Lisbon University

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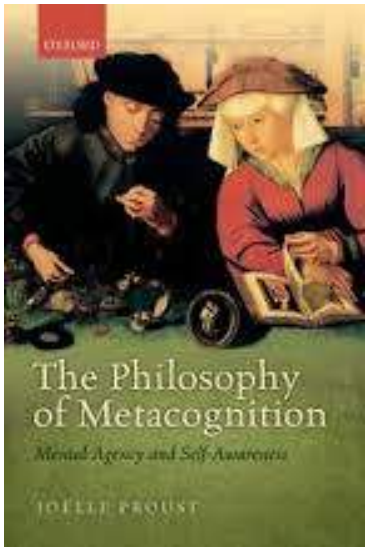
INTERSELF PROJECT

JOËLLE PROUST

PENSER VITE OU PENSER BIEN ?

Odile Jacob

METACOMPREHENSION ON SCREEN



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Institut | Nicod

CNRS L'ECOLE DES HAUTES ETUDES EN SCIENCES SOCIALES ENS

- The INTERSELF project means to explore the contrast between social interactions betwixt human versus humans and artificial Agents, and their impact on our sense of self and self-identity.

- This presentation will concentrate not on the issue of how these interactions affect self-identity, but on how they affect **self-evaluation**, in particular the **phenomenology of metacomprehension**

Metacomprehension

= the ability to evaluate how well one understands (an utterance, an interaction between others, a natural phenomenon, etc).

Awareness of this evaluation occurs through a specific **feeling for understanding**

- **well** (crystal clear!)
- **partially** (not so clear !)
- **not at all** (fully obscure!)

Metacognitive studies have recently studied illusions of metacomprehension based on medium: on whether the target content is presented on paper or on screen.

Outline

1. Comprehension and metacomprehension on screen/on paper: comparative evidence
2. Explaining the screen effect: the role of metacognition
3. Impulsive, routine, and strategic cognitive actions
4. Implications for digital processing
5. Conclusion: relevance to the INTERSELF project.

1 - Comprehension and metacomprehension on-screen and on-paper

"The screen effect"

- Screens have been a major source of access to contents of all kinds in the past 20 years.

- Yet reading on screen has been found to have a detrimental effect on reading comprehension, problem solving and learning

Delgado et al. 2018, Duncan, McGeown, Griffiths, Stothard, & Dobai, 2015, Pfost, Dörfler, & Artelt, 2013.

What is the effect of computers on learning and understanding?

The use of screens at school, at work or at home varies on a number of parameters:

- **goals:** communicating, learning, gaming, photo sharing, movie watching
- **types of media:** (computers, tablets, i-phones
- **software**: classic reading in word or pdf,
- **hypertext** (with or without)
- **fixed or "adaptive"** software (e.g. flexible task selection)

The screen effect in short

- Reading **on paper** allows students to better understand what they are reading **than on screen** especially in two cases:

- For **expository texts** (with disciplinary content) -- **not for narrative texts** (Clinton, 2019; Delgado et al., 2018)

- when reading time is set in advance -- but also when it is freely chosen (Delgado et al., 2018).

The screen effect

- Most adult readers prefer to read **important** material in a paper format rather than on a screen.
- Most children prefer to read on screen. (Dahan Golan, Barzillai, & Katzir, 2018 ; Huang, Liang, Su, & Chen, 2012).

- Why?

Two plausible hypotheses

1. **An adaptive cognitive habit?**

   Given their early experience with technology, children may achieve equivalent or even better levels of comprehension on screen than on paper (Chen, Cheng, Chang, Zheng, & Huang, 2014; Delgado et al., 2018).

2. **Superficial processing?**

   The screen experience leads children to process information on the screen more quickly and superficially, which impairs their reading comprehension. (Duncan, McGeown, Griffiths, Stothard, & Dobai, 2016; Pfost, Dorfler, & Artelt, 2013),

The second hypothesis is the most plausible

- **Evidence: Comprehension test (answering questions about reading)**

- **Children prefer to read texts on the screen but**

- **They understand texts read on paper better**

Cf. meta-analysis by Delgado et al, (2018), Dahan, Golan et al. (2018)

Evidence collected on primary school children

A study by Halamish et Elbaz (2020) on grade 5 school children (10 yr-old)

- Explores the **effect of the reading medium** used on comprehension and metacomprehension

- Its objective is to know if this effect is determined by
  - The preference for a medium,
  - the frequency of reading on screen
  - the level of reading skill.

