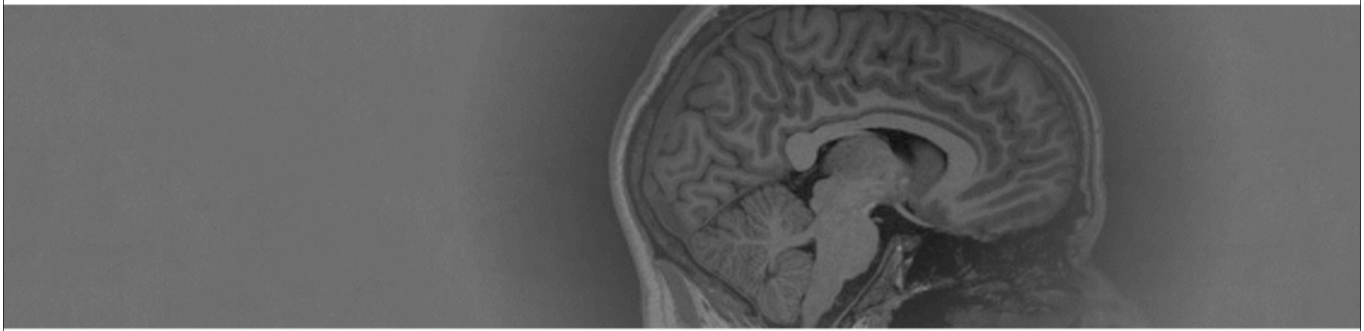
labneuroeducation.org youtube.com/stevemasson facebook.com/profstevemasson twitter.com/stevemasson



Comprendre la mémoire de travail pour mieux apprendre et enseigner

Semaine de la Chaire recherche-action 2024, Institut Villebon - 17 déc. 2024

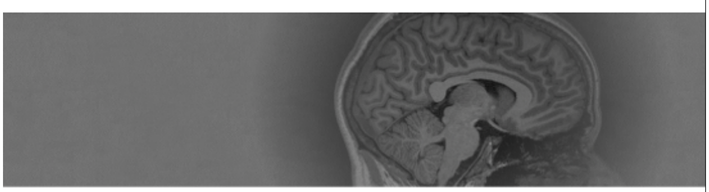
Steve Masson, professeur à l’Université du Québec à Montréal

1

Être compétent

C’est…

1. Être capable de réussir certaines tâches
2. Posséder des connaissances et autres ressources
3. Savoir utiliser ses ressources



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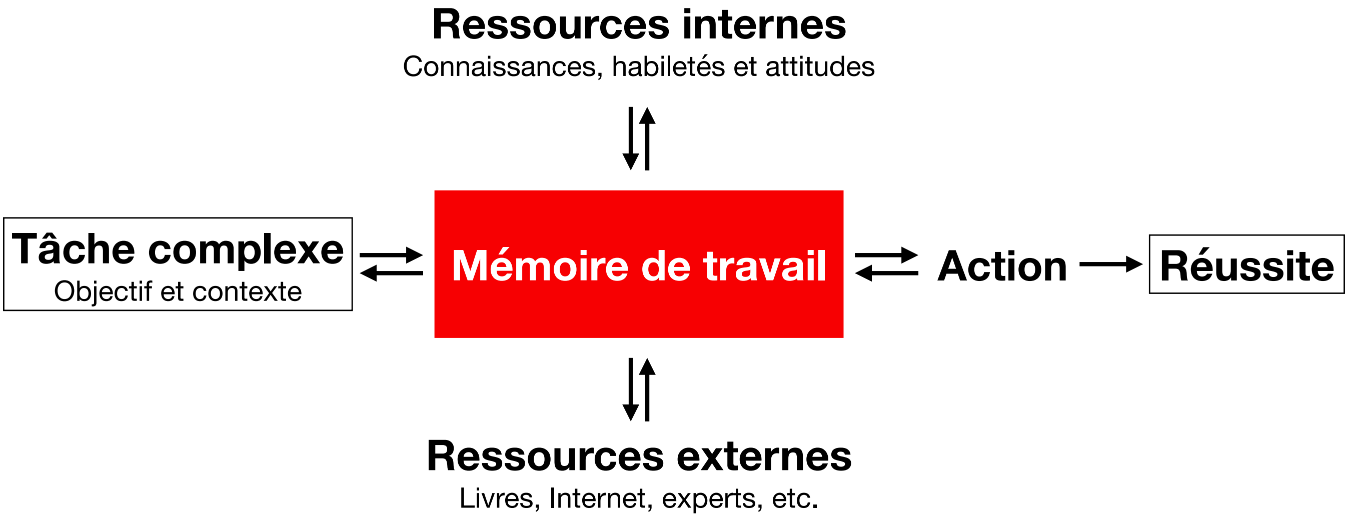
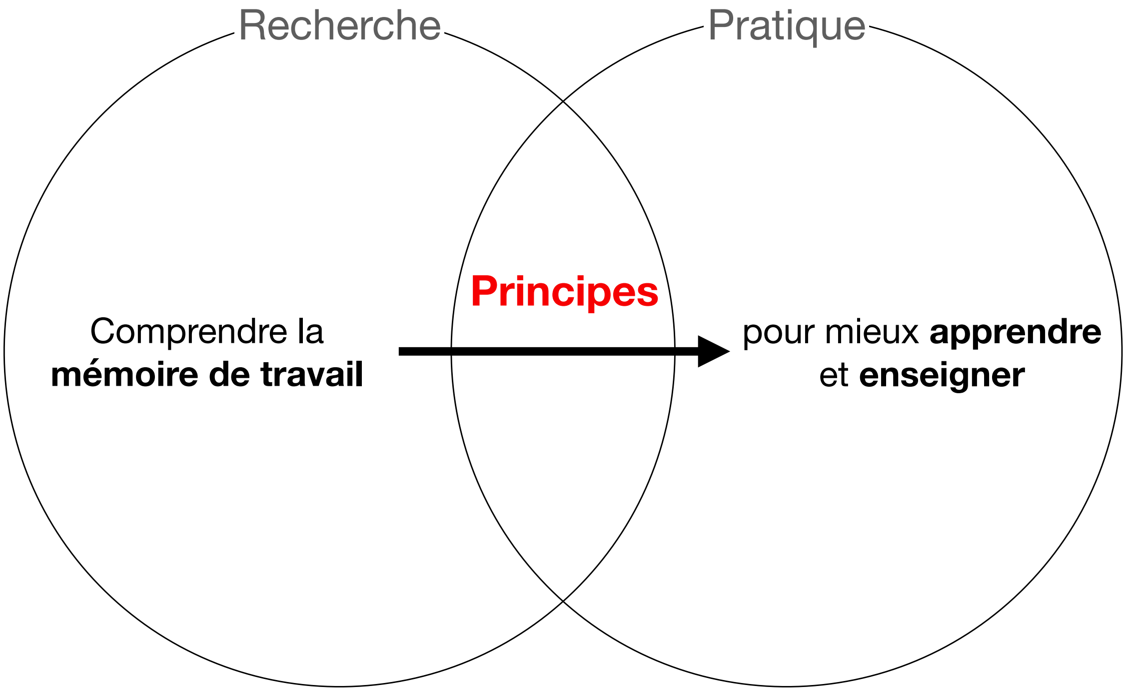


