5 Theorien und Untersuchungen zum multimedialen Lernen

Literatur:

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
    - » Animation is

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

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?

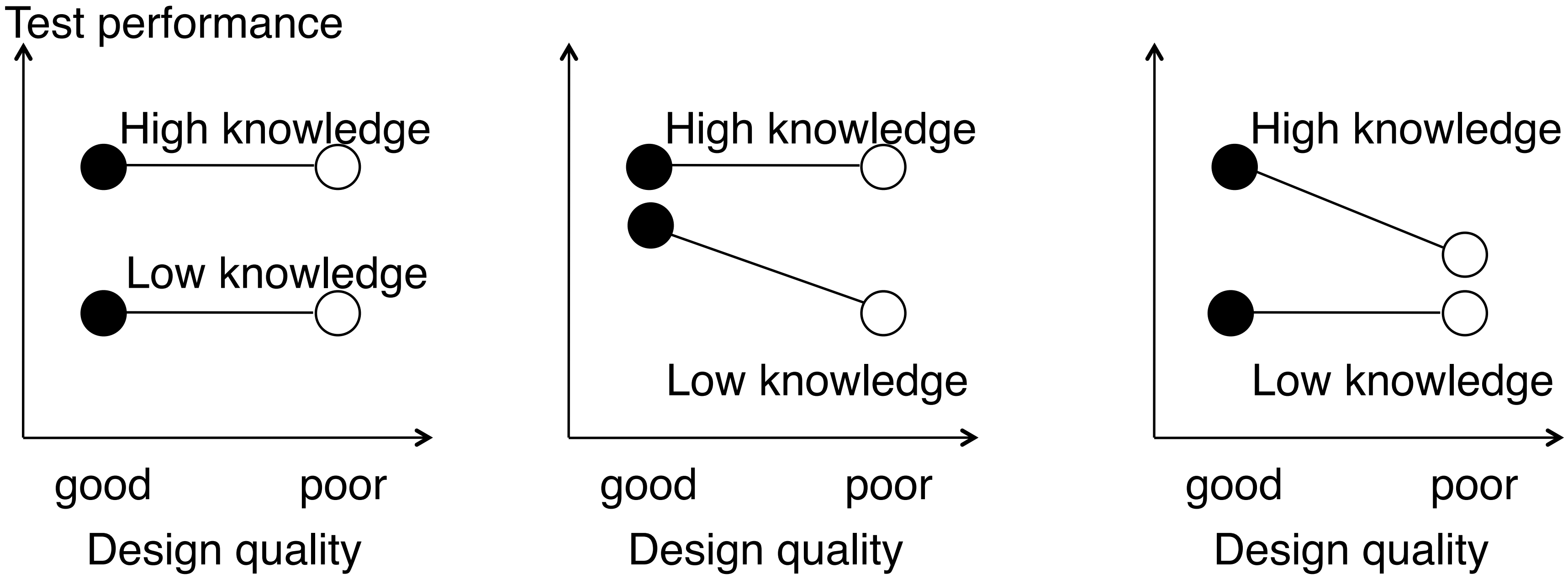
Example: Meteorology Questionnaire

- I regularly read the weather maps in a newspaper (yes/no)
- I know what a cold front is (yes/no)
- I can distinguish between cumulus and nimbus clouds (yes/no)
- I know what low pressure is (yes/no)
- I can explain what makes wind blow (yes/no)
- I know what these symbols mean:

Overall level of meteorology expertise (1 – 5): ?

Evaluation: 1 per positive answer plus level points
Score below 6: low-knowledge learner
Score 7 or more: high-knowledge learner

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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Warning!

Information taken from a scientific article does not have to be reliable and applicable

Scientific theories are hypotheses which may be falsified

Errors in experiments and evaluation exist

“Schools” and “marketing effects” exist in science

Alternative theories are in competition;
sometimes it depends on external criterial which theory is seen as superioi

General Approach

- Complex “end-to-end” question:
  - How can learning be improved by applying some media design rules?
  - Covers a very long cause-effect chain
    - » Many unknown influence variables
- Detailed and isolated questions (examples):
  - Which amount of extrinsic cognitive load is created by using a specific modality/codality?
  - Is there an influence of design quality on understanding?
    - » Clear layout vs. confusing layout
    - » Photos vs. sketches
    - » Keywords vs. elaborated text
    - » …
  - Is there an influence of the way how spoken narration is presented?
    - » Sex, age of speaker
    - » Speed, expressiveness of speech
    - » ...