Question 1 : Wat is the effect of medium on children's reading comprehension?

- Reading on paper allows for better comprehension
- This better comprehension is achieved without an increase in reading time compared to reading on a screen.
- Same results for Dahan Golan et al., 2018)

Question 2: Effect of medium on children's meta-comprehension of reading?

- Although comprehension on paper is better than on screen

- Metacomprehension judgments are insensitive to this effect

→ School children (like adults) are not aware that they learn/understand what they read on screen less well than on paper.

Question 3: Do children prefer to read on paper or on screen ? Does this preference change after reading and taking a comprehension test on both media?

- **Before** the test, students said they preferred to read on screen

- **After** the comparison test, students **did not indicate** a preference for either medium in the future

Question 4: Does the effect of medium on reading comprehension and metacomprehension depend on children's preferred medium?

Regardless of their prior media preference, participants are equally

- cognitively impaired by screen-reading,
- metacognitively insensitive to the screen effect

Question 5: Is the effect of the medium on reading comprehension and meta-comprehension related to *how often* children use computers?

- Frequency of computer use has no effect on screen reading comprehension and metacomprehension

Question 6: Does the effect of the medium on reading comprehension and metacomprehension depend on children's reading skills?

The effect of the medium is not correlated with individual students'

- reading speed
- reading comprehension

Meta-analysis by Delgado et al.(2018): comparing screen impact

The impact of screens on comprehension is more significant:

- for computers than for cell phones,
- for digital texts that require scrolling.

These differences are **not** modulated by:

- Age group (or education level),
- Text length,
- type of comprehension assessed
- Possibility offered to re-read the text before answering test questions

2. Metacognition explains the screen effect

Explaining the screen effect

What explains the differences in cognitive performance between reading on screen versus on paper is self-regulation, ie. metacognition.

Ackerman & Goldsmith, 2011
de Bruin, Thiede, Camp, & Redford, 2011

Explaining the screen effect

This can be shown by contrasting two conditions:

When reading duration is pre-set

When reading duration is left to self-regulation (i.e. self-determined).

Predicted performance (dark gray) and observed performance (light gray) on screen and on paper by students when study time is fixed (left) or when it is self-regulated (right)

