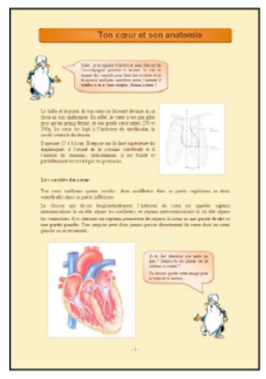
Multimedia Learning
Introduction

Cyril Brom, Tereza Hannemann
Charles University
Faculty of Mathematics and Physics
Advanced Multimedia Learning Laboratory

brom@ksvi.mff.cuni.cz
hannemann@ksvi.mff.cuni.cz
ksvi.mff.cuni.cz/amulab

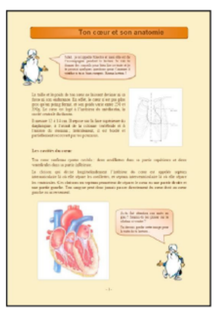
Multimedia learning

- Combines words and pictures (Mayer 2014)
- **Words**: written, spoken
- **Pictures**: illustrations, graphs, animations…
- Traditional:
  - textbooks, slides, animations, videos
- Interactive:
  - simulations, video games, tutoring systems, conversational agents

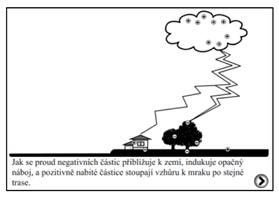


(Andery et al., 2016, SIG2)

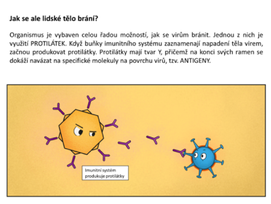
Examples – Fragments



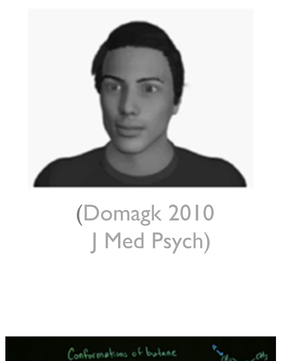
(Andery et al., 2016, SIG2)



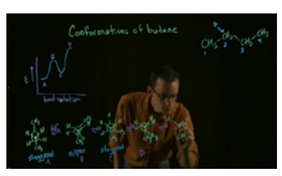
(Moreno & Mayer 2000
J Edu Psy)



(Starkova et al., submitted)

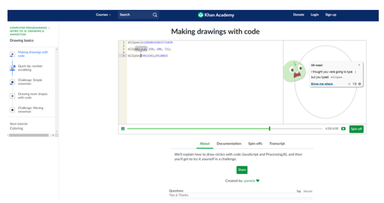


(Domagk 2010
J Med Psych)

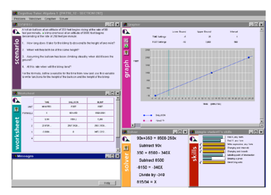


(Stull et al. 2018
Comp Hum Beh)

Examples – complex products

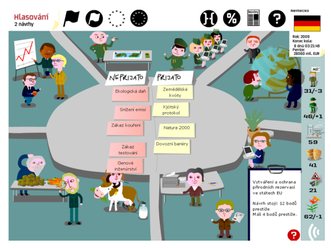


(Khan Academy, 2018)



(Corbett et al., 2011)

(Winter Park)

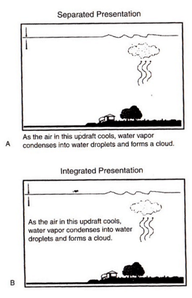


(Brom et al. 2016
Int J Comp-Sup Collab Learn)

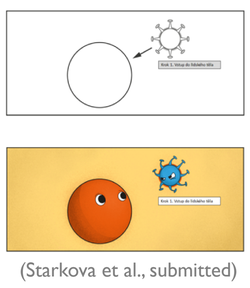
Research Questions

- Making the experiments simple

changes to the materials → + → cognitive processes → + → learning outcomes



(Mayer & Moreno, 1998, J Edu Psy)