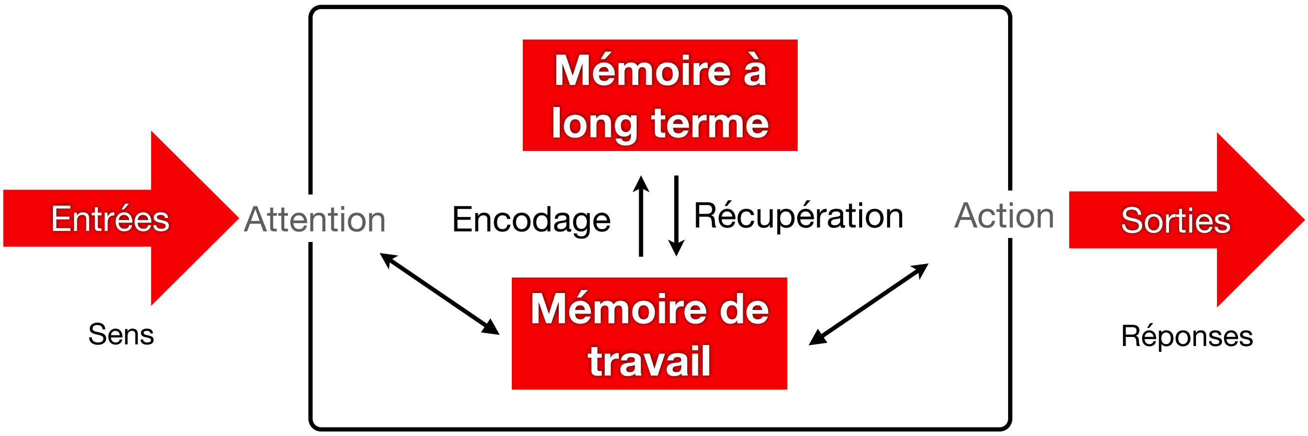
La **mémoire de travail** est donc nécessaire à la **compétence**.

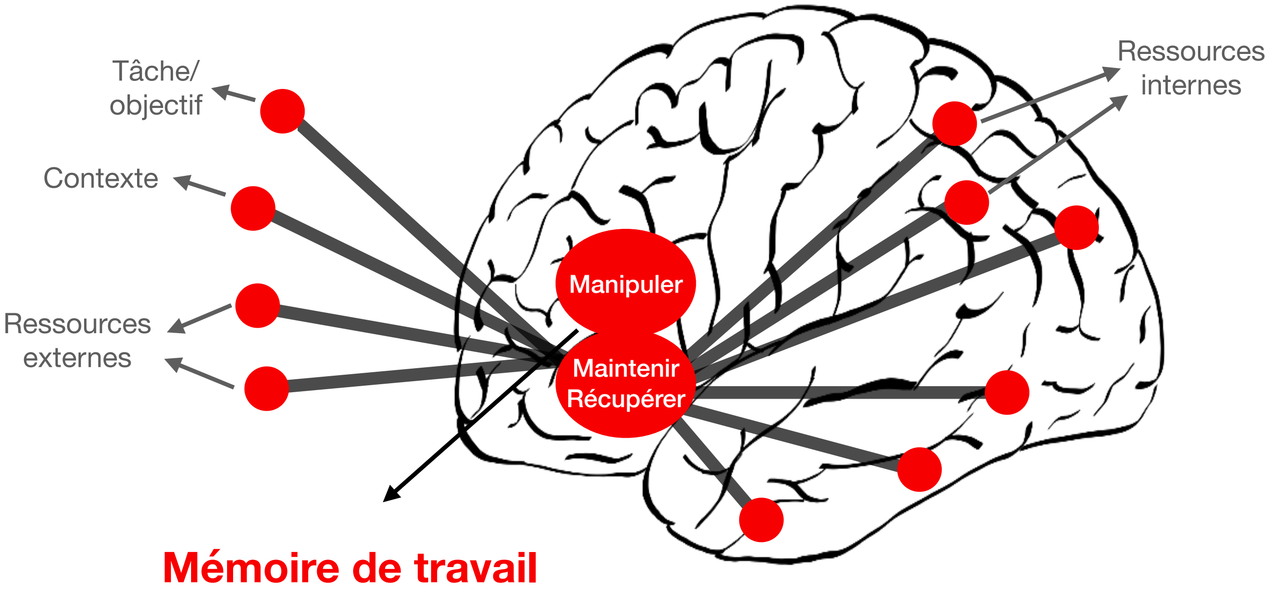


Partie 1

Qu’est-ce que la mémoire de travail ?

Mémoire de travail =
Espace de travail mental permettant
de **maintenir** en tête et de **manipuler** des informations





9

Problème

La mémoire de travail est très limitée.

10

Surcharge =

État dans lequel la mémoire de travail **n'arrive plus à traiter l'information**

Étude de

Cowan


BEHAVIORAL AND BRAIN SCIENCES

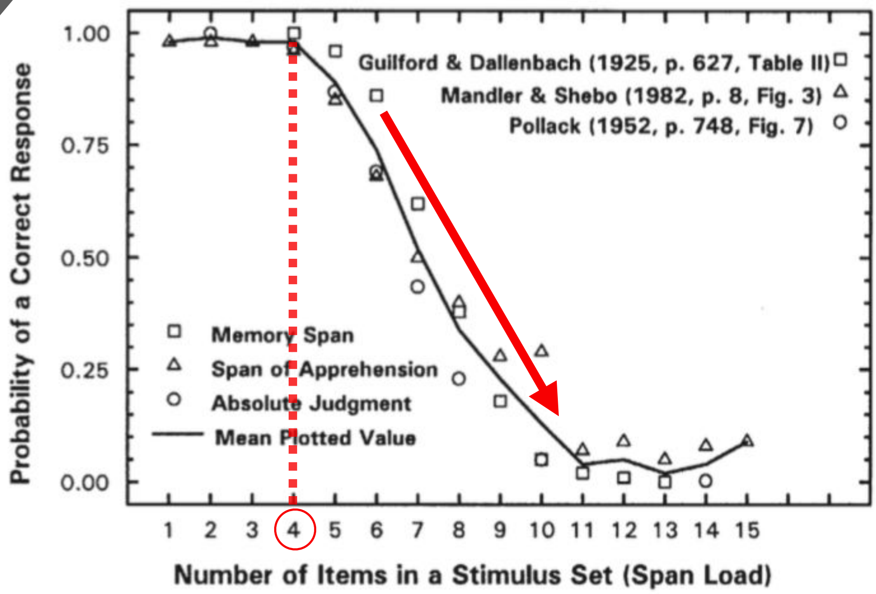
The magical number 4 in short-term memory: A reconsideration of mental storage capacity

Nelson Cowan

1. Introduction to the problem of mental storage capacity

Capacité de notre mémoire de travail

Étude de Cowan



Étude de Price et al.

Regional response differences within the human auditory cortex when listening to words

Cathy Price, Richard Wise, Stuart Ramsay, Karl Friston, David Howard, Karalyn Patterson and Richard Frackowiak

Effet de la **surcharge** de la mémoire de travail sur le **cerveau**

Étude de

Price et al.

