5 Principles of Multimedia Learning

5.1 Multimedia Learning: Expectations and Reality

5.2 Cognitive Theory of Multimedia Learning

5.3 Mayer's Principles of Multimedia Learning (Cont'd.)

5.4 Further Theories of Multimedia Learning

References:

Richard E. Mayer: Multimedia Learning, Cambridge University Press 2001

Richard E. Mayer (ed.): The Cambridge Handbook of Multimedia Learning, Cambridge University Press 2005

Summary CTML

- Cognitive Model of Multimedia Learning
  - Based on dual coding assumption (verbal and pictorial channels)
  - Stressing capacity limitations of working memory
- Multimedia Principle:
  - Cognitive load on knowledge construction processes can be reduced by multicodality
- Spatial and Temporal Contiguity Principle:
  - Learning is improved if corresponding codes in multicodal messages are presented together in time and space
- Modality Principle:
  - Multimodal messages, in particular using spoken instead of written narration, can improve learning
- Coherence Principle:
  - “Extra” informations (words, pictures, sounds, music) hurts learning
- Redundancy Principle:
  - Several encodings of the same information interferes with learning (in particular, parallel presentation of identical text, written and spoken)

Results on Animation?

- Animation is "the process of generating a series of frames containing an object or objects so that each frame appears as an alteration of the previous frame in order to show motion" (Baek/ Layne 1988)
- "a series of varying images presented dynamically according to user action in ways that help the user to perceive a continuous change over time and develop a more appropriate mental model of the task" (Gonzalez 1996)
- Separate interaction and animation:
  - Sequence of frames creating impression of motion (possibly without interaction)
  - User control (interaction)
  - Two types of user control (interaction):
    - » Control over pace and direction of frame succession (VCR-like control)
    - » Capability to act on objects appearing within frame

PLEASE STOP PLAYBACK NOW AND FOLLOW THESE INSTRUCTIONS!

We want to study the everyday skill of tying shoe laces!

Have a look at these three online resources on how to tie shoe laces:

Number 1: How to tie a Shoe Lace in 1 Second
https://www.youtube.com/watch?v=wMuNjnNyaiA

Number 2: How to Tie Shoe Laces Step By Step
https://www.youtube.com/watch?v=MhXXYuCpVwc

Number 3: Ian's Shoelace Site
http://www.fieggen.com/shoelace/knots.htm

From which of these instruction sites did you learn best?

Experiments on Animations in Learning

- Rieber et al 1989:
  - Animated lesson for Newton's laws of motion does *not* lead to better comprehension for elementary school children
- Byrne, Catrambone, Stasko 1999:
  - Benefits of using animation are equivalent to the benefits of prompting learners to make predictions
- Hegarty et al. 2002:
  - Students studying animation with oral commentary do *not* perform better than those who study equivalent static graphics with written text
  - In both cases, performance was significantly improved by prediction questions
- Possible explanations:
  - Continuous animations miss clear phase pictures
  - Animations may be helpful for learners with low ability to mentally simulate the processes

