Using the Time Based Resource Sharing model

Taking time into account for studying Cognitive Load Theory:

Using the Time Based Resource Sharing model

International Cognitive Load Theory Conference (ICLTC) 2016. Bochum: Germany
June 23, 2016
The question of learning

Biologically primary knowledge

Biologically secondary knowledge

Sensory Buffer → Short Term / Working Memory → Long Term Memory

Schema

CLT:
- Managing information in WM
- Using WM models

Atkinson & Shiffrin, 1968
Cognitive resources: Working memory

- Spatial
  - *e.g.* Baddeley (1986)
  - Modality effect

- Energetic
  - *e.g.* Ericsson & Kintsch (1995)
  - Expertise Reversal Effect

But: Self paced modality effect (Leahy & Sweller, 2005)
Transient information effect (Sweller, Ayres & Kalyuga, 2011)

Paas, Tuovinen, Tabbers & van Gerven, 2003
Spanjers, van Gog & van Merriënboer, 2010
van Gog, Paas, Marcus, Ayres & Sweller, 2009
Cognitive resources: Working memory

- Taking time into account:
  - Time Based Resources Sharing model
  - Resource = attention
  - Time related decay of activation
  - Memory maintenance = refreshing
  - Multitasking = rapid switching

- Based on ACT-R architecture (e.g., Anderson, 1993)

Camos & Barrouillet (2014) for a review
WM: Time Based Resource Sharing model

- Representation
  - Activation level
    - (amodal representation)

- Time
  - Refreshing each chunk at a given time
  - No interference
  - Processes are attention consuming

Barrouillet, Portrat, Vergauwe, Diependaele & Camos (2011)

- e.g., Barrouillet, Bernardin & Camos (2004)
Switch between refreshing / processing

Cognitive load = time ratio
- Time allowed to refresh memory traces
- Time needed to perform concurrent activities

Complex span tasks
Time Based Resource Sharing model

- Items to memorize
  - Span task

  Letters
  
  G  K  W  O

  Numbers
  
  2  9  0  1

- Distraction task
  - Spatial judgment

  Is the square in top or the bottom half of the screen

  Portrat, Camos & Barrouillet (2009)
Rappel
Time Based Resource Sharing model

- Easy condition
- Hard condition
Time Based Resource Sharing model

Working memory span

Portrat, Camos & Barrouillet (2009)

- Close squares
- Distant squares
Time Based Resource Sharing model

- TBRS: Cognitive load as a time ratio
  - Time to process interferent task
  - Time allowed to refresh memory traces

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Experiment 1

- Replication of Portrat, Camos and Barrouillet (2009)
  - 69 students of 5th grade (french system)

- Meaningful items: calculus terms
  - Spatial judgment task

- Calculus ranging from 3 to 8 terms
  - $3 \times 2 \div 6$
  - $8 + 6 + 4 \div 9 \times 7 - 9 - 4 - 1$

- Two groups of 20 children
Experiment 1

- Complex span task

Pre-test Calculus → Train Squares (80%) → Bloc Xp → Pause cartoon → Post-test Calculus

- Squares close / distant
- Squares distant / close
Experiment 1

Nb correct calculus

Distant squares vs. Close squares

- "Experts":
  - p = .004
  - p = .019
  - p < .001

- "Novices":
  - p = .709

Graph showing the comparison between "Experts" and "Novices" in terms of the number of correct calculus problems solved for distant and close squares.
Experiment 1

- Time ratio manipulation had effect on performance

- Effect on novices
  - No effect on experts

- Interference and Working memory capacity?
  - Different judgment tasks

Adams & Hitch, 1997
Experiment 2

Xp 1

Distant squares

Item 1  Proc  Proc  Proc

Close squares

Item 1  Proc  Proc  Proc

Different squares, different time needed, same time available

Xp 2

Slow squares

Item 1  Proc  Proc  Proc

Fast squares

Item 1  Proc  Proc  Proc

Exact same squares, same time needed, different time available
Experiment 2

- 59 students of 4th (same school)
  - 54 reached 80%

- Same protocol
- Same calculus

- Different distracters
  - Close squares in both conditions
    - Fast : 1 sec
    - Slow : 2 sec

- 2 Groups of 20
Experiment 2

- Slow squares
- Fast squares

- "Experts":
  - p = 0.032
  - p = 0.310

- "Novices":
  - p = 0.154
  - p = 0.012
Experiment 2

- No interference
  - Time related decay

- Extraneous load and expertise
Effect of the time ratio on WM performance

No effect of the number of interfering tasks
Experiment 3

- 61 students (5th and 4th French grades)
  - 38 reached 80% performance criterion

- Same protocol
- Same calculus

- Spatial judgment task:
  - Close squares: 1s
  - 2 modalities: 4 squares & 8 squares

- 10 “novices” / 28 “experts”
Experiment 3

- "Experts":
  - p = 0.016
  - p = 0.073

- "Novices":
  - p = 0.154
  - P = 0.007
Experiment 3

- Extraneous load as a time ratio
- Expertise effect
- Number of elements and time ratio
Thank you for your attention

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