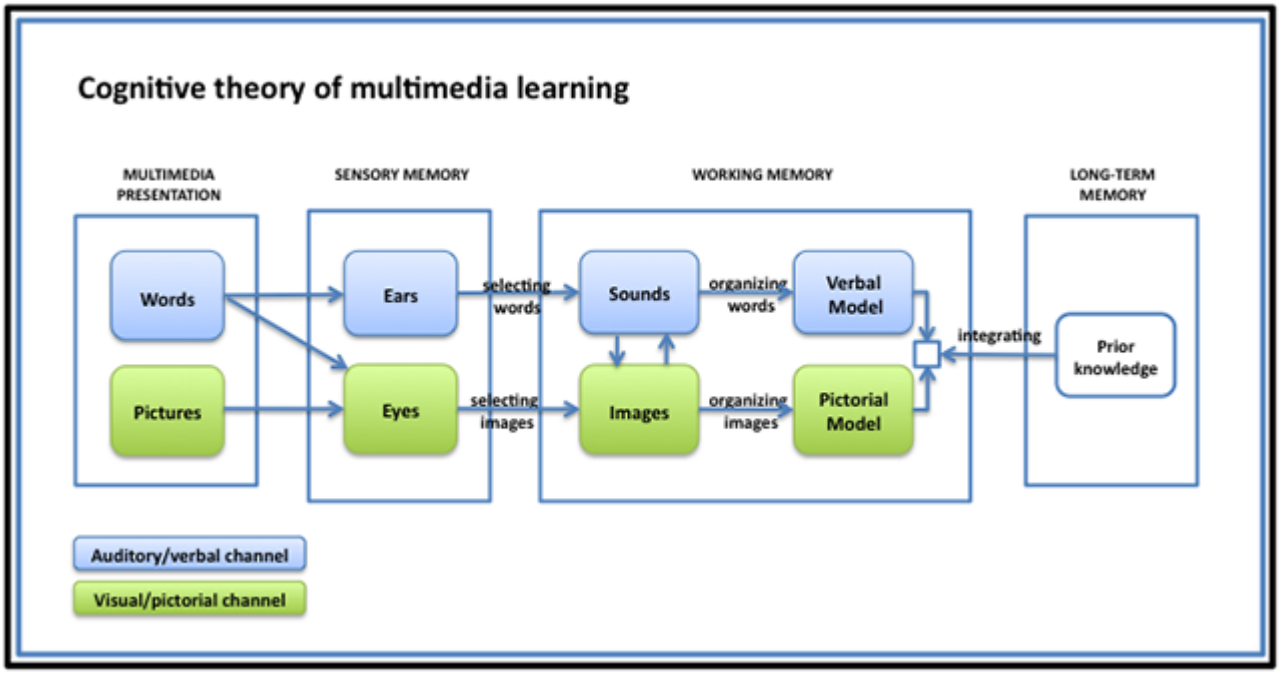
Cognitive Theory of Multimedia Learning

General

Cognitive theory of multimedia learning is one of the cognitivist learning theories introduced by an American psychology professor Richard Mayer in the 1990s. This theory is a sub-theory of the cognitive load theory applied especially for multimedia learning, and therefore has many similarities with it. Basic assumption of Mayer's theory is that the **human working memory** has **two sub-components** that **work in parallel** (visual and verbal/acoustic) and that learning can be more successful if both of this channels are used for information processing at the same time.

What is cognitive theory of multimedia learning?



Mayer's theory is based on three assumptions suggested by cognitive research[1)2)]:

1. **Dual-channel assumption** - The verbal and visual channels (similar to what Baddeley called *phonological loop system* and *visuospatial sketchpad*[3)]) in our working memory are separated and can be used for processing information simultaneously thus enhancing process of learning. The suggestion that human working memory has more sub-components firstly came from the working memory models designed by Alan Baddeley and Graham Hitch in 1974[4)] and reviewed by Baddeley in 1992[5)]. These findings where further incorporated to the Dual coding theory by Allan Paivio[6)] and later by Mayer and his colleagues.
2. **Limited capacity assumption** - As Miller's Information processing theory has shown, these channels have limited capacity[7)] and limited time[8)] they can hold information. Too much information can therefore cause *cognitive overload*.[9)]
3. **Active-processing assumption** - Learning is an active process of collecting, organizing and integrating new information[10)]. Similarities with constructivist learning may be noticed in this definition.