QUESTIONS

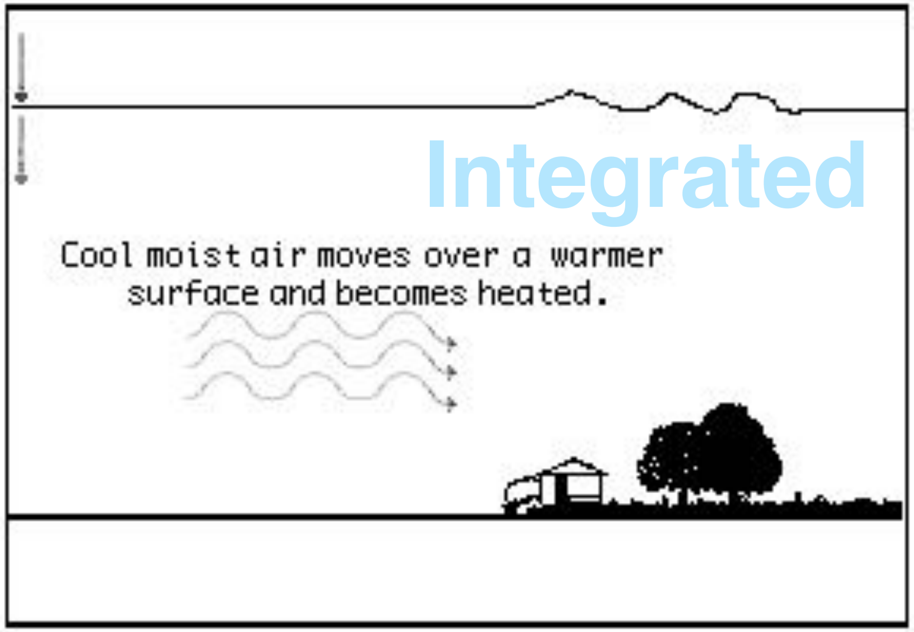
- Do the results reported on the last slide relate to your experiences with the shoe lace experiment?
  - Were the continuous video presentations superior to the step-by-step drawings?
- Which of the animations studied in our example would you suggest to children to learn how to tie their shoe laces?
- ***YOU MAY WANT TO PAUSE AND REPLAY PARTS OF THE VIDEO HERE. THIS IS OK AND RECOMMENDED.***

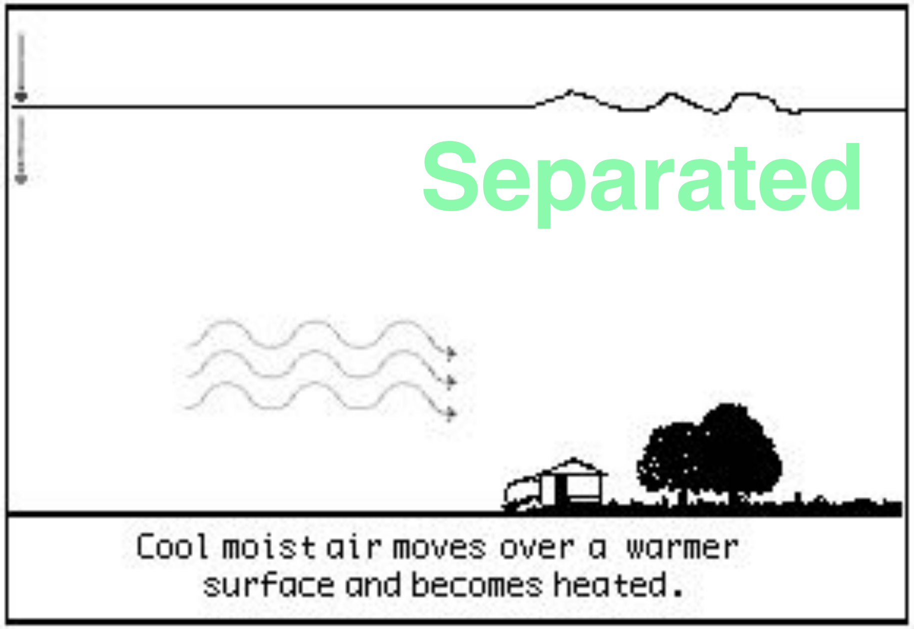
Individual Differences Principle

- Mayer (2001):
  - Design effects are stronger for low-knowledge learners than for high-knowledge learners
  - Design effects are stronger for high-spatial learners than for low-spatial learners
- Good instructional message:
  - Contiguous
  - Coherent
  - Modality efficient
  - Non-redundant
- Who benefits most from good design?