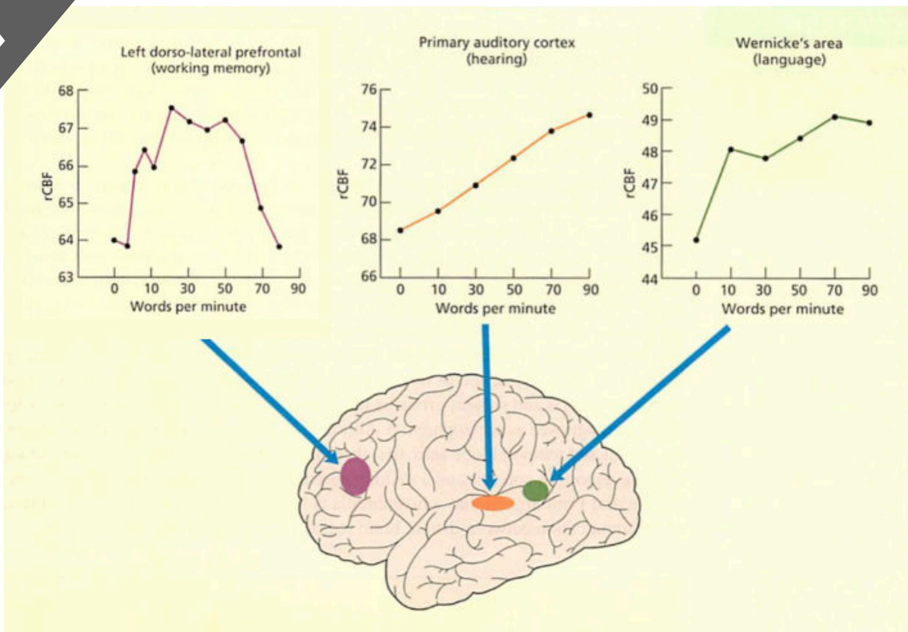


Figure tirée de Ward (2010, p. 61)

Étude de

Price et al.

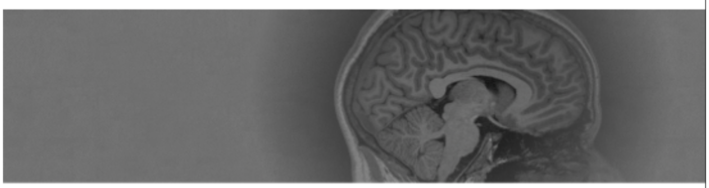
La surcharge est liée à une **désactivation** de régions cérébrales liées à la mémoire de travail.