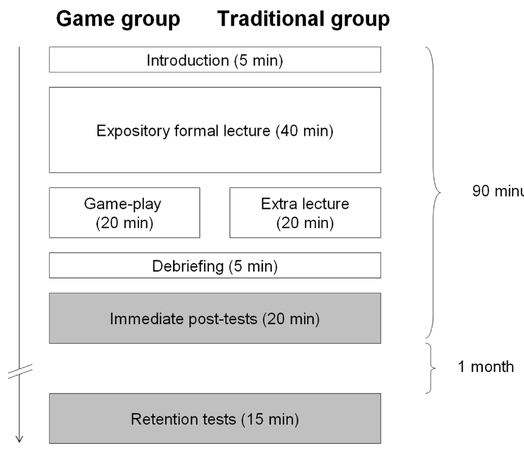


(Starkova et al., submitted)

Searching for the TRUTH

- Observation — dancing parrot
- Experiment
- Building a prototype
- By chance
- …

Example I



- 4 classes
- Split by ENG
- Taught by the teacher
- Normal class
- **Issues?**

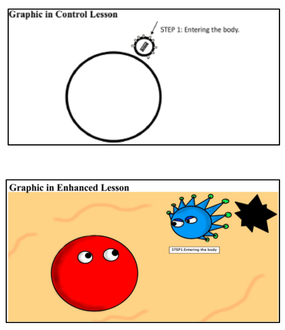
(Brom et al., 2011, Comp & Edu)

Key issues

- Randomization
- N = 8 (classroom effect)
- More than one factor
- Teacher factor
- Duplication of the teacher
- Low stake condition for students

Example II

- N = 47
- Psychology subject pool
- 68% female
- In a lab
- No teacher involved



(Mayer & Estrella 2014 Ln Instr; Exp. 2)

Key issues

- Ecological validity
  - context lacking
  - external motivation to complete the exp.
- Small sample
- Biased sample
- Other than color & anthropomorphisms differences

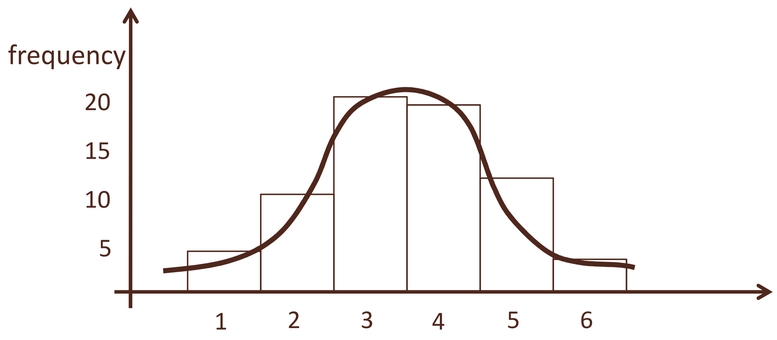
Value-added vs. media-comparison studies

Positives? Negatives?

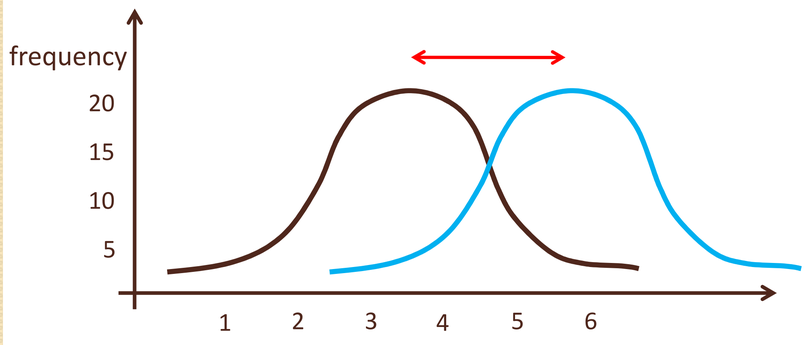
Do people learn differently from different media? (Clark ed. 2012)