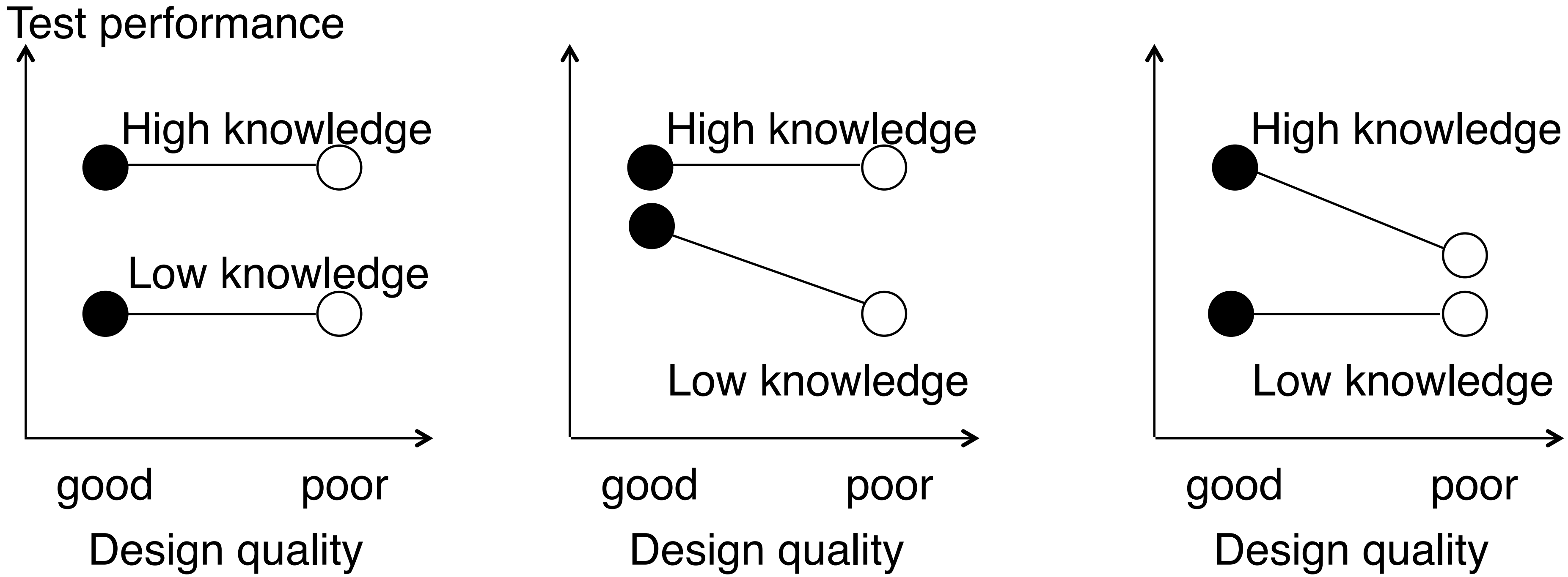
How Well Do Well-Designed Multimedia Resources Assist You In Learning?

- Have a look at the material on right.
- If your expertise level is low, and assuming you have to pass a test on meteorology soon:
  – Which one is more helpful?
- Same question, if your expertise level is high!





How does prior knowledge influence learning?



Theory A:
Knowledge main effect
Independent of design

Theory B:
Knowledge as
compensator

Theory C:
Knowledge as
enhancer

Experimental results: Tend to support theory B.

Expertise Reversal Effect

- Expertise reversal
  - Instructional technique is effective for dealing with novices
  - Becomes less effective when dealing with experts
- Examples:
  - Learning from worked examples vs. abstract descriptions
  - Variability in various exercises
  - Imagination of pre-learned knowledge
- Redundancy effect as explanation for expertise reversal:
  - Novices: Some explanatory material is essential
  - Experts: The same material becomes redundant!
- Other explanations for expertise reversal effect:
  - Zone of proximal development (material of adequate difficulty)
  - Flow experience (equilibrium between task and abilities)

Further Individual Learner Differentiations

- Field dependence
  - Field dependent learner:
    Holistic approach, typically interested in literature or history
  - Field-independent learner:
    Separate and analytic processing of information units, typically interested in mathematics and sciences
  - Ongoing studies...
- Verbalizer, Visualizer
  - Verbalizer:
    Prefers text for information presentation
    Learns well by hearing and talking
  - Visualizer:
    Prefers pictures for information presentation (combined with text)
    Learns well by looking and drawing
  - Mixed empirical results on influence on learning effectiveness