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 pronounciation) 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?

Implicit Media Dependencies

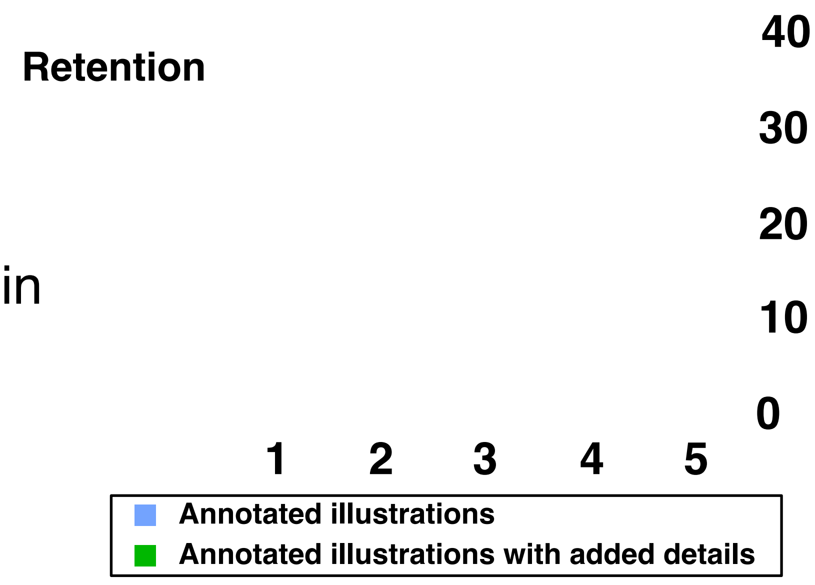
- Comparing an animated graphical presentation with a textbook
  - How to present the textbook content?
    - » On a computer screen, to be comparable?
    - » In a book, to maintain the media characteristics?
  - How to present the animation?
    - » In phase pictures?
    - » Continuously?
    - » With/without control functions?
- Comparing an audio narration with structured text
  - How to present the structured text?
    - » As continuous text, to be consistent with the audio narration?
    - » As outline + keywords, to emphasize the potential superiority of the visual medium?

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)



From last lecture
(Coherence Principle)

- Reported results for CTML experiments in previous lecture are ***meta-study*** results
  - Each number corresponds to a separate study
- Individual studies
  - Reported in various separate publications
  - Using varying thematic content
  - Publications contain more information on method (subjects and design, materials, procedure) and evaluation
- Typical group size
  - 30 to 40 participants per study
- Typical subjects
  - Female (only!) college students
  - Low knowledge of mechanics/physics

