The Cognitive Load Theory: a framework to study effects of hypertexts and prior knowledge on learning

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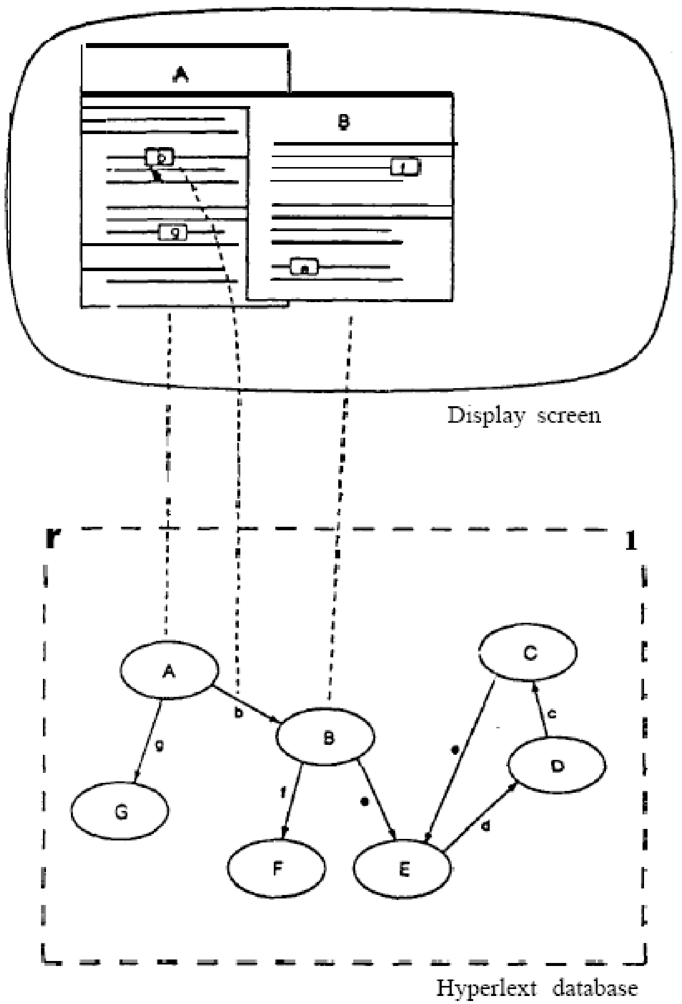
What is a hypertext?

- Different types of hypertext devices: Macro literacy Systems, problem exploration tools, browsing systems…

- Shared characteristics:
  - Information semantically interconnected (nodes and links)
  - A non-linear organization: the reader can choose his own path
  - Information is structured (e.g. network, hierarchical)
  - User navigates through the information space

Hypertext according to Conklin (1987)



Hypertexts: effects on learning

- No consensus about a positive effect on learning (Amadieu & Tricot, 2006 ; Chen & Rada, 1996 ; Dillon & Gabard, 1998 ; Shapiro & Niederhauser, 2004)

- Low generalizability of all findings → several reasons:
  - Differences between studies (participants, devices, learning tasks, knowledge domain…)
  - Methodological weakness and diversity
  - Technological-centered approach = no psychological theory specific to the learning with hypertext

Hypertext processing = a high cognitive cost?

- Hypertexts impose control of navigation
- Disorientation = a cognitive overload → reduces performance (Ahuja et Webster, 2001)
- No reliable empirical evidences:
  - Few empirical evidences corroborating disorientation (no measures or missing accurate measures like navigational behaviors)
  - Few empirical evidences corroborating relationships between disorientation and learning performance
- To suppress disorientation → Guidance = overviews (e.g. conceptual map)

Hypertexts (highly non-linear) require high cognitive resources

- <u>Metacognitive resources</u> supporting learning strategies, monitoring and planning (Azevedo *et al*., 2004 ; Azevedo & Cromley, 2004 ; Kauffman, 2004, Veenman *et al*., 2002).
- <u>Spatial abilities</u> supporting navigation (Downing et al., 2005 ; Lin, 2003 ; Nilsson et Mayer, 2002, Stanney et Salvendy, 1995)
- <u>Field Independence</u> supporting non-linear navigation and free exploration (Chen, 2002 ; Chen & Macredie, 2002, Reed & Oughton, 1997)
- <u>Systems knowledge</u> supporting the use of tools (Kraus *et al.,* 2001), a flexible navigation (Hölscher & Strube, 2000 ; Reed *et al*., 2000).