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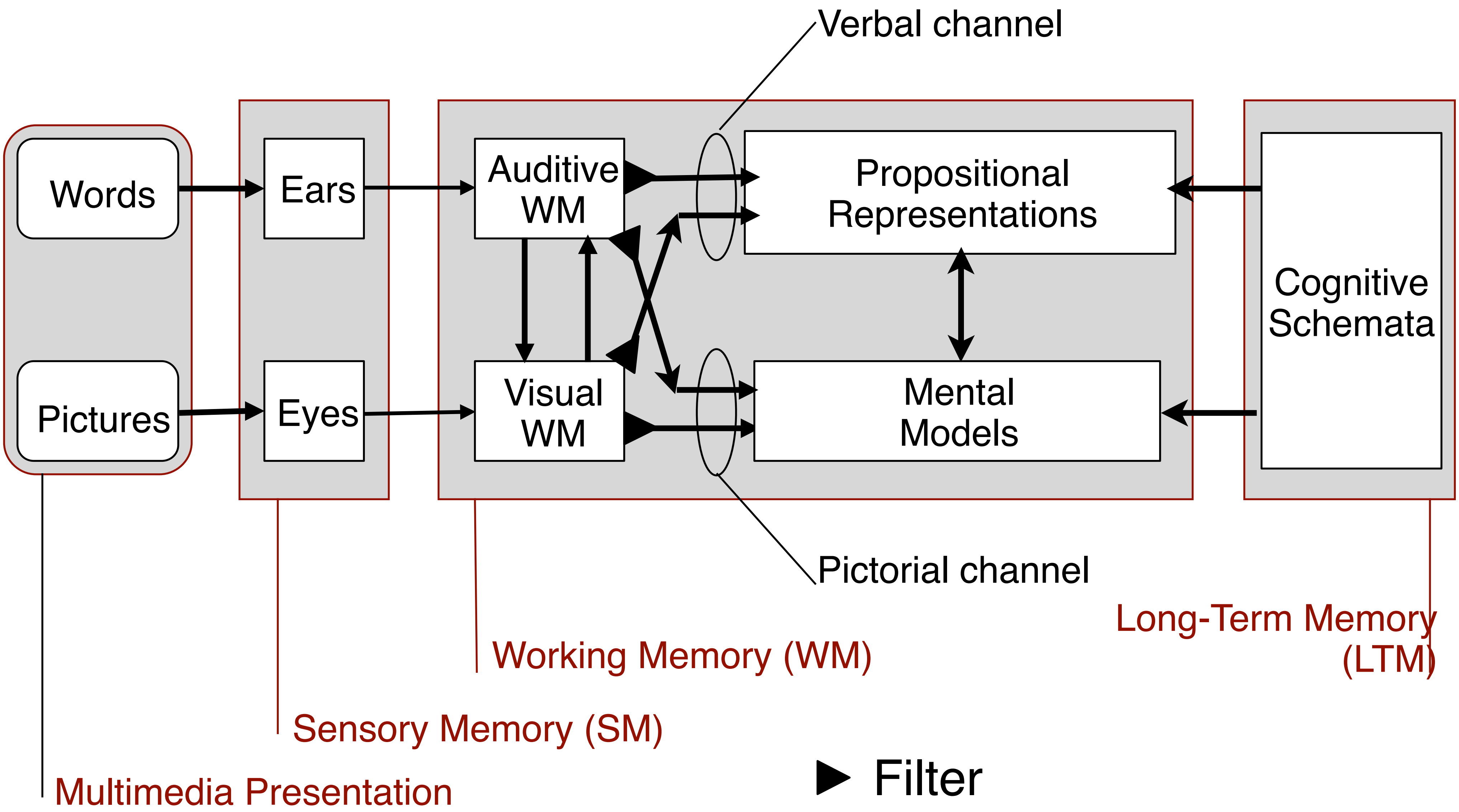