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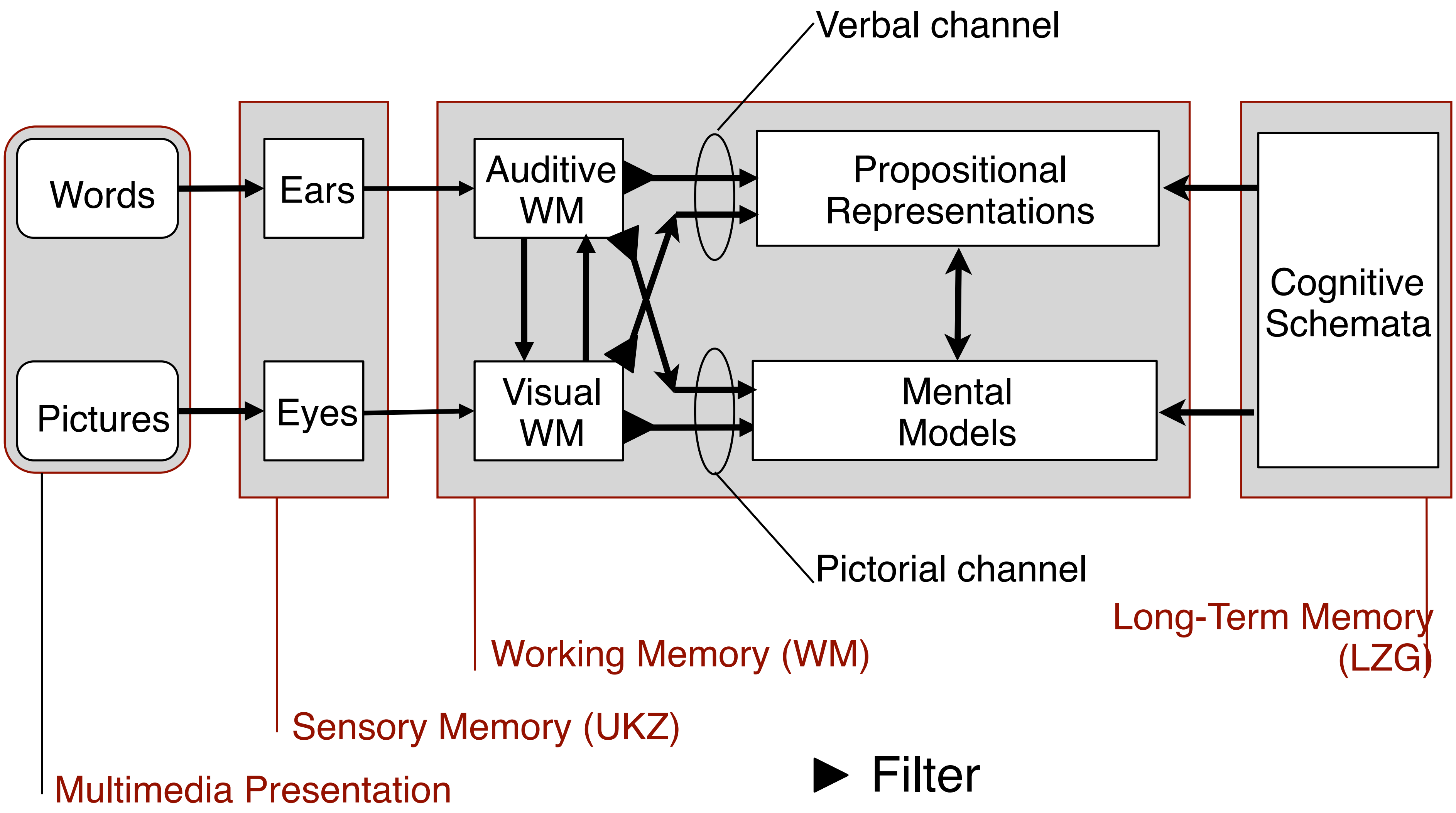