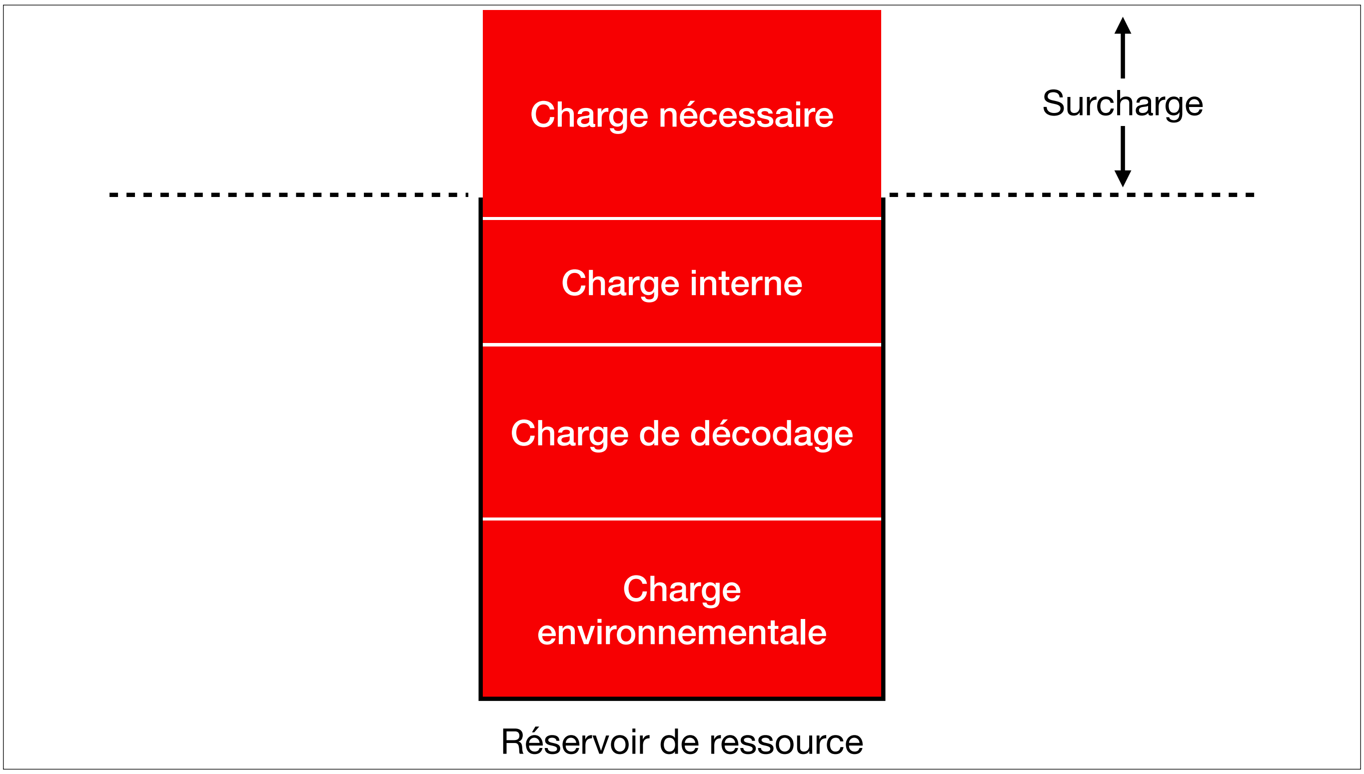
Piste de solution

Réduire la charge non nécessaire

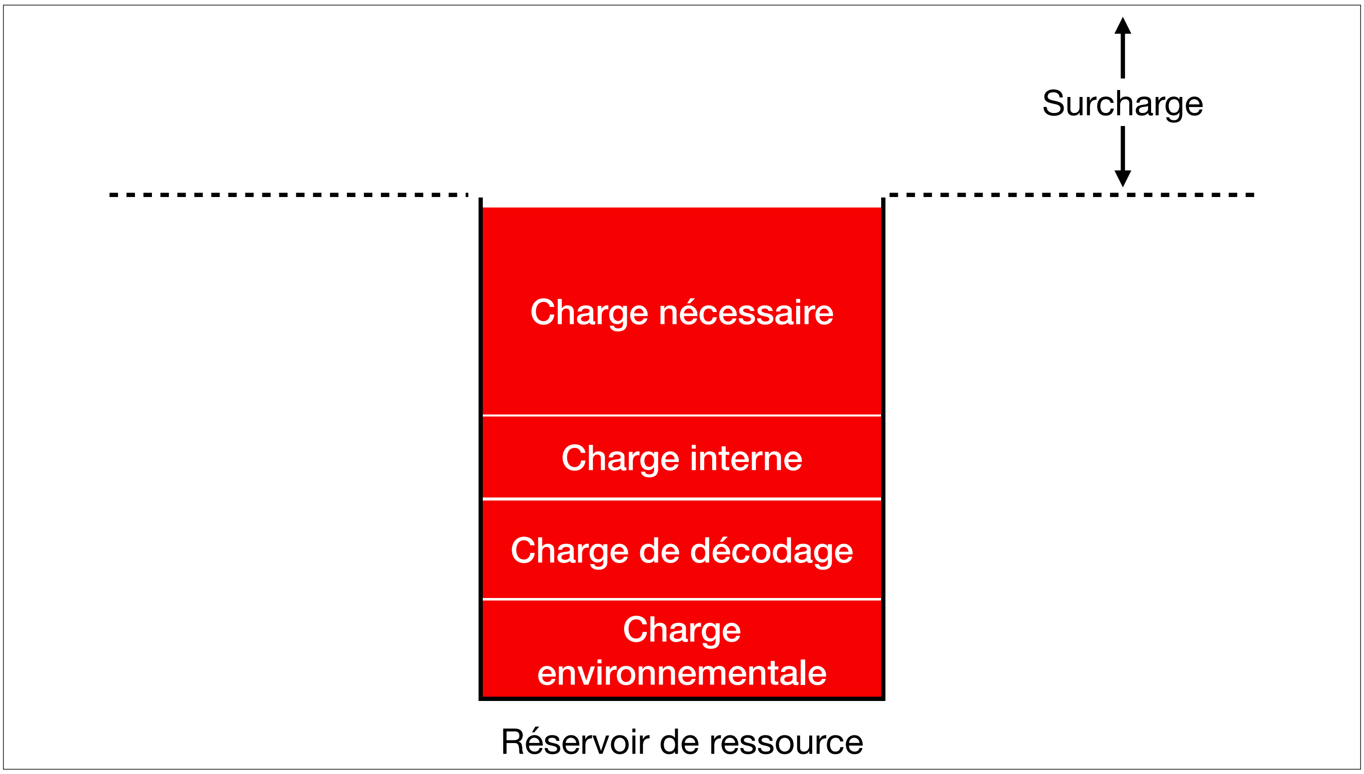
Qu'est-ce qui contribue à la charge ?

1. Charge **interne** : liée au niveau d'**expertise**
2. Charge **de décodage** : liée aux modalités de **présentation**
3. Charge **environnementale** : liée aux **distractions**
4. Charge **nécessaire** : liée au **contenu** à apprendre




Charge nécessaire
Charge interne
Charge de décodage
Charge
environnementale
Surcharge
Réservoir de ressource

19


Surcharge
Charge nécessaire
Charge interne
Charge de décodage
Charge
environnementale
Réservoir de ressource

20

Il faut :

charge **interne** ↓ + charge **de décodage** ↓ + charge **environnementale** ↓

—> charge **nécessaire**

Partie 2

Comment réduire le risque de surcharge ?

Principe 1
Automatiser les préalables
(diminue la charge interne)

Principe 1
Automatiser les préalables
(diminue la charge interne)

Comment ?

Étape 1
Identifier les préalables

Comprendre un texte

Exemple

↓
Comprendre les liens entre les mots
↓
Connaître le sens de chacun des mots
↓
Décoder les mots du texte
↓
Décoder un mot
↓
Connaître les correspondances graphèmes-phonèmes

↙ Savoir distinguer les différents phonèmes
↓
Savoir qu'un mot est formé d'une séquence phonèmes
↓
Savoir qu'un mot est formé de phonèmes

↘ Savoir reconnaître les différents graphèmes
↓
Savoir reconnaître les lettres
↓
Savoir qu'un mot est formé de lettres

Principe 1
Automatiser les préalables

Comment ?

Étape 1 – Identifier les préalables → **Étape 2** – Vérifier si les préalables sont acquis et automatisés → **Étape 3** – Acquérir et automatiser les préalables qui ne le sont pas

Principe 1
Automatiser les préalables

Pour réduire la charge cognitive interne

Comment ?

Stratégie 1
Activer les préalables à plusieurs reprises

Stratégie 2
Entraîner la récupération en mémoire des préalables

Stratégie 3
Élaborer des explications liées aux préalables

Stratégie 4
Espacer l'activation des préalables

Principe 2

Optimiser les modalités de présentation

(diminue la charge de décodage)

Principe 2

Optimiser les modalités de présentation

(diminue la charge de décodage)

Comment ?

Stratégie 1

Catégoriser l'information

Étude de **Bor et al.**

Encoding Strategies Dissociate Prefrontal Activity from Working Memory Demand

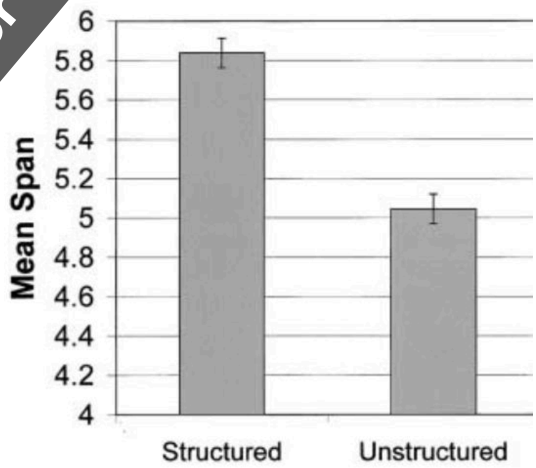
Daniel Bor, John Duncan, Richard J. Wiseman, and Adrian M. Owen

Medical Research Council Cognition and Brain Sciences Unit
15 Chaucer Road
Cambridge CB2 2EF
United Kingdom
Department of Psychology
University of Hertfordshire
Hatfield
United Kingdom
Wolfson Brain Imaging Centre
University of Cambridge
Cambridge
United Kingdom

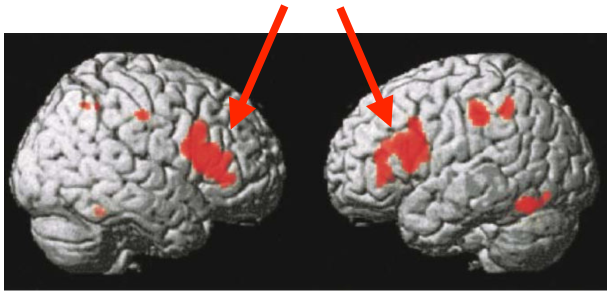
Summary

Effet de la **structuration** sur la surcharge cérébrale

Étude de Bor et al.

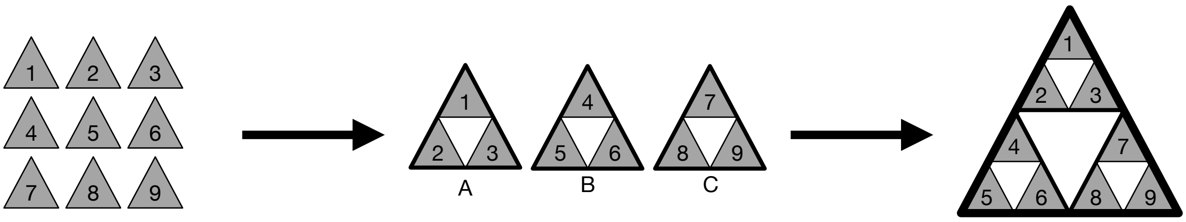


Cortex préfrontal non surchargé



Structuré >
non structuré

Quand l'information est structurée,
le cortex préfrontal s'active davantage (**pas de surcharge** de la mémoire de travail).