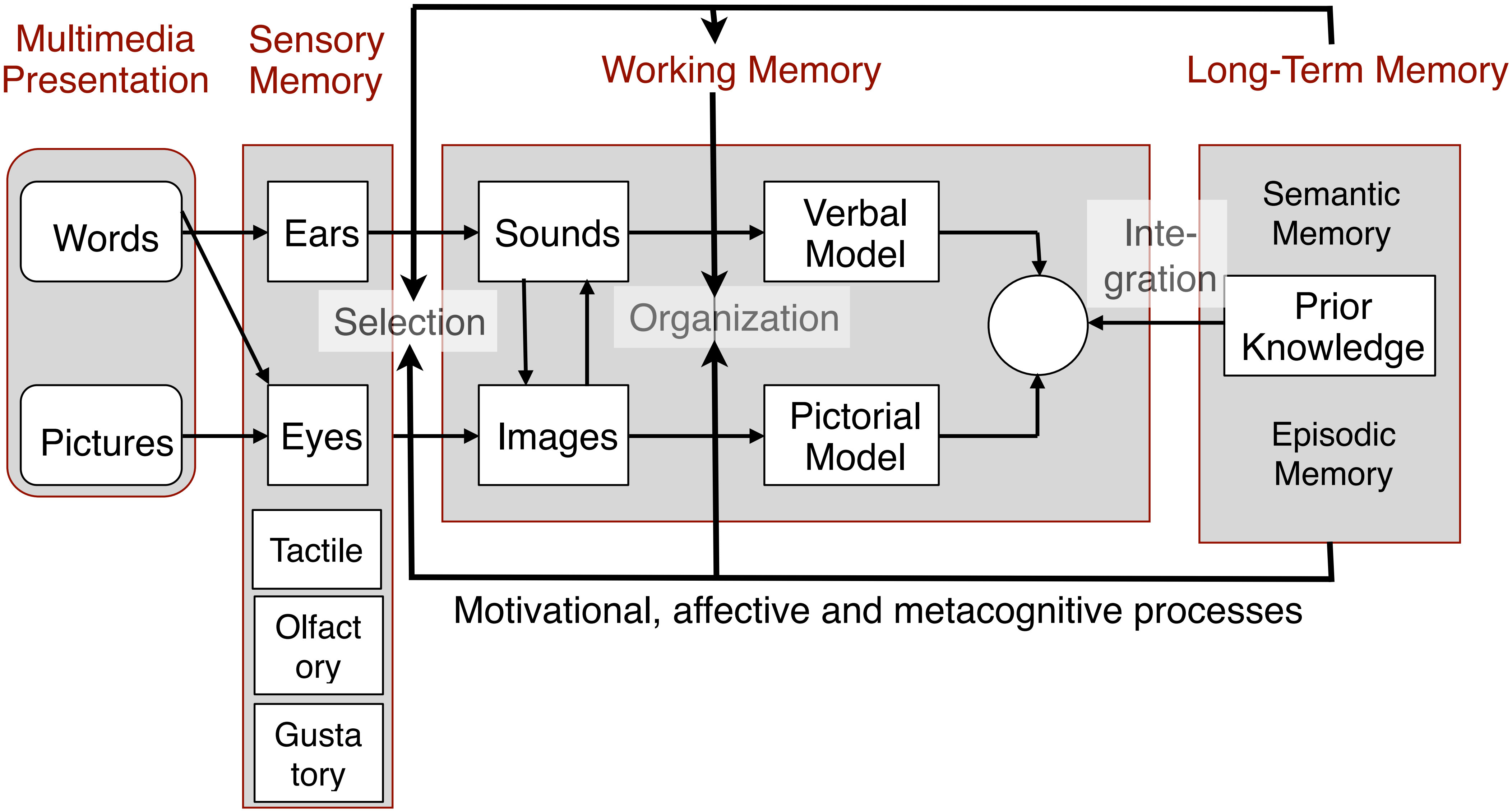
Modified Model of Multimedia Learning (Schnotz)