Together with cognitive load theory, which offers a more detailed description of cognitive load types and possible causes of cognitive overload, the mentioned assumptions of cognitive theory of multimedia learning form a framework and **theoretical basis** for most contemporary research on learning. This research resulted in a number of so called *principles* and *effects* describing different phenomena related to learning. Principles of cognitive theory of multimedia learning identified by Mayer[11] and other researchers are the following:

Principle	Description
Modality principle	Learning will be enhanced if presenting **textual information in an auditory format**, rather than in visual format, when it is accompanied with other visual information like a graph, diagram or animation.[12]
Redundancy principle	Capacity of both human information channels can unnecessarily be **overloaded by redundant information** presented through both channels thereby negatively affecting learning process.[13]
Split-attention effect	"*when each source of information is essential for understanding the represented subject matter, learning improves when multiple sources of information are presented in a spatially and temporally integrated rather than separated format.*"[14] Split attention effect can here be interpreted as *spatial* or *temporal* resulting in spatial and temporal contiguity effect.
Spatial contiguity principle	Information processing is easier when two related visual information **sources are closer to one other**. For example, text placed near the referred place in the diagram will result in more successful learning than if it is placed under the diagram.
Temporal contiguity principle	**Simultaneous presentation** of related information should be most similar to the way human mind operates and has provided good experimental results, same as presenting related multi-modal information with very short time differences.
Coherence principle	(Also called *seductive details effect*) claims that **extraneous material** that may be interesting or motivating but is irrelevant and generally **wastes learning resources**.
Individual differences principle	It emphasizes influence of prior knowledge and cognitive capacity to results of learning. Design effects are stronger for learners with little prior knowledge, and for high-spatial learners who have higher cognitive capacity to mentally integrate verbal and visual information.

Some of the effects and learning aids researched also in frames of cognitive theory of multimedia learning and cognitive load theory are:

Effect	Description
Signaling effect	(*Signaling* or *cuing*) presents the increase in the learning outcomes due to promotion of attention to relevant information. Signals are based on natural attention attractors like movement or contrast. In multimedia this can also be achieved through underlining, arrows or color-coding.[15]
Segmenting effect	Learning should be more efficient if a continued animation or narration could be split into more smaller parts.[16]
Worked examples effect[17]	The reduction in imposed cognitive load due to "*... a step-by-step **demonstration** of how to perform a task or how to solve a problem.*"[18]
Expertise reversal effect[19]	"*Instructional techniques that are highly effective with inexperienced learners can lose their effectiveness and even have negative consequences when used with more experienced learners.*"[20]

Effect	Description
Explanation prompts[21]	Prompting students to self-explain steps of a worked example or a procedure they're studying has a positive effect on conceptual knowledge.[22]
Collaborative learning	When the complexity of the material to be learned is low, individual learning is more effective and more efficient than collaborative. For complex materials, collaborative learning is superior since it allows sharing working memory load among participants.[23]
Schema activation	"*Activation and utilization of learners' prior knowledge.*"[24]
Learner control	"*Too much control causes cognitive overload and even experts might experience difficulties in selecting, sequencing and pacing huge amounts of information.*" [25]

What is the practical meaning of cognitive theory of multimedia learning?

Principles of the cognitive theory of multimedia learning have a very practical application in educational theory. As stated by Mayer[26], these principals suggest that students learn better

- from **words and pictures** than from words alone
- from **animation and narration** together than only from animation or narration or on-screen text
- when corresponding words and pictures are presented **close** rather than far from each other on the page or screen
- when corresponding words and pictures are presented **simultaneously** rather than one after another
- when extraneous interesting but irrelevant material is excluded rather than included
- when important information in the learning material is marked or emphasized
- animation or text are broken down into smaller segments
- when they are presented with worked examples before they try to solve a problem on their own
- when they are prompted to self-explain a step in a procedure
- when they study complex material in collaboration with other students
- when their prior knowledge is activated prior to learning new material
- when they receive amount of guidance depending on their expertise level

All of this design effects are stronger for low-knowledge learners than for high knowledge learners, and for high-spatial learners rather than for low-spatial learners.

Criticisms

Cognitive theory of multimedia learning is mostly subjected to same criticisms as the cognitive load theory since it is an extension of it.

Keywords and most important names

- **Cognitive theory of multimedia learning**, **dual coding theory**, **visual and**

verbal/acoustic channel, **modality principle**, **redundancy principle**, **spatial contiguity principle**, **temporal contiguity principle**, **coherence principle**, **individual differences principle**

- Richard Mayer

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