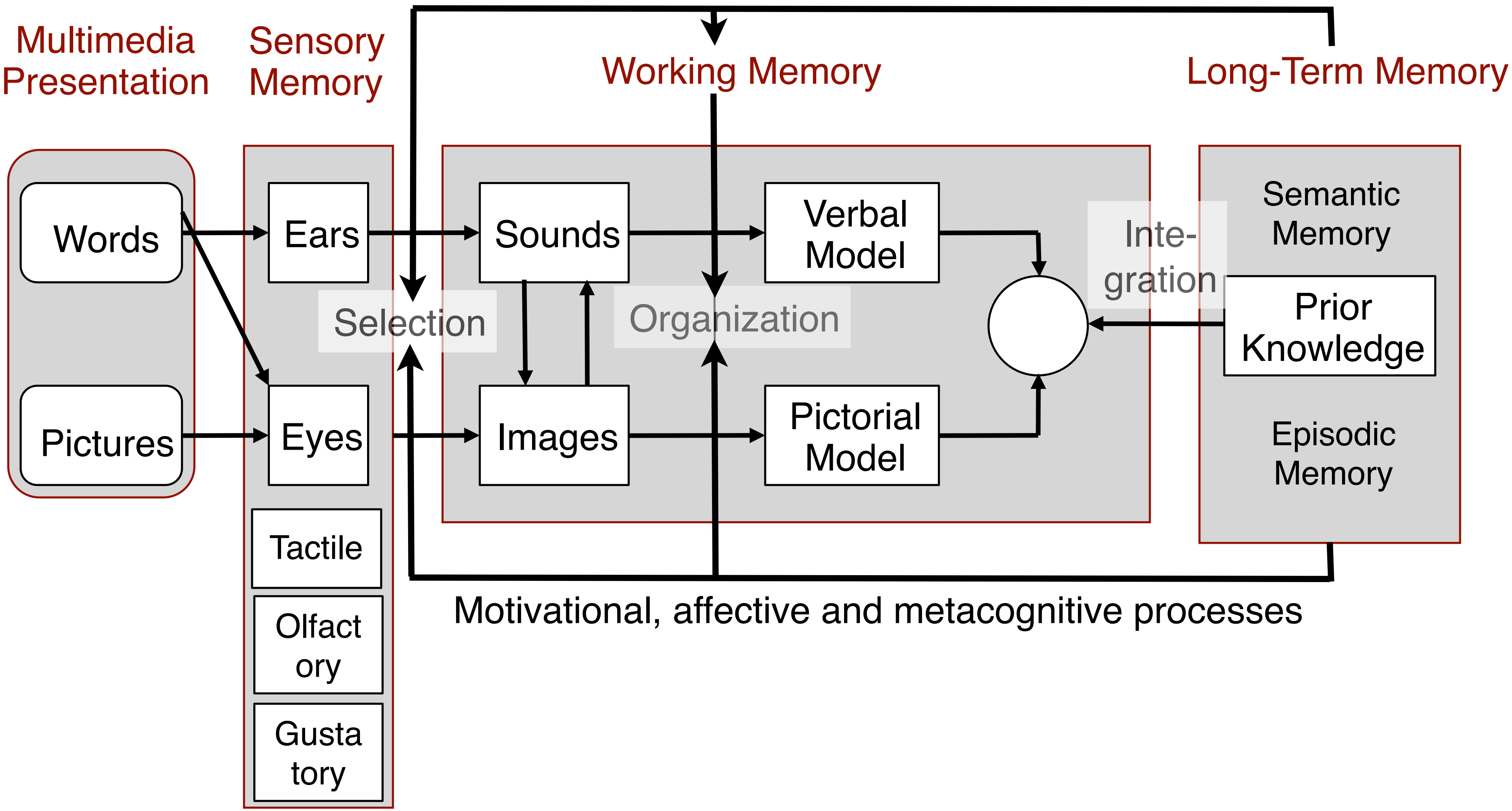
Integrative Model by Schnotz (U Koblenz/Landau)