Cognitive-Affective Theory of Multimedia Learning CATLM (Moreno 2005)



Stay Critical!

- Do you think the CTML theory is universally applicable?
- Can you find possible shortcomings in the methodology of how CTML was developed?
- May alternative and even contradicting theories be possible?
- ***PLEASE STOP PLAYBACK AND TAKE A FEW MOMENTS TO THINK!***

Content Dependencies

- Comparison of different media (e.g. book vs. computer)
  - Applied to learning of historical facts vs.
    applied to learning a programming language
- Comparison of different codings (e.g. static picture vs. animation)
  - Applied to explanation of a mechanical clockwork vs.
    applied to explanation of learning theories
- Comparison of different modalities (e.g. visual vs. auditive)
  - Applied to unknown vocabulary (including pronunciation) vs.
    applied to architectural styles of churches
- Comparison of different degrees of interactivity
  - Applied to a mathematical/geometrical model vs.
    applied to a philosophical approach
- Combination of various aspects
  - Well/ill-adapted presentation of mathematical model vs.
    well/ill-adapted presentation of philosophical approach

Novelty Effect, Willingness to Suffer

- Novelty effect
  – Using innovative (unknown) media may lead to wrong conclusions
  – Some users have difficulties to adapt to the new media
  – Some users are fascinated by the new media
  – Long term effects may differ drastically from short term experiment results
- Willingness to suffer
  Example: Comparison of a learning game with a traditional lecture
  – Expectation about own contribution varies with chosen medium
  – Learners using the game expect they have to suffer less

Predictions, Test Adequacy

- Learners' predictions
  - Well known effective pedagogical tool
  - How can we compare a book with an interactive presentation by keeping the same level in invoking learners' predictions?
- Adequacy of tests
  - Do tests use the same modalities/codings as the learning material? (e.g. pictures vs. words)
  - What is the effect if the test stipulates a transfer between modalities/codings?

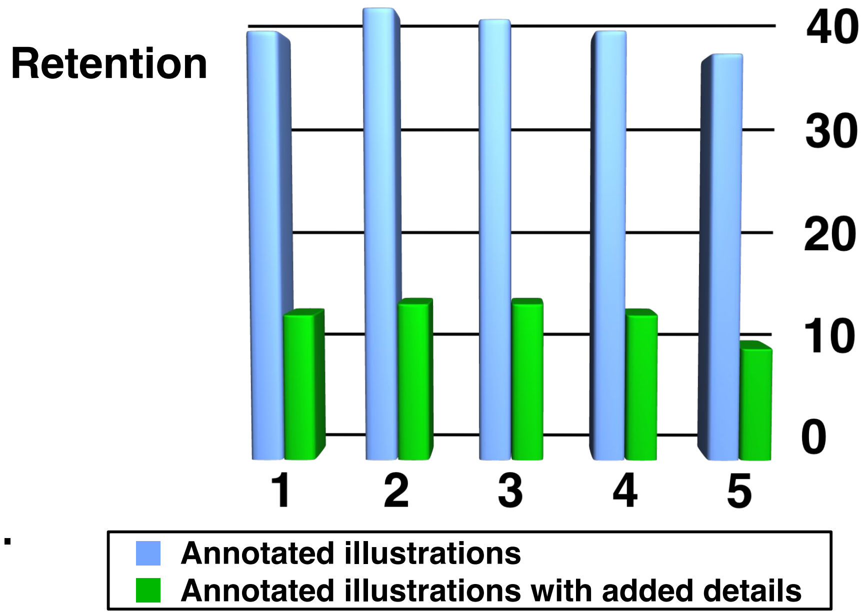
Learning Time

- Time to get acquainted with the new material
  - Sometimes limited to a few minutes
    (e.g. some of the Mayer et al experiments)
  - Sometimes without limitation
- What is learning time?
  - Independent variable (setting a limit)
  - Dependent variable
    (asking when the time was enough and recording the time)
  - Control variable/covariate
  - Not considered
  - Used for elimination of excess values

A **covariate** is a variable that is *possibly* predictive of the outcome under study.

Empirical Evidence (CTML)

- Do you know what the numbers (1 – 5) in the graphics from the last lecture actually mean?
- Typical subjects for Mayer et al' s experiments are female college students.
  – Do you think this has an influence on the results reported?