9 éléments

3 éléments

1 élément

11 éléments: 1 | 5 | 1 | 4 | 9 | 8 | 7 | 3 | 0 | 0 | 0

4 éléments: 1 | 514 | 987 | 3000

1 → Canada

514 → Montréal

987 → UQAM

3000 → Poste spécifique

33

Principe 2
Optimiser les modalités de présentation

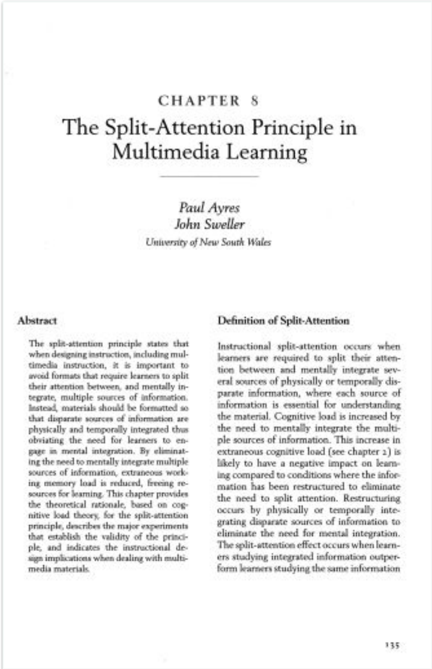
Comment ?

Stratégie 1
Catégoriser l’information

Stratégie 2
Rassembler l’information

34

Étude de Ayres et Sweller



CHAPTER 8

The Split-Attention Principle in Multimedia Learning

Paul Ayres
John Sweller
University of New South Wales

Abstract

The split-attention principle states that when designing instruction, including multimedia instruction, it is important to avoid formats that require learners to split their attention between, and mentally integrate, multiple sources of information. Instead, materials should be formatted so that disparate sources of information are physically and temporally integrated thus obviating the need for learners to engage in mental integration. By eliminating the need to mentally integrate multiple sources of information, extraneous working memory load is reduced, freeing resources for learning. This chapter provides the theoretical rationale, based on cognitive load theory, for the split-attention principle, describes the major experiments that establish the validity of the principle, and indicates the instructional design implications when dealing with multimedia materials.

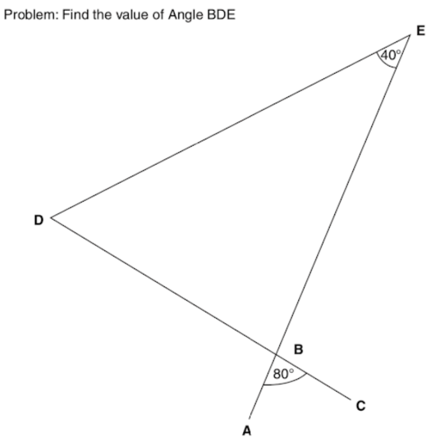
Definition of Split-Attention

Instructional split-attention occurs when learners are required to split their attention between and mentally integrate several sources of physically or temporally disparate information, where each source of information is essential for understanding the material. Cognitive load is increased by the need to mentally integrate the multiple sources of information. This increase in extraneous cognitive load (see chapter 2) is likely to have a negative impact on learning compared to conditions where the information has been restructured to eliminate the need to split attention. Restructuring occurs by physically or temporally integrating disparate sources of information to eliminate the need for mental integration. The split-attention effect occurs when learners studying integrated information outperform learners studying the same information

Synthèse sur l'**attention partagée**

Étude de Ayres et Sweller

A



Solution
∠DBE=80 (Vertically opposite angles)
∠BDE+40+80=180 (Angle sum of a triangle)
∠BDE+120=180
∠BDE=60

Figure 8.1. *Split-attention format.*

B

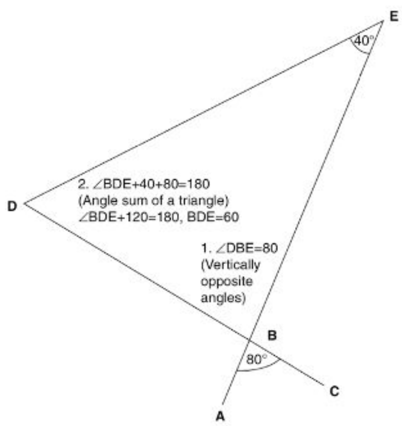


Figure 8.2. *Integrated format.*

Principe 2
Optimiser les modalités de présentation

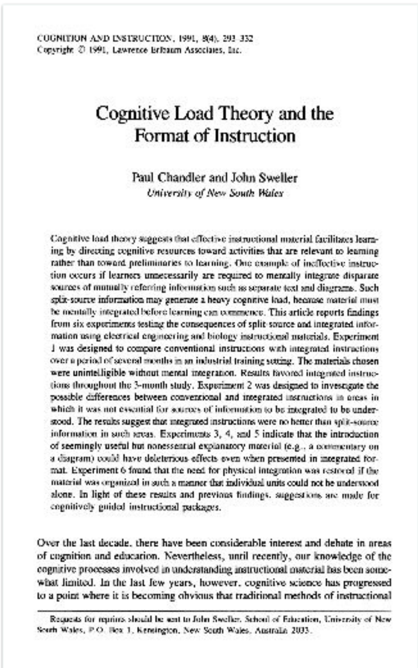
Comment ?

Stratégie 1
Catégoriser l'information

Stratégie 2
Rassembler l'information

Stratégie 3
Éviter la redondance

Étude de Chandler et Sweller



COGNITION AND INSTRUCTION, 1991, 8(4), 293–332

Cognitive Load Theory and the Format of Instruction

Paul Chandler and John Sweller
University of New South Wales

Cognitive load theory suggests that effective instructional material facilitates learning by directing cognitive resources toward activities that are relevant to learning rather than toward preliminaries to learning. One example of ineffective instruction occurs if learners unnecessarily are required to mentally integrate disparate sources of mutually referring information such as separate text and diagrams. Such split-source information may generate a heavy cognitive load, because material must be mentally integrated before learning can commence. This article reports findings from six experiments testing the consequences of split-source and integrated information using electrical engineering and biology instructional materials. Experiment 1 was designed to compare conventional instructions with integrated instructions over a period of several months in an industrial training setting. The materials chosen were unintelligible without mental integration. Results favored integrated instructions throughout the 3-month study. Experiment 2 was designed to investigate the possible differences between conventional and integrated instructions in areas in which it was not essential for sources of information to be integrated to be understood. The results suggest that integrated instructions were no better than split-source information in such areas. Experiments 3, 4, and 5 indicate that the introduction of seemingly useful but nonessential explanatory material (e.g., a commentary on a diagram) could have deleterious effects even when presented in integrated format. Experiment 6 found that the need for physical integration was restored if the material was organized in such a manner that individual units could not be understood alone. In light of these results and previous findings, suggestions are made for cognitively guided instructional packages.