- affordances

Dependent variables

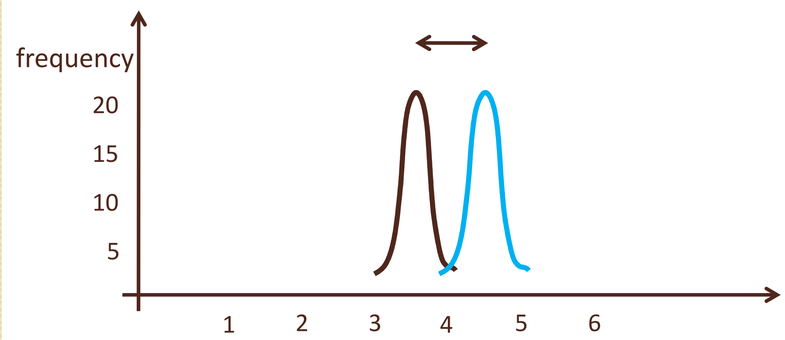


Dependent variables

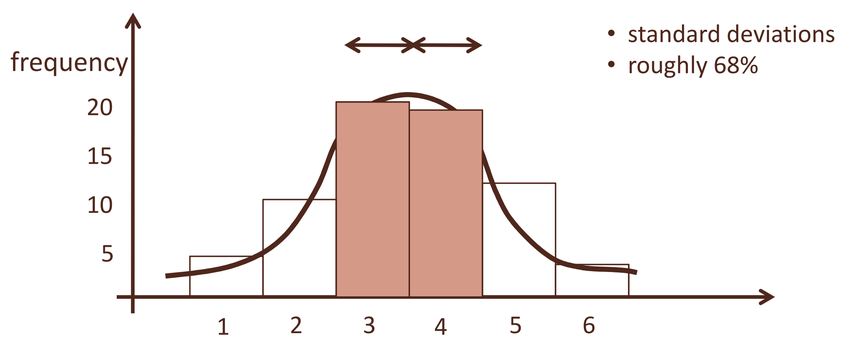


How to measure the distance between the hats?

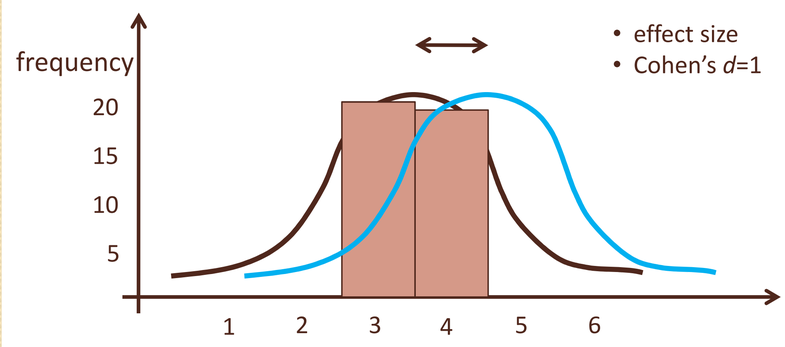
Dependent variables



Dependent variables



Dependent variables



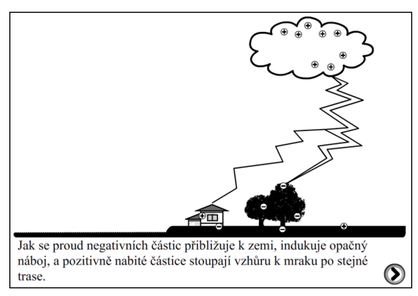
Effect sizes in educational sciences

(Cohen, 1988)

- 0.2 ~ small
- 0.5 ~ medium
  - ~ 0.4 (Hattie, 2007)
- 0.8 ~ large

Knowledge

- **Mental models**
  (e.g., Jones et al.,2011, Ecol Soc)
- Retention
- Transfer



(Moreno & Mayer, 2000, J Edu Psy)

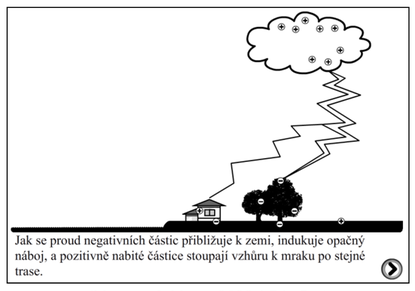
Table 2.1. Retention and Transfer Questions for the Lightning Lesson

Retention Test
Please write down an explanation of how lightning works.
Transfer Test
What could you do to decrease the intensity of lightning?
Suppose you see clouds in the sky, but no lightning. Why not?
What does air temperature have to do with lightning?
What causes lightning?

(Mayer 2009)

Knowledge

- **Mental models**
  (e.g., Jones et al.,2011, Ecol Soc)
- Retention
- Transfer



(Moreno & Mayer, 2000, J Edu Psy)

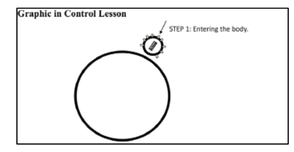
Table 2.1. Retention and Transfer Questions for the Lightning Lesson

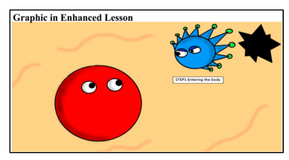
Retention Test
Please write down an explanation of how lightning works.
Transfer Test
What could you do to decrease the intensity of lightning?
Suppose you see clouds in the sky, but no lightning. Why not?
What does air temperature have to do with lightning?
What causes lightning?