From last lecture (Coherence Principle)

Cognitive Flexibility Theory CFT (Spiro)

- Rand J. Spiro et al. (published 1988 - 1995)
- Over-simplification of *complex information* can hurt learning efficiency
  - Applicable mainly for low-structured and highly complex knowledge
  - Enable problem-based learning!
  - Follow a constructivist approach
- Recommendation: Multiple representations of knowledge
  - Unidimensional representations may lead to misunderstandings
  - E.g. textual explanation + several different illustrations
- Recommendation: Knowledge transfer
  - Let the learner transfer abstract knowledge to several concrete examples
  - Use examples of large variability
- Recommendation: Present full complexity
  - Do not isolate aspects of the knowledge too much
  - Introduce learners to complexity right from the beginning
- Recommendations are to some extent in contradiction to CTML!

Learning with Multiple External Representations

- Multiple External Representations (MER) of knowledge:
  - Diagrams, equations, tables, text, graphs, animations, sound, video, ...
- Perceptual variability helps in building abstractions
  - Cognitive Flexibility Theory (Spiro) and other research
  - Empirical studies prove that learners benefit from multiple representations
- Mixed results:
  - "Unfortunately, just as many studies have shown that learners can fail to benefit from these proposed advantages of MERs"
  - Main problem: Integration of information from more than one source
  - Similarities to Redundancy and Contiguity Principles of CTML

Shaaron Ainsworth 2006:
DeFT: a conceptual framework for considering learning with multiple representations.
DeFT = *De*sign, *F*unctions, *T*asks