Over the last decade, there have been considerable interest and debate in areas of cognition and education. Nevertheless, until recently, our knowledge of the cognitive processes involved in understanding instructional material has been somewhat limited. In the last few years, however, cognitive science has progressed to a point where it is becoming obvious that traditional methods of instructional

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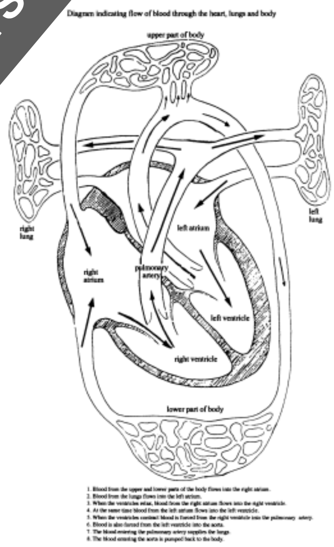
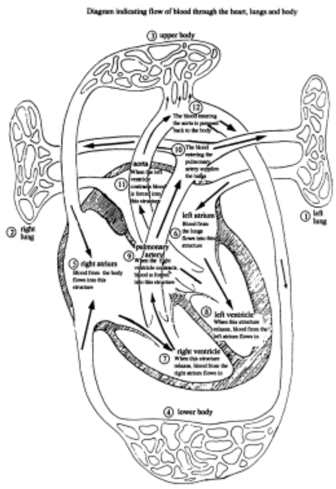
Effets de la **redondance** de l'information

Étude de Chandler et Sweller



A



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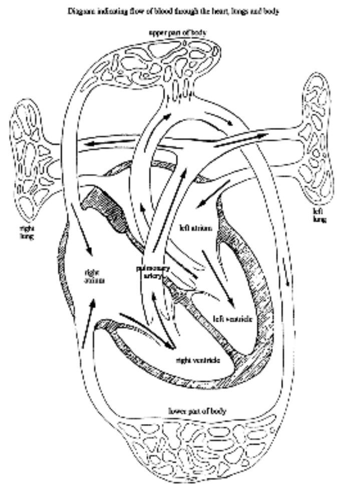


C

Étude de Chandler et Sweller

Diagramme seulement (C)

Redondant (B)

Redondante + attention partagée (A)

Instruction Times (in Seconds) and Test Scores on the Problems of Experiment 5

Group	*Instruction Time*	*Problem* 1	2	3	4	5	6
Diagram only							
M	69.1	5.3	4.9	3.7	3.5	14.9	1.8
SD	12.0	1.2	1.5	2.1	2.8	1.4	1.5
Modified							
M	105.7	4.5	2.8	1.7	1.4	7.8	0.9
SD	9.6	1.2	2.4	1.6	2.1	4.5	1.1
Conventional							
M	158.8	3.5	1.7	0.8	1.1	7.6	0.9
SD	38.5	1.2	1.3	0.8	1.5	4.1	0.9

Diagramme seulement = plus **efficace** et plus **rapide**

Principe 3

Réduire les distractions

(diminue la charge environnementale)

Principe 3

Réduire les distractions

(diminue la charge environnementale)

Comment ?

~~Bruit~~
~~Conversation~~
~~Musique~~
~~Décoration~~

Stratégie 1
Réduire les distractions sonores et visuelles

Stratégie 2
Réduire les distractions technologiques + multitâche

~~Téléphone~~
~~Médias sociaux~~
~~Multitâche~~

~~Anxiété~~
Meilleure préparation aux examens
Méditation

Stratégie 3
Favoriser le bien-être

youtube.com/stevemasson

43

Principe 4

Complexifier progressivement

(assure que la charge nécessaire n'est ni trop grande ni trop faible)

44

Il faut :

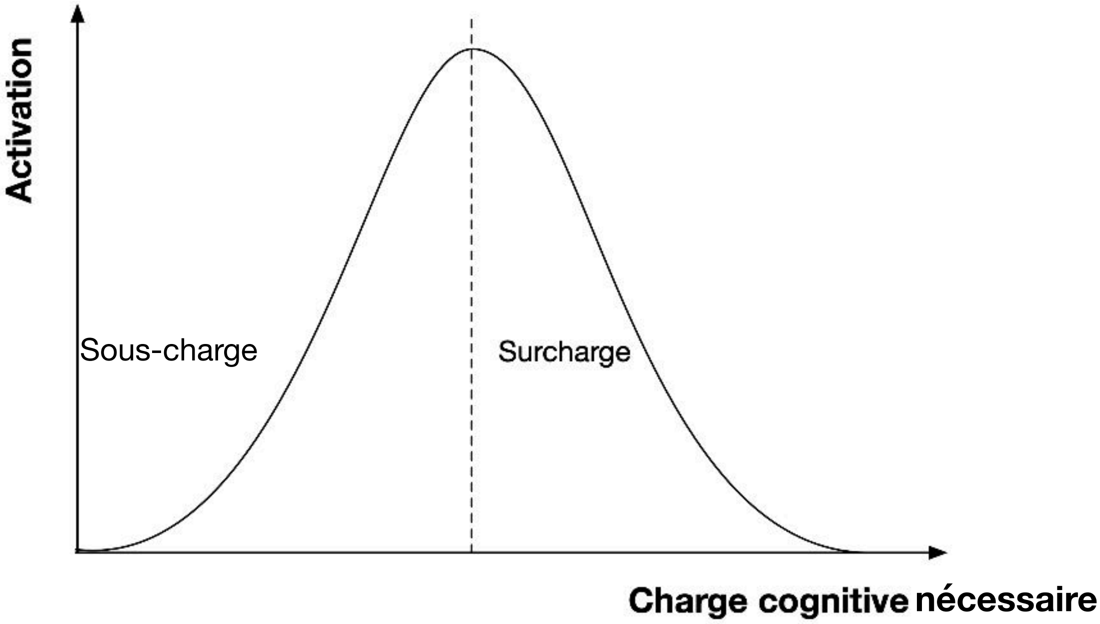
charge **interne** ↓ + charge **de décodage** ↓ + charge **environnementale** ↓

—> charge **nécessaire** pour apprendre

Principe 4

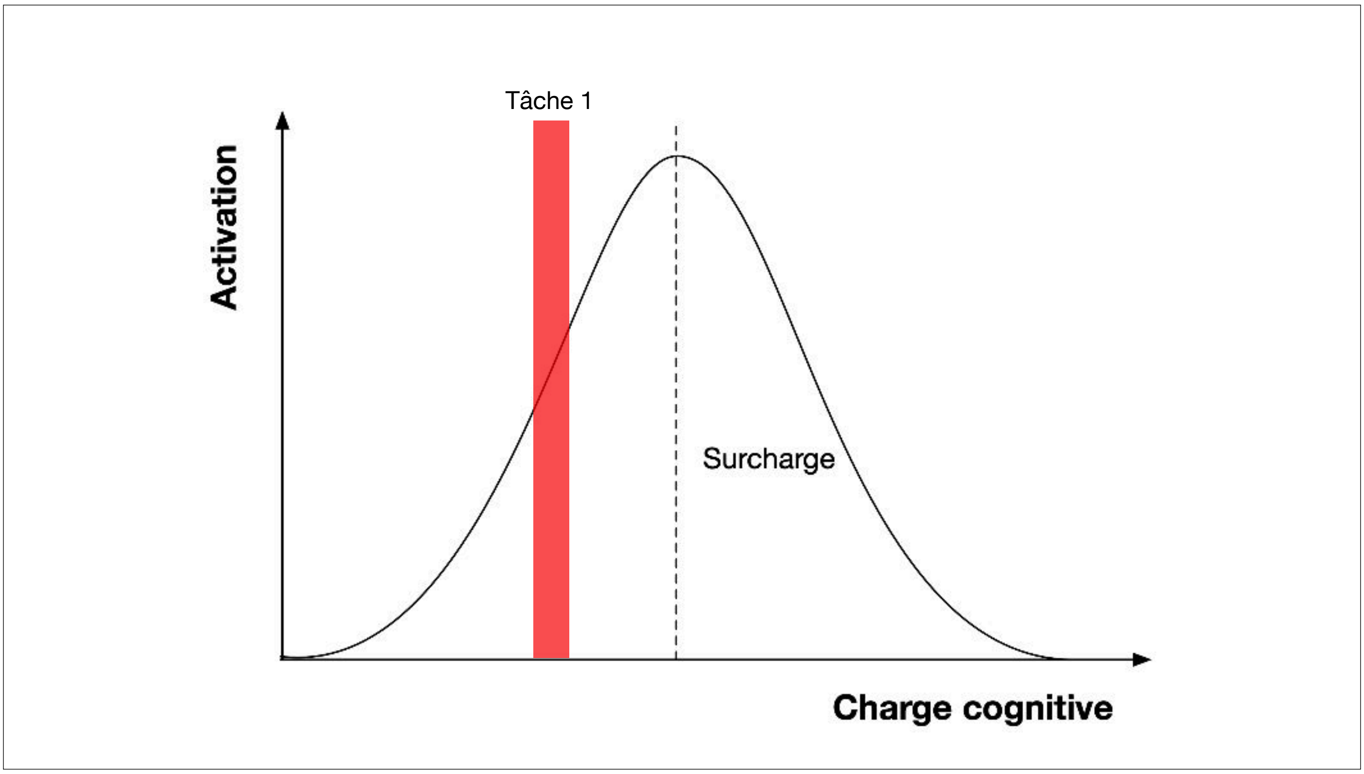
Complexifier progressivement

(assure que la charge nécessaire n’est ni trop grande ni trop faible)

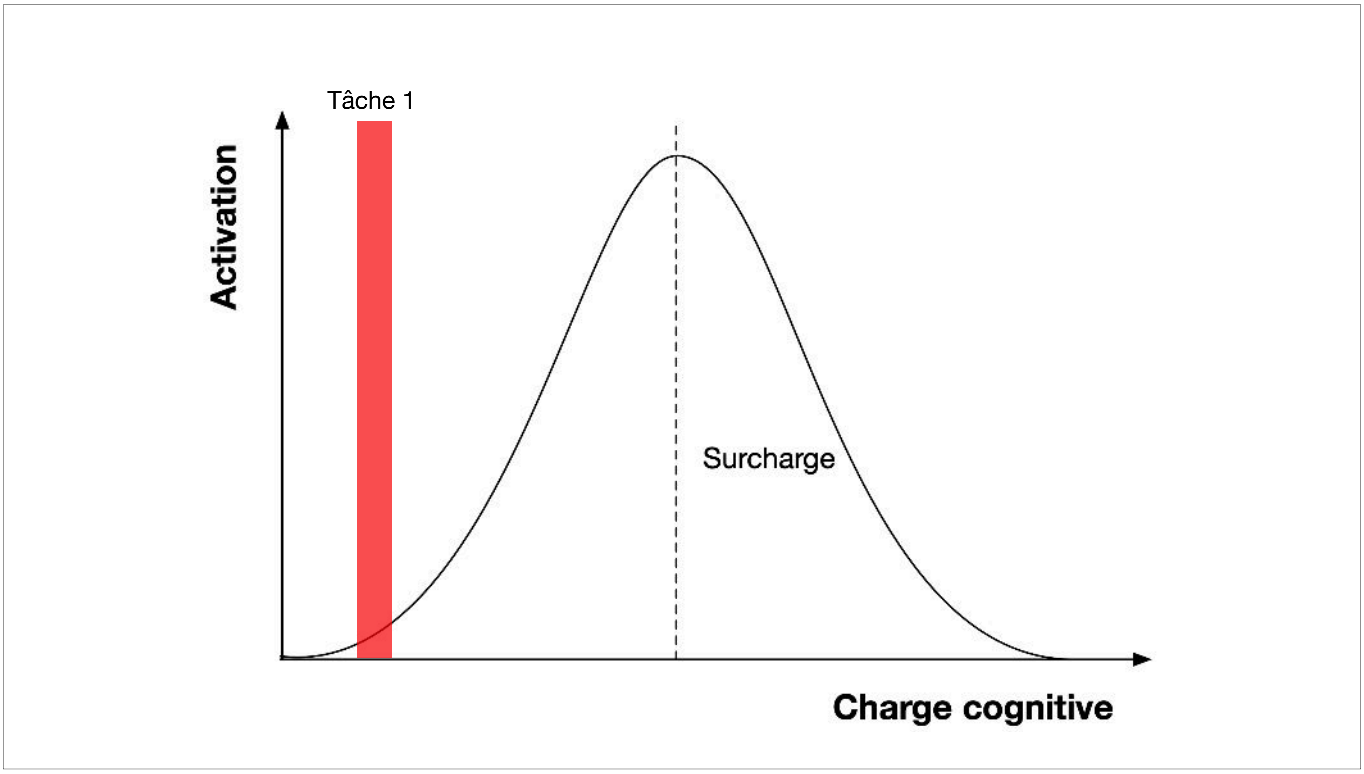


La charge d’une tâche dépend du **niveau d’expertise.**

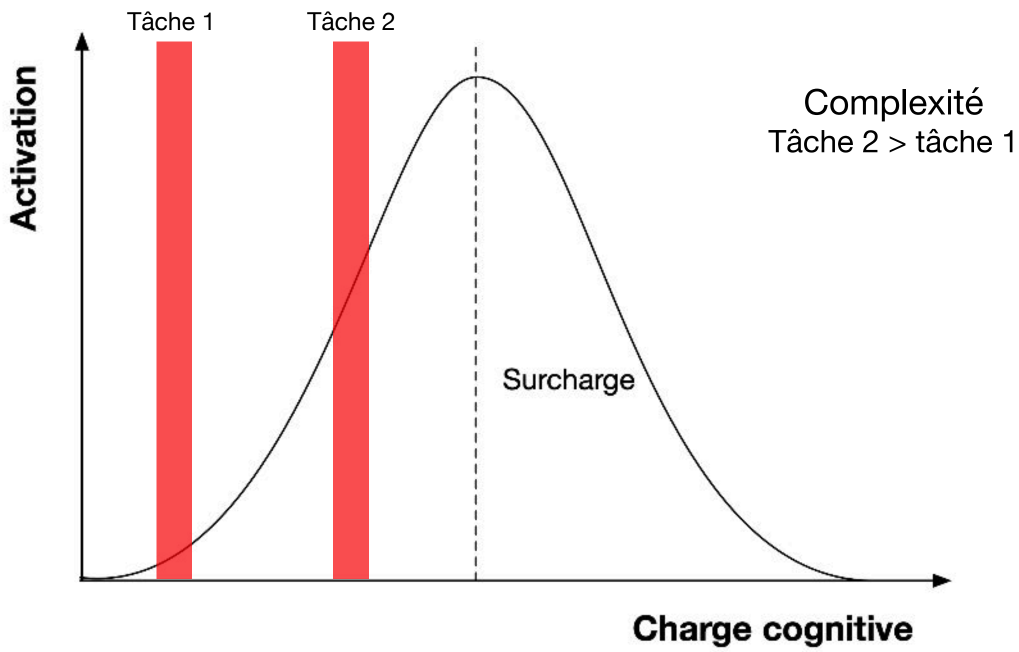
La charge d’une tâche **se déplace** donc au cours de l’apprentissage.


