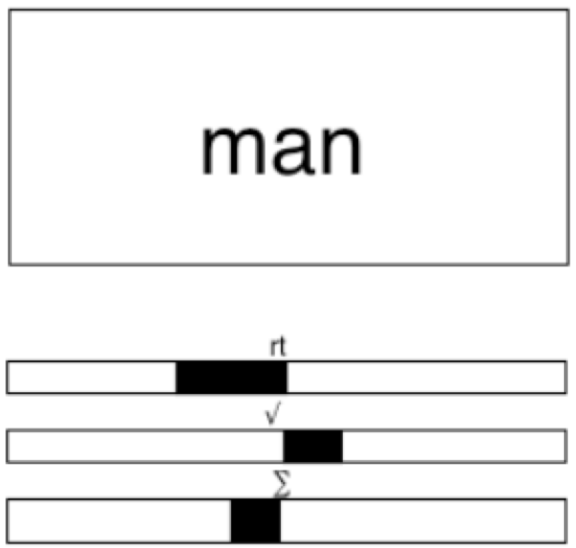
Developmental psychology

Balance scale task data, children either pass or fail the task



Cognition & learning

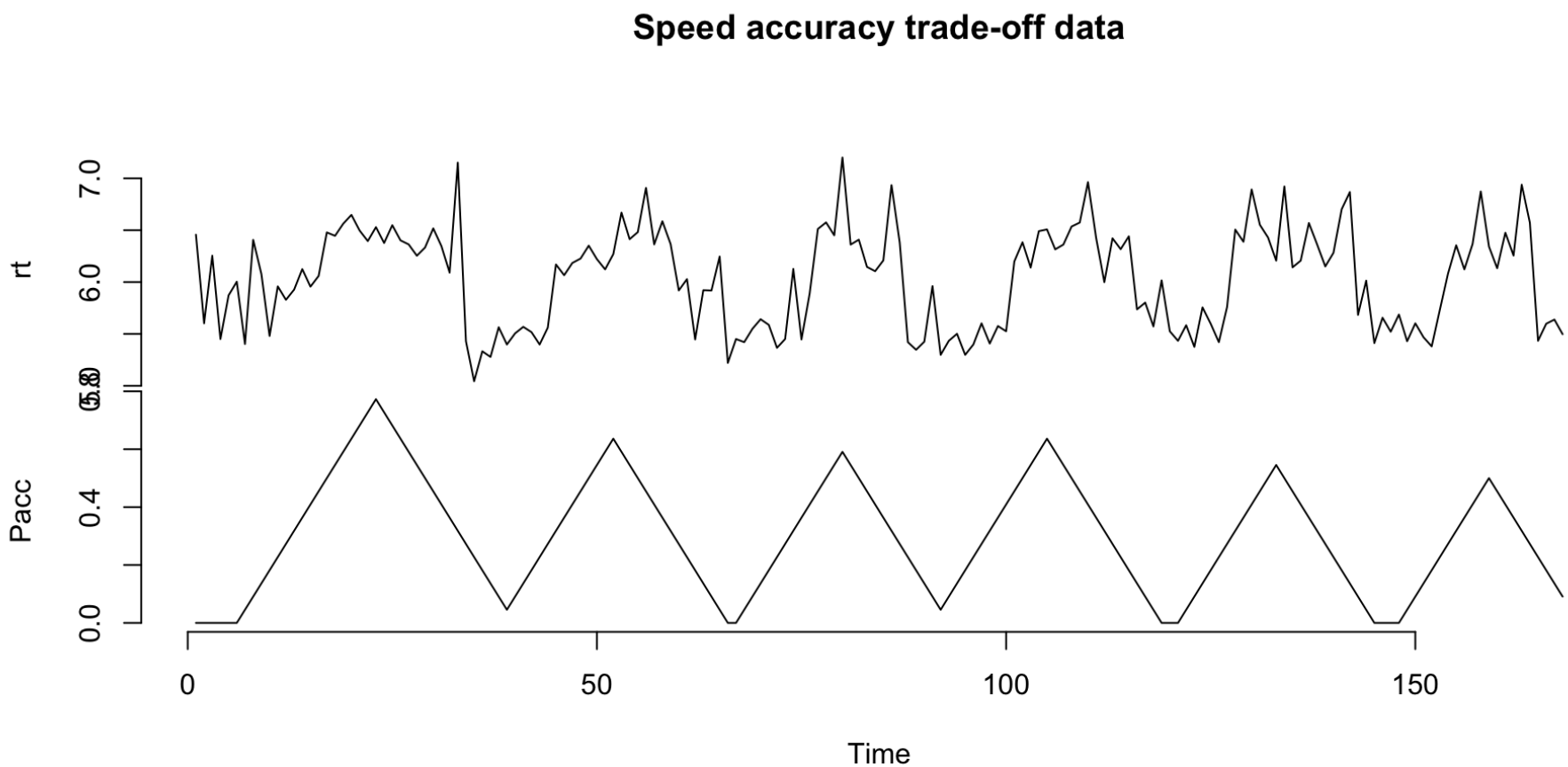
Speed accuracy trade-off task



1. Lexical decision: word or non-word
2. Reward for speed versus accuracy changes during the experiment
3. Is the trade-off discrete of gradual?