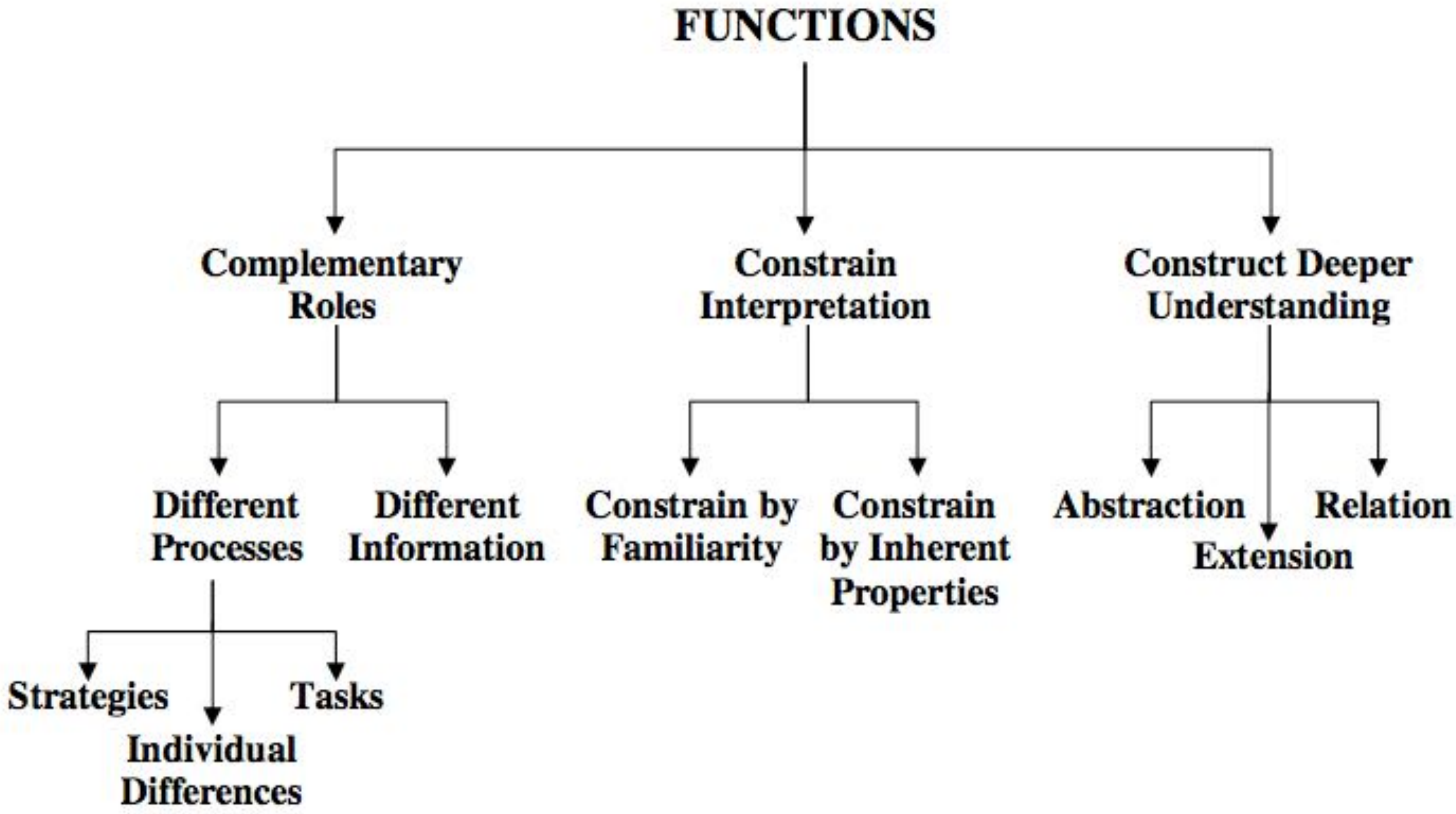
QUESTION

- Please think of concrete examples for ***multiple representations*** of learning material you have used already!
  - Text vs. pictures vs. video
  - Examples vs. conceptual explanations
  - Audio support or not
- ***PLEASE STOP PLAYBACK AND TAKE A MOMENT TO THINK!***
- Does your personal experience tell you that multiple representations may be helpful for learning?

Design Parameters in DeFT

- Number of representations
  - Multiple (two or more) representations can assist learning
    - » Individual representation simple enough to be understood
    - » Excessive number rarely helps
- Information distribution in multiple representations
  - Completely complementary information
  - Completely redundant information
  - Partially overlapping information
- Form of representations employed
- Sequence
  - Parallel or sequential presentation of MERs
  - Learner options: Switch, advance, add representation
- Translation support (between MERs)
  - Existence of support
  - Level (semantic, syntactic)

Functional Taxonomy of Multiple Representations



Complementary Functions (of MERs)

- Individual differences
  - Learners are able to choose the representation which fits their learning style best
  - “Limited evidence” exists
- Task adequacy
  - Test performance is facilitated “when the structure of information required by the problem matches the form provided by the representational notation” (Gilmore & Greene 1984)
  - Example: Control panel device
    - » Learners using tables and diagrams are better in identifying faulty components
    - » Learners using procedures are better in identifying mispositioned switches
  - For multiple tasks, multiple learning materials can be helpful
- Strategy
  - MERs encourage learners to try more than one strategy

Constraining Functions (of MERs)

- One representation constrains interpretation of another representation
  - Learning benefits from existence of multiple representations
- Constraining by familiarity
  - Example:
    - » Graph representation of a physical law: Unfamiliar and complex
    - » Accompanying animation/simulation: Constrains interpretation, i.e. makes more concrete what the meaning is
- Constraining by inherent properties:
  - Example: Graphical representations are implicitly over-specific
    - » Text: “the knife is beside the fork”
    - » Picture: knife has to be placed either left or right of the fork
    - » Using several representations can help to find the right interpretation

Constructing Functions (of MERs)

- Support for deeper understanding
  – Learners integrate information from different representations
- Abstraction
  – Learners construct references across MERs
  – Stimulation and feedback tool for abstractions
- Extension
  – Learners can transfer isolated previous knowledge (bound to one representation) into a larger conceptual framework
  – E.g. knowing about velocity-time graphs, extending to acceleration measure
- Relation
  – Knowledge about the relationship between representations is helpful in itself
  – Example: Formula vs. graph