(Mayer 2009)

Generalization

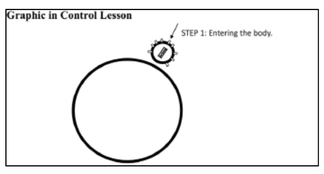
- Results
  - retention: d = 0.72
  - transfer: d = 0.24
- **Textbook?**
- **E-learning system?**
- **Educational game?**



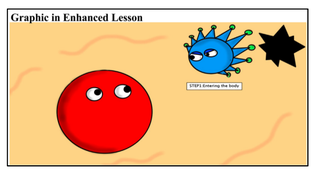


(Mayer & Estrella 2014 Ln Instr; Exp. 2)

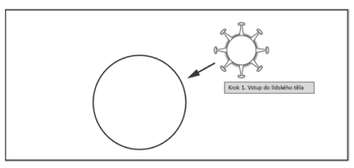
Replication



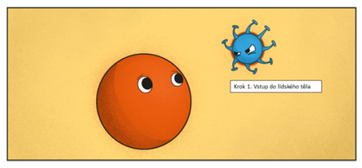
≥



(Mayer & Estrella 2014 Ln Instr; Exp. 1, 2)



=

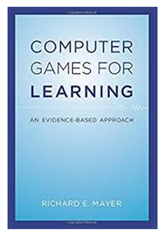


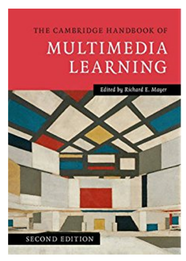
(Starkova et al., submitted)

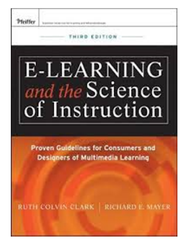
Principles of multimedia learning

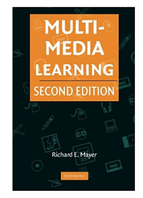
(e.g. Mayer 2014; Renkl & Scheiter 2015 Edu Psy Rev)

- Do this:
  - "Highlight key information"
  - "Use voice rather than text"
  - "Position corresponding text and picture near each other"
  - …



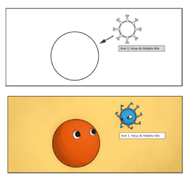




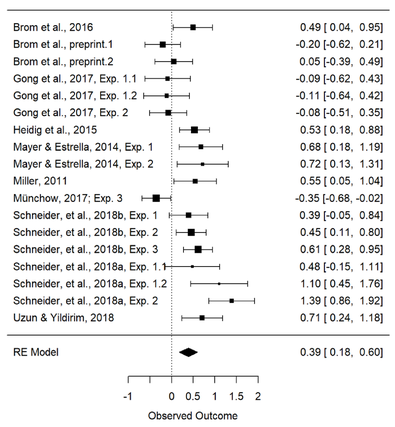


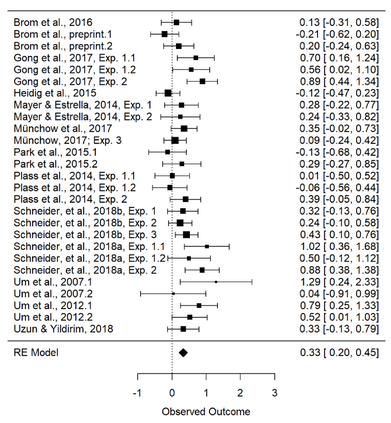
Meta-analyses

95% confidence interval for d



- Retention: d = **0.39** [0.18 – 0.60]
- Transfer: d = **0.33** [0.20 – 0.45] (Brom et al., 2018 Edu Res Rev)





Meta-analyses vs. narrative reviews

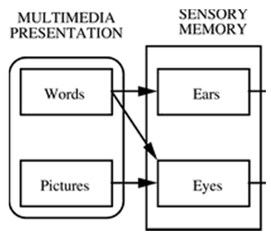
Positives vs. negatives?