- Extension/refinement of CTML
  - Wolfgang Schnotz (2005).
    An Integrated Model of Text and Picture Comprehension.
    In R.E. Mayer (Ed.), Cambridge Handbook of Multimedia Learning
- Distinction between
  - descriptive representations
  - depictional representations
- Distinction between
  - propositional representations
  - mental models

Modified Model of Multimedia Learning (Schnotz)



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



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

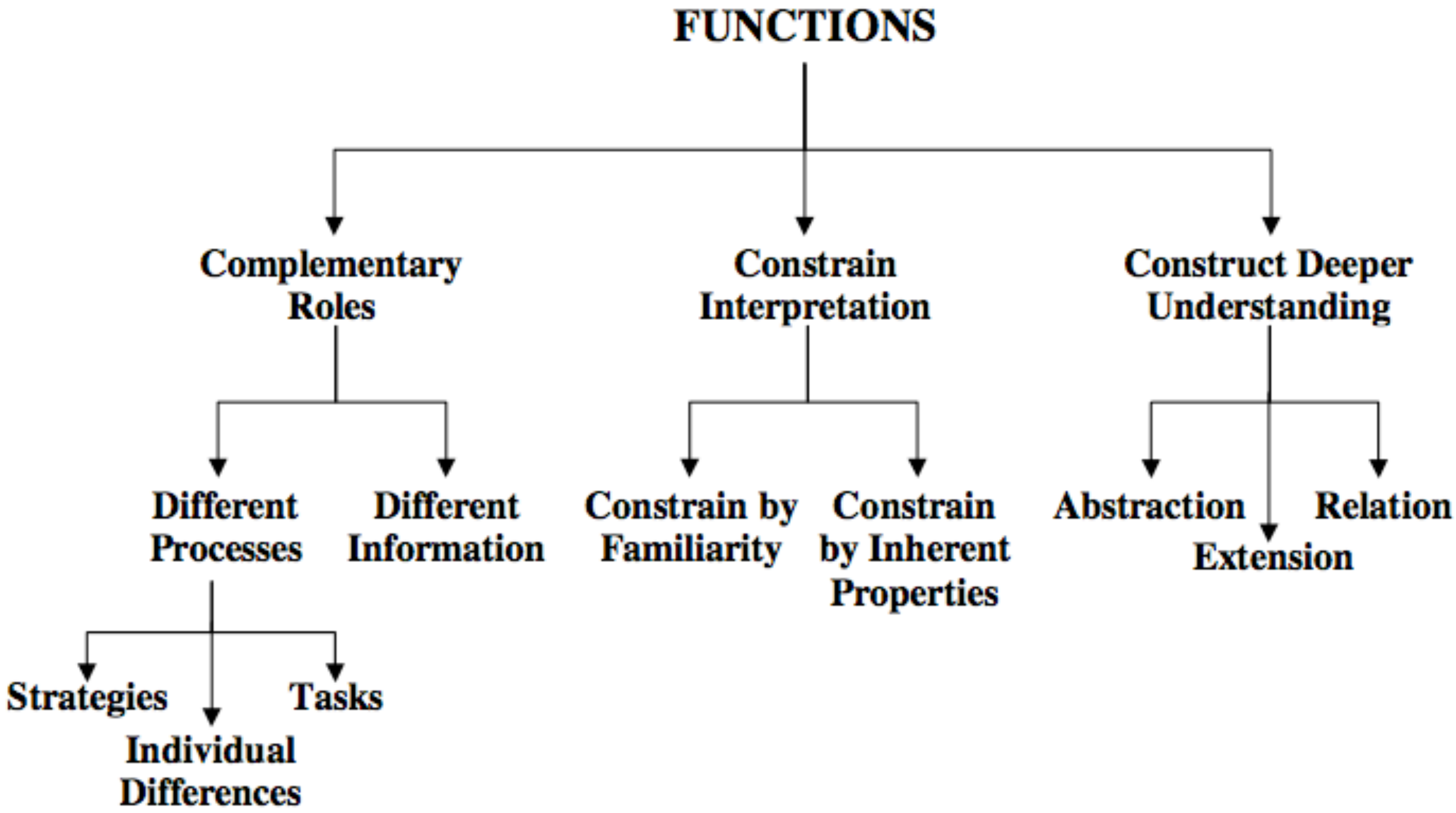
- Multiple External Representations (MER) of knowledge:
  - Diagrams, equations, tables, text, graphs, animations, sound, video, ...
- Perceptual variability helps in building abstractions
  - Cognitive Flexibility Theory (Spiro) and other research
  - Empirical studies prove that learners benefit from 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

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
      - Picture constrains the meaning of the text
      - Several pictures (examples) together can clarify constraints

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

Cognitive Tasks in Learning with ERs

- Understand the form of representation
  - Example graph: lines, labels, axes, gradients, maxima, minima, …
  - Misunderstandings are frequent
    Example: Velocity-time graph of a vehicle passing a hill
- Understand the relationship between representation and domain
  - Particularly difficult under incomplete domain knowledge
  - Example: Read velocity from a time-distance graph
- Understand how to select an appropriate representation
  - More difficult for novices than for experts
- Understand to construct an appropriate representation
  - Construction can lead to better understanding than passive reading
  - Implementation between interpretation and construction of representation appears to be complex

DeFT: Influence Factors on Difficulty

- Representation characteristics:
  - Sensory channels (modalities)
  - Coding (codality)
  - Level of abstraction
  - Specificity of representations
  - Type of representation
  - Integration of representations
  - Static/dynamic representations
  - Dimensionality
- Individual characteristics:
  - Representational familiarity
  - Domain familiarity
  - Age
  - Individual differences

Integrative Model of Multimedia Learning (Hede/Hede)

No predictions on effectiveness of specific designs

Just a compilation of design-relevant factors
– Very comprehensive

http://www.ascilite.org.au/aset-archives/confs/2002/hede-t.html