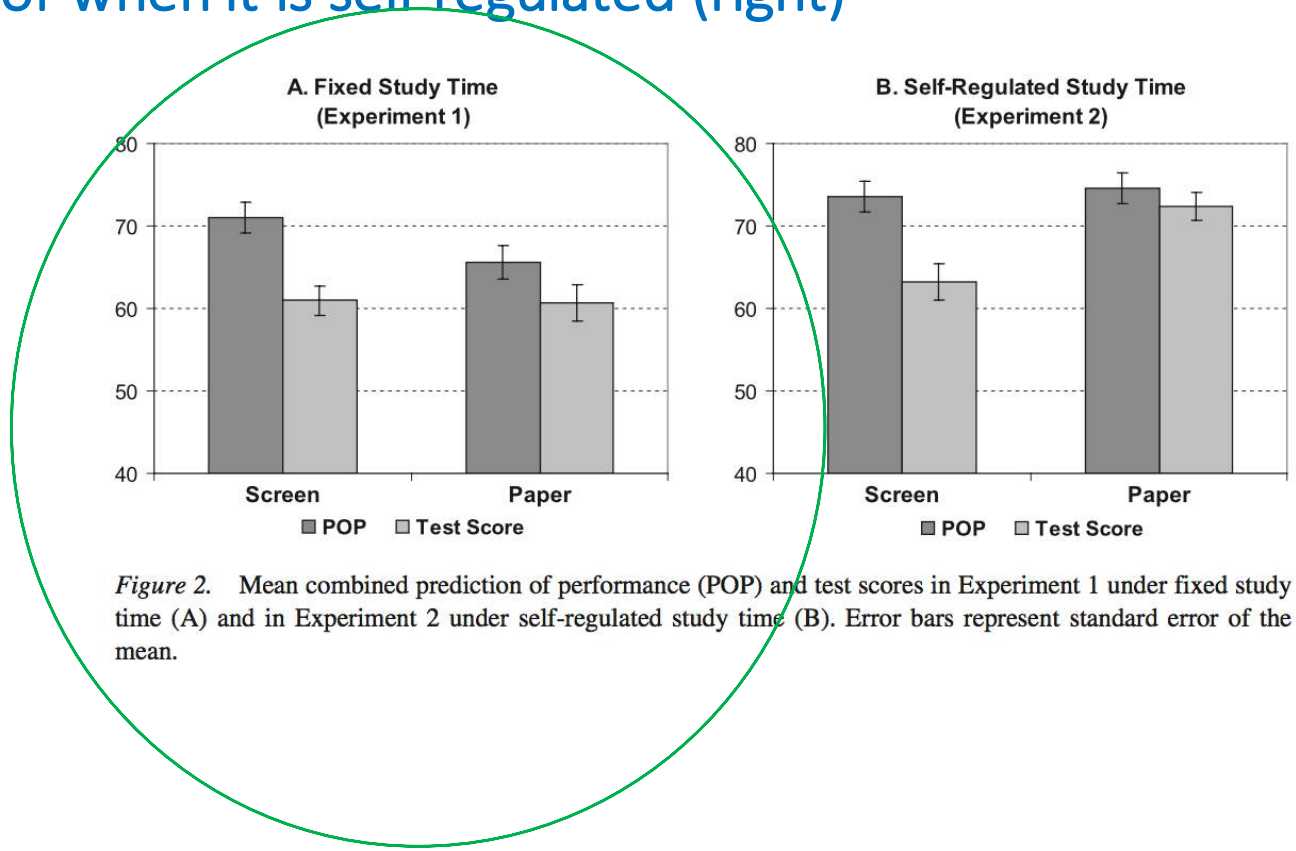


Figure 2. Mean combined prediction of performance (POP) and test scores in Experiment 1 under fixed study time (A) and in Experiment 2 under self-regulated study time (B). Error bars represent standard error of the mean.

- **Data in A: When the time to be spent studying is fixed, students' prediction of success is slightly overconfident, but the performance is the same on screen and on paper.**

Ackerman & Goldsmith (2011)

Predicted performance (dark gray) and observed performance (light gray) on screen and on paper by students when study time is fixed (left) or when it is self-regulated (right)

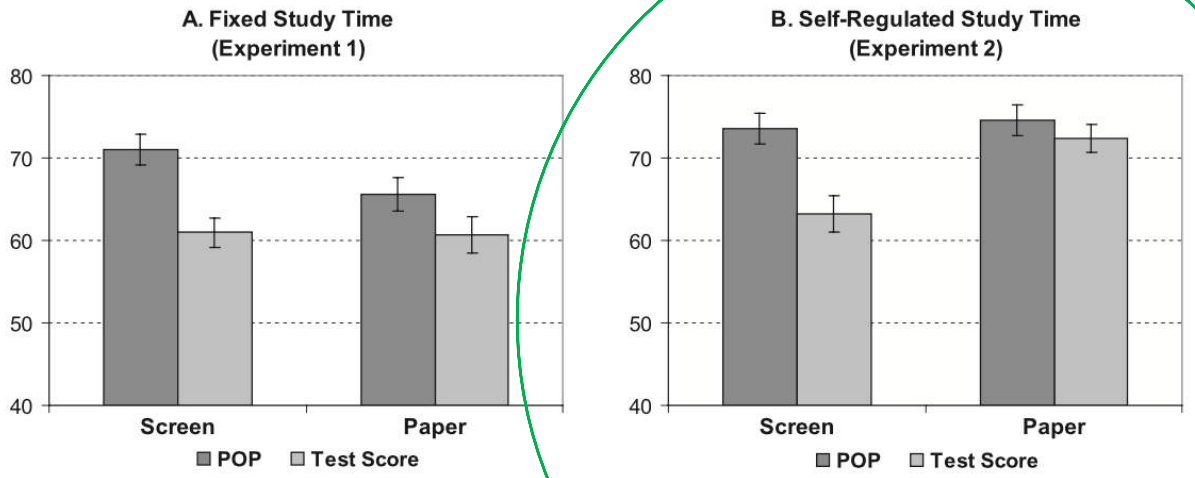


Figure 2. Mean combined prediction of performance (POP) and test scores in Experiment 1 under fixed study time (A) and in Experiment 2 under self-regulated study time (B). Error bars represent standard error of the mean.

- **Data in B: When time spent studying is self-regulated, the prediction of success is overconfident on screen, which explains lower observed performance**

PROCESSING DEPTH modulates METACOGNITION

Readers tend to process information more superficially on screen than on paper.

As a result, on screen, metacognitive assessments are **overconfident**, which results in

- Poor self-regulation of cognitive effort,
- Absence of awareness of inadequate reading depth
- poorer performance

Annisette & Lafrenière, 2017
Lauterman & Ackerman, 2014
Sidi et al., 2017.