Learner's prior knowledge in learning with hypertext: no consensus

- Prior domain knowledge: a main factor for learning (Dochy, 1999), and for learning with hypertext (Dillon & Gabbard, 1998 ; Shapiro & Niederhauser, 2004 ; Shlechter, 1993).

- It is usually argued that high prior knowledge learners :
  - Use flexible, elaborated and deep navigation strategies
  - Do not encounter disorientation and cognitive overload

  ➔ Benefit from low guidance instruction (type of hypertext structures) or no particular type of hypertext instruction

Learner's prior knowledge in learning with hypertext: no consensus

- <u>Low prior knowledge</u> learners:
  - Navigation strategies are based on shallow cues
  - Do encounter disorientation and cognitive load
  - ➔ Benefit more from « well organised » structures

- Weakness of the links between: navigational behaviors / learning performance / disorientation (and cognitive overload)

The need of a learning model to study prior knowledge in learning with hypertext

- Nowadays: no specific model to study prior knowledge effects within the hypertexts domain
- Most used models (no investigations on cognitive load and disorientation):
  - Cognitive Flexibility Theory
  - Schemas Theory
  - Construction-Integration model
- Our position: the cognitive load theory (Sweller, 2003)

Cognitive load theory : a theoretical framwork to study hypertexts

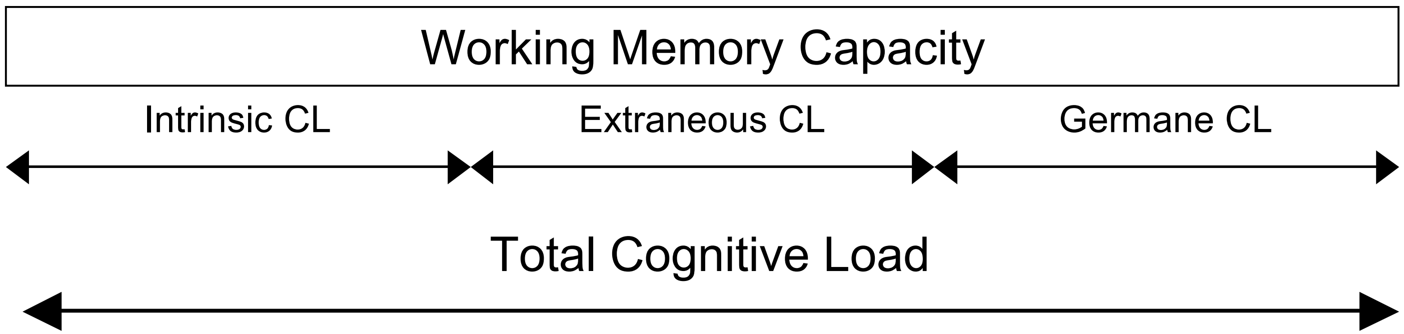
- The central concept: <u>Working Memory</u> with limited capacities
- A <u>subjective measure</u> to assess the cognitive load imposed by the learning task (Paas & van Merriënboer, 1993).
- The theory explains the <u>guidance effects</u> on learning and cognitive load.
- The theory highlights interaction effects between the level of prior knowledge and the guidance provided by the instruction: <u>expertise reversal effect</u> (Kalyuga et al., 2003).

The cognitive load theory

- Design instructions
- Instructional effects: split attention effect, worked example effect ,…
- 3 forms of cognitive load: (Sweller, van Merrienboer et Paas, 1998)
  - Intrinsic cognitive load: difficulty of concepts (interactivity between elements)
  - Extraneous cognitive load: due to the design of the instructional materials – do not contribute to learning
  - Germane cognitive load: processes useful for learning
    - selective attention processes on conceptual information
    - organization processes of information in a coherent representation
    - integration of information in knowledge base

Learning with hypertext: a processing balance

- To reach an effective learning:
  - Reducing the intrinsic cognitive load
  - Reducing the extraneous cognitive load
  - Imposing a high germane cognitive load: freeing WM capacity and favoring the engagement of the learner