Ideas for new experiments

- Gaps in knowledge
- Theoretical predictions (not yet supported)
- Practice

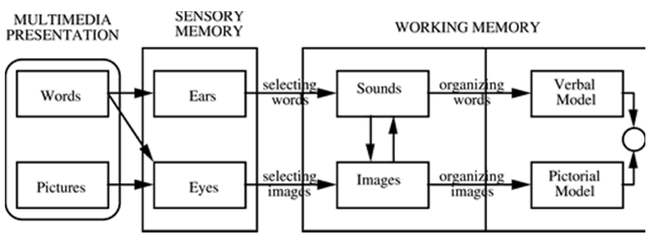
Theoretical model

- Cognitive theory of multimedia learning (Mayer, 2009; based on Miller, 1956; Baddeley, 1986; Paivio, 1986; Sweller, 1999)
  - dual-channel
  - limited capacity
  - active learning, knowledge construction
  - selecting, organizing, integrating



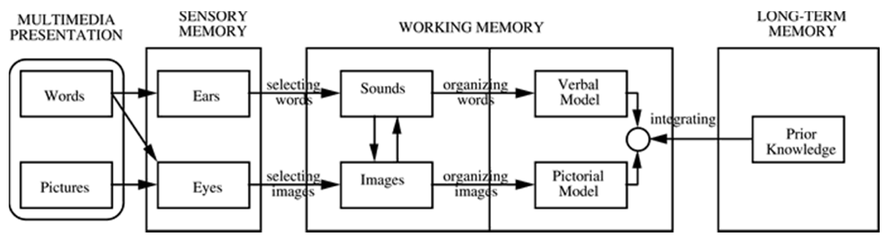
Theoretical model

- Cognitive theory of multimedia learning (Mayer, 2009; based on Miller, 1956; Baddeley, 1986; Paivio, 1986; Sweller, 1999)
  - dual-channel
  - limited capacity
  - active learning, knowledge construction
  - selecting, organizing, integrating



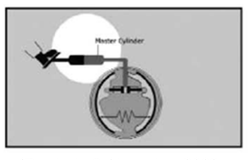
Theoretical model

- Cognitive theory of multimedia learning (Mayer, 2009; based on Miller, 1956; Baddeley, 1986; Paivio, 1986; Sweller, 1999)
  - dual-channel
  - limited capacity
  - active learning, knowledge construction
  - selecting, organizing, integrating

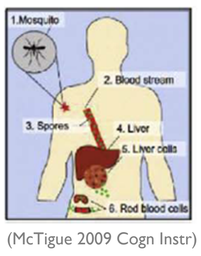


Prediction example I

- Do this: **"Highlight key information"**
- Why:
  - theory: can help in selecting / organizing, …
  - data: (Schneider et al 2018 Edu Res Rev)
    - retention: Cohen's *d* = **0.53** [0.42 – 0.64]
    - transfer: Cohen's *d* = **0.33** [0.22 – 0.43]



(Doolittle & Alstaedter 2009 J Res Innov Teach)



(McTigue 2009 Cogn Instr)

Now heat the product to 75 DEGREES Centigrade. This is the temperature at which enzymes BEST CONVERT starches into sugars. There are also more complex methods of brewing that allow for better tasting beer.

(Brom et al. 2014 Comp & Edu)

Prediction example II

- Do this: **"Present words in voice rather then text"**
- **Why?**
  - theory: two channels – sketchped (text) vs. phonological loop (voice)
  - data: (Ginns 2005 Ln Instr)
    - overal learning outcomes: *d* = **0.72** [0.52 – 0.92]

Summary

- Multimedia learning = words + pictures
- Media-comparisons vs. value-added studies
- Learning outcomes – retention, transfer
- Effect size: Cohen's *d*
- Research: empirically-based, theoretically-driven
- Experiments → Meta-analyses / Reviews → Principles
- Principles = implications for practice

This course – topics

- Principles of multimedia learning and beyond
  - meta-analyses
  - boundary conditions
  - motivational factors
- Theories
- Dependent variables
  - knowledge outcomes
  - subjective evaluation
  - objective data
- A brief history of educational innovations
- Planning a research, proposing a research project
  - general skills

Seminar

- Analysis of:
  - a paper
  - a meta-analysis
  - a model experiment
  - an existing multimedia learning material
  - a model lecture & teacher materials
- Participation in an experiment
  - October/November
- Feedback on your project

Evaluation

- Writing a grant proposal – 75%
  - for a multimedia learning study
  - possible in couples, but evaluated toghether
- Writing reviews of grant proposals – 25%