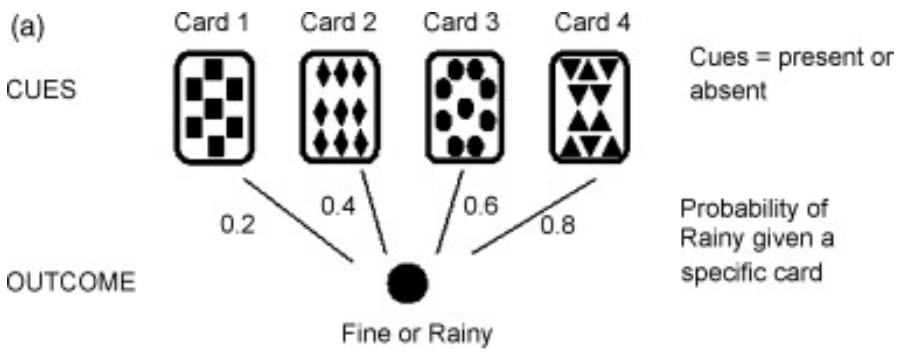
Cognition & learning

Speed accuracy trade-off data



Cognition & learning

Weather Prediction Task



What is the weather going to be like? Rainy or Fine?

(b)

RAINY

FINE

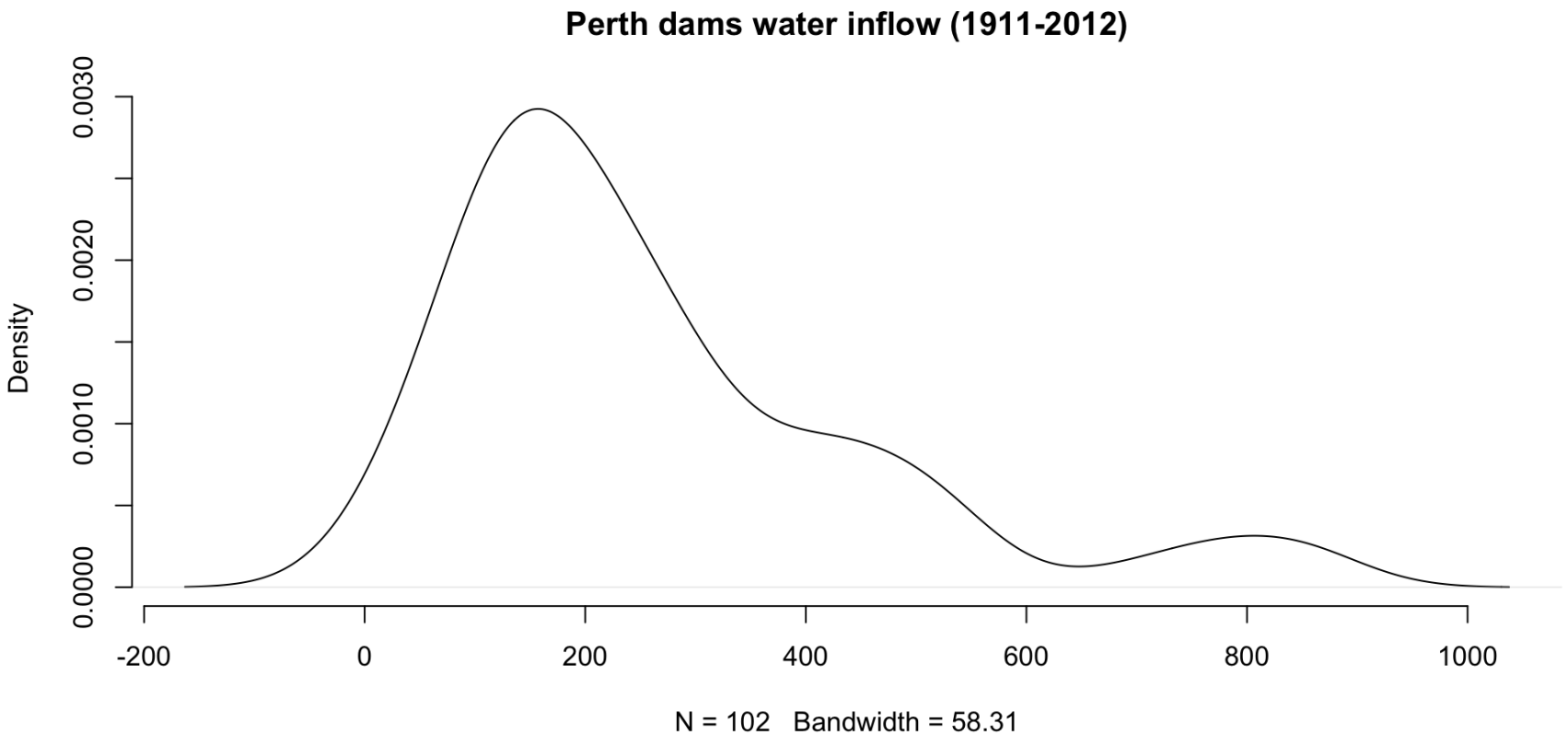
Are there discrete prediction strategies and do people switch between them?

Climate change

Inflow in water catchment dams around Perth, south-west Australia

Climate change

Are there change points in this time series, or is it a purely random process?



Why do we need mixture and hidden Markov models?

1. Data stem from multiple (cognitive) processes/strategies (dimensional change card sorting, balance scale, weather prediction task), (inter-)individual differences
2. Data generating process changes over time (speed-accuracy trade-off, climate change), intra-individual differences (development & growth)
3. Differences and changes are discrete in nature rather than gradual or continuous