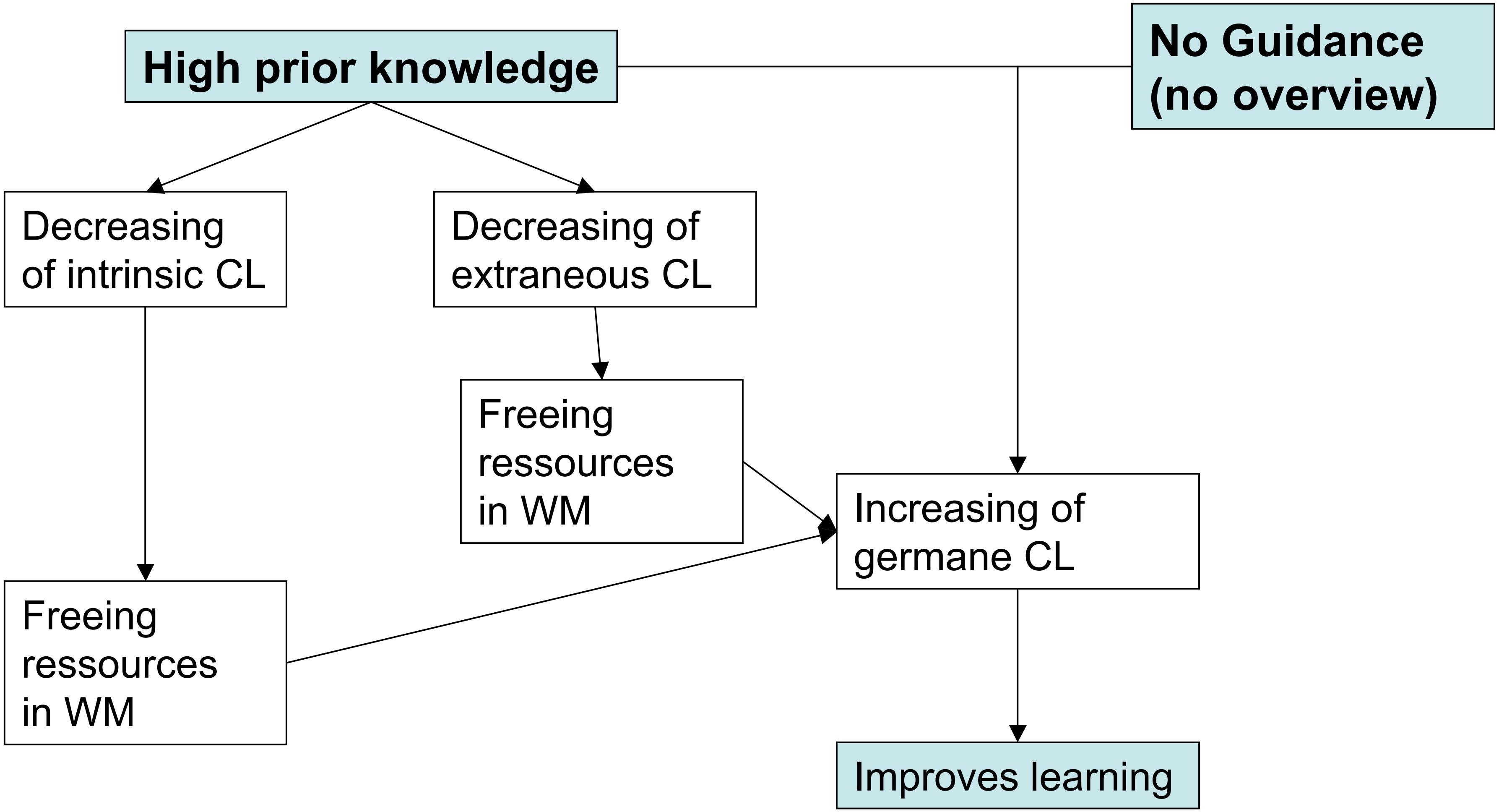
The cognitive overload in hypertexts: disorientation

- Many authors argue the main problem is disorientation and cognitive overload but few investigation were carried out.
- Recently, authors suggest using the Cogntive Load Theory to study the learning with hypertext (Amadieu & Tricot, 2006 ; DeStefano & LeFevre, 2005).
- Conversely to the DeStefano & Lefevre's approach, we suggest studying the effects of extraneous as germane cognitive load on learning.