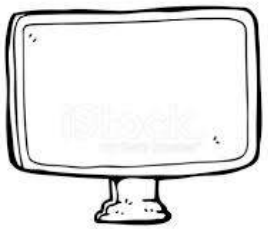
Why do screens invite superficial processing?

From shallow to deep reading: 4 steps

1. **Decoding:** from graphemes or phonemes to word identification
2. **Lexical recognition:** recovering the meaning of words
3. **Recovering the meaning of the sentence** from the particular combination of words (including pronouns, demonstratives, etc.)
4. **Simulation of the situation expressed by the sentence, based on the background knowledge and text content already processed.**

McNamara, Kintsch, Songer, 1996

From shallow to deep reading



1

Grapheme decoding

2

Lexical processing

Evaluation

I know this word

3

Constructing sentence meaning

Evaluation

I understand this sentence

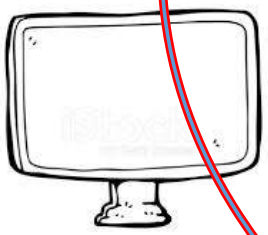
4

Simulation of the situation described in the sentence

Evaluation

I understand what the situation is like

From shallow to deep reading



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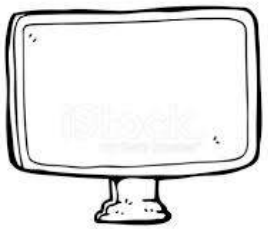
Two feelings of comprehension

- If no errors are encountered, and if the reading progress is normal, as early as stage 3, the reader has **a feeling of understanding** the meaning of the sentence, based on his knowledge of the language.

- But step 4 is decisive for concept use, learning and reasoning

From shallow to deep reading



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Hypothesis: Shallow thinking is ENCOURAGED on screen

- Invitations to "like" a Facebook post, a video on youtube, a restaurant on Tripadivisor, etc. are meant to trigger **impulsive cognitive actions**

Proust (2021) *Penser vite ou penser bien ?* Odile Jacob

- The fast-paced interactions with immediate rewards of digital reading **make it more difficult** to engage in tasks requiring sustained attention, such as deep reading.

Annisette & Lafrenière, (2017), meta-analysis Delgado et al (2018).

Shallow versus conceptual **goals**

- **Impulsive processing** generates superficial attention and fluency-based monitoring: hence metacomprehension stops at level 3

- **Strategic processing** generates sustained conceptual attention and relevance-based monitoring until level 4 is fully processed.

Proust, (2015). Time and action: Impulsivity, habit, strategy? *The Review of Philosophy and Psychology*

Hypothesis: Attention "superficialized"

- The more digital medias are used in impulsive, reactive ways, the less able their users are to use it to perform challenging tasks.

- This may explain the disturbing decline in text comprehension among adolescents (Duncan et al., 2015; Pfost et al., 2013)

Why is metacomprehension fooled?

When we really understand a statement, we are usually aware that we understand it.

But when we don't really understand a statement, we can still believe that we understand it**.**

- To explain that a similar feeling of understanding may be experienced **at two different processing steps,** we need to analyse the underlying cognitive actions.

3. Impulsive, routine, and strategic cognitive actions

The trade-off of attention modes in cognitive actions

- The hypothesis is that agents select their cognitive goals as a function of a contextual trade-off.
- An organism should only be motivated to act when **the resources** used in order to attain its goal are not likely to exceed, all things considered, **the gain** likely to result from acting **(probabilistic benefit-cost ratio).**

  E.G.: is it worth trying to get food or water when there is a high probability of being killed in this process?

The trade-off of attention targets time response

- The anticipated gain
- The resources made available to reach it

are both a matter of respecting a temporal window.

Kahneman, 2012, Proust, 2015

Constitutive role of time in the trade-offs shaping action systems (Proust, 2015)

- **fast-moving** objects & **unexpected** risks & opportunities: **impulsive action system**
- **recurrent** needs: **habitual or routine action system**
- Planning long-term future changes: **strategic action system**

Each trade off uses adaptive representations and processes

Each action is triggered by an intention i.e. a representation enabling its selection and guidance

- Goal representations and action guidance differ across systems.