Tâche 1
Activation
Surcharge
Charge cognitive

49


Tâche 1
Activation
Surcharge
Charge cognitive

50



Il faut constamment **adapter** les tâches en fonction du niveau d'**expertise** des apprenants.

Complexité ni trop grande ni trop faible

Principe 4

Complexifier progressivement

(assure que la charge nécessaire n'est ni trop grande ni trop faible)

Comment ?

Stratégie 1

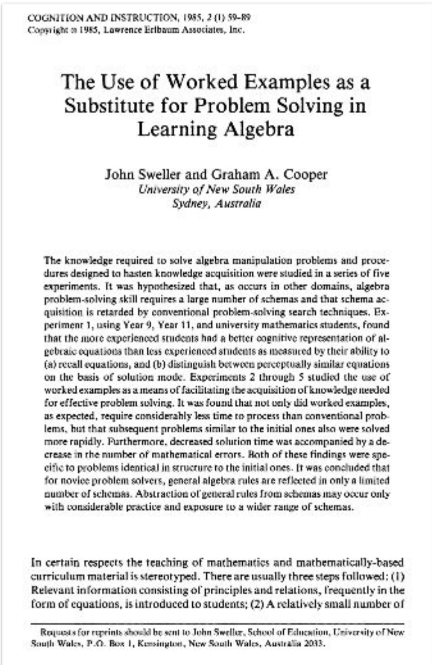
Complexifier progressivement les tâches

Stratégie 2

Fournir un exemple de solution

Étude de

Sweller et Cooper



COGNITION AND INSTRUCTION, 1985, 2 (1) 59–89

The Use of Worked Examples as a Substitute for Problem Solving in Learning Algebra

John Sweller and Graham A. Cooper
University of New South Wales
Sydney, Australia

The knowledge required to solve algebra manipulation problems and procedures designed to hasten knowledge acquisition were studied in a series of five experiments. It was hypothesized that, as occurs in other domains, algebra problem-solving skill requires a large number of schemas and that schema acquisition is retarded by conventional problem-solving search techniques. Experiment 1, using Year 9, Year 11, and university mathematics students, found that the more experienced students had a better cognitive representation of algebraic equations than less experienced students as measured by their ability to (a) recall equations, and (b) distinguish between perceptually similar equations on the basis of solution mode. Experiments 2 through 5 studied the use of worked examples as a means of facilitating the acquisition of knowledge needed for effective problem solving. It was found that not only did worked examples, as expected, require considerably less time to process than conventional problems, but that subsequent problems similar to the initial ones also were solved more rapidly. Furthermore, decreased solution time was accompanied by a decrease in the number of mathematical errors. Both of these findings were specific to problems identical in structure to the initial ones. It was concluded that for novice problem solvers, general algebra rules are reflected in only a limited number of schemas. Abstraction of general rules from schemas may occur only with considerable practice and exposure to a wider range of schemas.

In certain respects the teaching of mathematics and mathematically-based curriculum material is stereotyped. There are usually three steps followed: (1) Relevant information consisting of principles and relations, frequently in the form of equations, is introduced to students; (2) A relatively small number of

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Effets de fournir un **exemple de solution**

Étude de Sweller et Cooper

Meilleure séquence ?

Exemple → Problème → Test

Problème → Problème → Test

Exemple = charge ↓

Étude de Sweller et Cooper

Mean Seconds and Errors Per Problem on Initial and Repeat Problem Presentation During Acquisition, and on Test Problems in Experiment 3

	Acquisition		
Group	*Initial Presentation*	*Repeat Presentation*	*Test*
Worked Example	32.0 (–)	53.2 (0.45)	43.6 (0.18)
Conventional Problem	185.5 (2.73)	59.5 (0.36)	78.1 (1.64)

Note: Mean errors appear in parentheses.

Moins d'erreurs et **plus rapide** si exemple de solution avant

Principe 4

Complexifier progressivement

(assure que la charge nécessaire n'est ni trop grande ni trop faible)

Comment ?

Stratégie 1
Complexifier progressivement les tâches

Stratégie 2
Fournir un exemple de solution

Stratégie 3
Diminuer progressivement la guidage

Étude de **Van Merr. et al.**

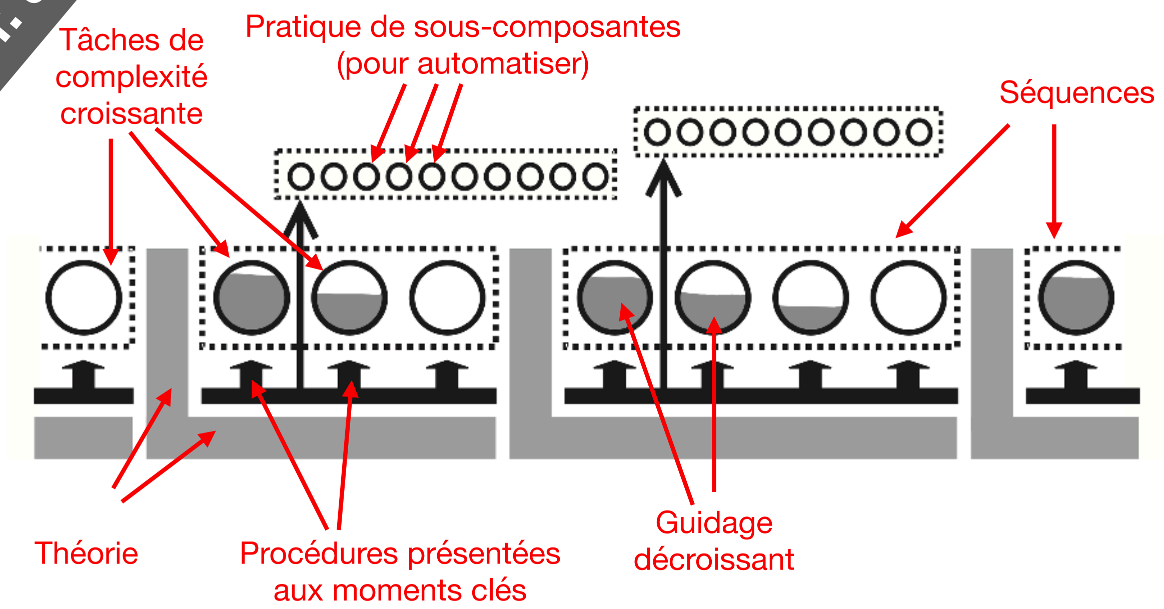
Taking the Load Off a Learner's Mind:
Instructional Design for Complex Learning

Jeroen J. G. van Merriënboer, Paul A. Kirschner, and Liesbeth Kester

Educational Technology Expertise Center
Open University of The Netherlands, Heerlen

Modèle d'enseignement prenant en compte les limites de la **mémoire de travail**

Étude de Van Merr. et al.



Synthèse

Principe 1 Automatiser les préalables	**Charge interne ↓** Identifier, vérifier et automatiser les préalables
Principe 2 Optimiser les modalités de présentation	**Charge de décodage ↓** Catégoriser Rassembler l’information Éviter la redondance
Principe 3 Réduire les distractions	**Charge environnementale ↓** Réduire les distractions sonores, visuelles, technologiques, etc.
Principe 4 Complexifier progressivement	**Charge nécessaire optimisée**