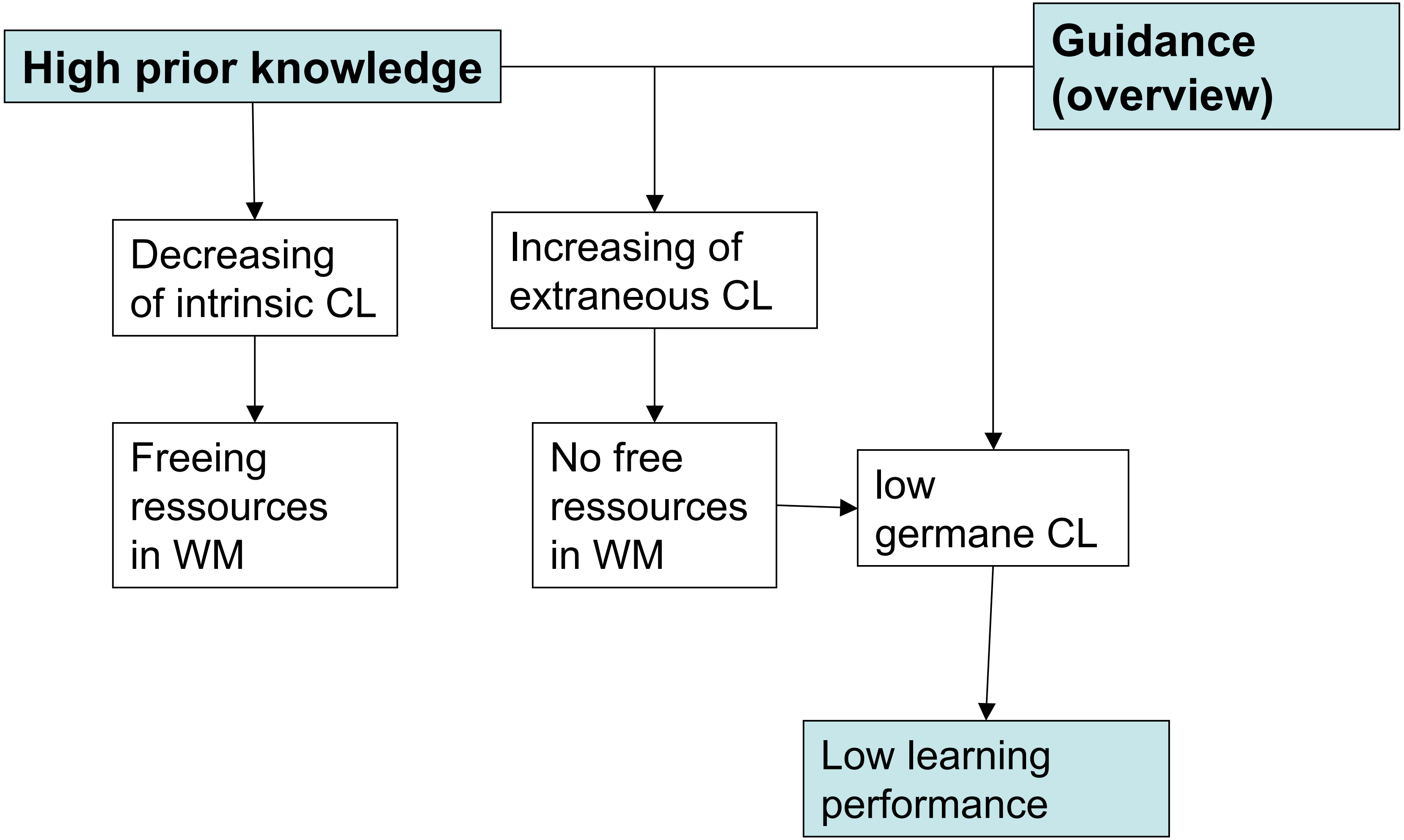
For novices: hypertext without any guidance

Intrinsic Cognitive Load	**Extraneous Cognitive Load (secondary tasks interfering learning)**
-Depends on the <u>content</u>: level of elements interactivity - Depends on the <u>temporary mental model</u>	-<u> Using tasks</u>: navigation activity (Disorientation) and using of tools (functions hypertext) - <u>Establishing conceptual coherence</u> between information chunks

For experts: hypertext without any guidance



For experts: hypertext with guidance



Similar cognitive activities belong to different forms of cognitive load

- Establishing coherence: inferential activities
  - Low prior knowledge learners: extraneous CL (Conceptual Disorientation)
  - High prior knowledge learners: germane CL (deep processing = elaborative inferences)

- Processing of overview (guidance):
  - Low prior knowledge learners: germane and intrinsic CL
  - High prior knowledge learners: extraneous CL (redundant information or information interfering with the expert's domain structures)

Conclusion

- Multiplying and designing different cognitive load measures (e.g. different subjective scales for disorientation)
- Designing measurements of the 3 forms of CL
- Identifying processes linked to the different forms of CL

3 dimensions interrelated

Cognitive load

- Disorientation
- Forms of CL

Navigation

- Strategies
- Coherence
- Using tasks (functions)
- …

Performance

- Searching task
- Comprehension
- Learning

Thank you for your attention