Impulsive actions

- **"impulsivity" = what Frijda (1986) calls "control precedence**"
- Examples : running away, shouting when watching a game, ducking to avoid a projectile etc.
- In agentive thinking:
  - Taking a second look (perceptual reactivity)
  - Trying to remember (memorial reactivity)
  - Correcting a word
  - conspiracy or cheater detection-based processing

Empirical evidence for a specialized system for impulsive reactings

- Impulsive actions involve activation of a ventral system, including the amygdala, insula, ventral striatum, and ventral regions of the anterior cingulate gyrus and prefrontal cortex:
  - Phillips et al (2003).
  - Bechara ,Damasio & Damasio 2000
  - LeDoux & Phelps (2006)

Routine actions

- Performed when an agent deals with habitual, recurrent situations, such as driving, preparing food.
- Cognitive examples: checking up a bill, trying to remember a fact, a date, comparing restaurants on internet.
- Control precedence: controlled "here and now" by recurrent cue-based action-programs and model-free feedback.

- **Automatic and shortsighted**

Empirical evidence for an habitual " model-free" action system

- Habits are acquired through **extensive experience** by a process of model-free reinforcement learning

- Unlike goal- directed, model-based control, habitual control **cannot**
  - direct action selection according to new outcome utilities
  - Be sensitive **to outcome reevaluations.**

Daw et al. (2005), Niv, Joel and Dayan (2006)
Jog et al., (1999)

Strategic actions

- The ability to coordinate one's thoughts and actions in relation to a goal to be attained in the future, independently of present or later solicitations
- is the mode of action selected for high-stake goals in more complex, uncertain, but still relatively predictable environments
- Is performed and guided as a consequence of a prior intention, often at a temporal distance from its initiating mental event.

Strategic action

E.g. planning to go to London at a given time for a specific purpose

- Strategic physical actions depend on planning (a strategic cognitive action).
- Other strategic cognitive actions:
  - Deliberating
  - Weighing evidence
  - demonstrating

Empirical evidence in favor of a system for "model-based" strategic action

- The agent uses a forward model to work out the ultimate outcomes consequent on his planned actions by searching through the tree of state-actions consequences, along with the current utilities of outcomes.

Doll, Simon, Daw (2012)

"In a model-based system, a cognitive map or model of the environment is acquired, which describes how different situations are connected to each other. Action values for different paths can then be computed by a sort of mental simulation

Gläscher, Daw, Dayan Doherty (2010)

Distinct neural signature for model-based strategic actions (LatPFC, FPC frontopolar prefrontal cortex)

How is deep metacomprehension "fooled"?

Because evaluation depends on the cognitive goal pursued:

- For an impulsive action, and for a routine action superficial evaluation **is functional.**
- For a strategic action, a superficial evaluation **fails to meet the goal requirements.**

- However, **the phenomenology of understanding** fails to reflect this difference:
- As long as **the agent is not** confronted to what she fails to understand, she will assume that she does !

4. Digital processing and collective actions

On screen cognitive activity

Automatically triggers reactive cognitive actions, depending on context:

- **Impulsive fluent goals** are involved in digital communication that primes different emotions as a function of
  - personal preferences
  - affiliative motivations etc.

- **Routine metafluent goals** consist in automatically activating reactive responses in recurrent collective contexts
  - in digital gaming, action movie-watching, sport events, unformal conversation
  - In an academic context: at school most students apply an effort heuristic that limits processing to "level one" (memory- efficient rather than reasoning-efficient).

Metafluency

- = Shared fluency at the group level, that reinforces social cohesiveness (Reber & Norenzayan, 2018)

- Metafluency **adds** **positive valence and attractivity to cognitive habits** that are shared by one's social group of reference in a certain context:
  - habit of impulsively giving one's opinion in social networks, under the influence of a shared bias of cognitive equality.

How to deepen comprehension and metacomprehension on screen ?

AS A RULE

- Because attention to digital content tends to be superficial, it is advised to **implement cognitive techniques** known to stimulate the deep attention of readers.
- Techniques can target:
  - **Duration**
  - **Cognitive load**
  - **Text contents and style**
  - **Self-checking exercises.**

Duration

- **Time-limited exercises** have a negative impact on
  - deep processing.
  - Metacomprehension

  - Allow readers to study documents on screen as long as they want

Sidi, Shpigelman, Zalmanov, & Ackerman. (2017). Understanding metacognitive inferiority on screen by exposing cues for depth of processing. *Learning and instruction*, *51*, 61-73.

Lauterman & Ackerman (2014)

Optimize cognitive load

To reduce the cognitive load *and* stimulate attention, it is necessary to propose reasoning exercises that are both

- Comparatively challenging
- Briefly expressed (the data to think about should fit on one screen page).

Goal and content style favorable to deep processing

- