

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 1974⁴ and reviewed by Baddeley in 1992⁵. These findings were 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 capacity⁷ and limited time⁸ 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 information¹⁰. 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 Mayer¹¹⁾ 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	<i>"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."</i> ¹⁴⁾ Split attention effect can here be interpreted as <i>spatial</i> or <i>temporal</i> 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 <i>seductive details effect</i>) 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	(<i>Signaling</i> or <i>cuing</i>) 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 <i>"... a step-by-step demonstration of how to perform a task or how to solve a problem."</i> ¹⁸⁾
Expertise reversal effect ¹⁹⁾	<i>"Instructional techniques that are highly effective with inexperienced learners can lose their effectiveness and even have negative consequences when used with more experienced learners."</i> 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	<i>"Activation and utilization of learners' prior knowledge."</i> ²⁴⁾
Learner control	<i>"Too much control causes cognitive overload and even experts might experience difficulties in selecting, sequencing and pacing huge amounts of information."</i> 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 Mayer²⁶⁾, 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](#)

Bibliography

[Mayer, Richard E. *Multimédia learning*. Cambridge University Press, 2001.](#)

[Mayer, R. E, J. Heiser and S. Lonn. Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology* 93, no. 1: 187–198. 2001.](#)

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[Baddeley, Alan D. Is Working Memory Still Working? *European Psychologist* 7, no. 2: 85-97. July 2002.](#)

[Moreno, R., and Mayer, Richard E. Cognitive Principles of Multimedia Learning: The Role of Modality and Contiguity. *Journal of Educational Psychology* 91, no. 2: p358-368. June 1999.](#)

[Mayer, R. E, and V. K Sims. For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of educational psychology* 86: 389–389. 1994.](#)

1)

[Mayer, RE, and R Moreno. Animation as an aid to multimedia learning. *Educational psychology review* 14, no. 1: 87-99. March 2002.](#)

2) 3) 10) 26)

[Mayer, Richard E. *Multimédia learning*. Cambridge University Press, 2001.](#)

4)

[Baddeley, A. D., Hitch, G. J. Working Memory. In Bower, G.A. *The psychology of learning and motivation: advances in research and theory*. 8. New York: Academic Press. pp. 47–89. 1974.](#)

5)

[Baddeley, A. Working memory. *Science \(New York, N.Y.\)* 255, no. 5044: 556-559. January 31, 1992.](#)

6)

[Paivio, A. *Mental representations: A dual coding approach*. Oxford, England: Oxford University Press. 1986.](#)

7)

[Miller, G. A. The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychology Review* 63: 81-97. 1956.](#)

8)

[Peterson, L. and Peterson, M. Short-term retention of individual verbal items. *Journal of Experimental Psychology*, 58, 193–198. 1959.](#)

9)

[Mayer, Richard, and Roxana Moreno. Nine Ways to Reduce Cognitive Load in Multimedia Learning. *Educational Psychologist* 38: 43-52, March 2003.](#)

11)

[See: Mayer, Richard E. *Multimédia learning*. Cambridge University Press, 2001. Pp 63, 81, 96, 113, 134, 147, and 161.](#)

12)

Ginns, Paul. Meta-analysis of the modality effect. *Learning and Instruction* 15, no. 4: 313-331. August 2005.

13)

For example see: Schmidt-Weigand, Florian, and Katharina Scheiter. The role of spatial descriptions in learning from multimedia. *Computers in Human Behavior* 27, no. 1: 22-28. January 2011.

14)

Florax, Mareike, and Rolf Ploetzner. What contributes to the split-attention effect? The role of text segmentation, picture labelling, and spatial proximity. *Learning and Instruction* 20, no. 3: 216-224. June 2010.

15) 16)

Visser, R. D. Exploring different instructional designs of a screen-captured video lesson: A mixed methods study of transfer of learning. PhD thesis. Clemson University. 2009.

17)

Sweller, John, and Graham Cooper. The Use of Worked Examples as a Substitute for Problem Solving in Learning Algebra. *Cognition and Instruction* 2: 59-89, 1985.

18)

Clark, Ruth Colvin, Frank Nguyen, and John Sweller. Efficiency in learning: evidence-based guidelines to manage cognitive load. John Wiley and Sons, 2006.

19) 20)

Kalyuga, Slava, Paul Ayres, Paul Chandler, and John Sweller. The Expertise Reversal Effect. *Educational Psychologist* 38: 23-31, March 2003.

21)

Berthold, Kirsten, Tessa H. S. Eysink, and Alexander Renkl. Assisting self-explanation prompts are more effective than open prompts when learning with multiple representations. *Instructional Science* 37: 345-363, April 2008.

22)

Berthold, Kirsten, Heidi Röder, Daniel Knörzer, Wolfgang Kessler, and Alexander Renkl. The double-edged effects of explanation prompts. *Computers in Human Behavior* 27, no. 1: 69-75, January 2011.

23)

Kirschner, Femke, Fred Paas, and Paul A. Kirschner. Individual Versus Group Learning as a Function of Task Complexity: An Exploration into the Measurement of Group Cognitive Load. In *Beyond Knowledge: The Legacy of Competence*, edited by Jörg Zumbach, Neil Schwartz, Tina Seufert, and Liesbeth Kester, 21-28. Dordrecht: Springer Netherlands, 2008. cited by Kirschner, Femke, Fred Paas, and Paul A. Kirschner. Superiority of collaborative learning with complex tasks: A research note on an alternative affective explanation. *Computers in Human Behavior* 27, no. 1: 53-57, January 2011.

24)

Kirschner, Paul A., Paul Ayres, and Paul Chandler. Contemporary cognitive load theory research: The good, the bad and the ugly. *Computers in Human Behavior* 27, no. 1: 99-105, January 2011.

25)

Corbalan, Gemma, Liesbeth Kester, and Jeroen J.G. van Merriënboer. Learner-controlled selection of tasks with different surface and structural features: Effects on transfer and efficiency. *Computers in Human Behavior* 27: 76-81, January 2011. cited by Kirschner, Paul A., Paul Ayres, and Paul Chandler. Contemporary cognitive load theory research: The good, the bad and the ugly. *Computers in Human Behavior* 27, no. 1: 99-105, January 2011.

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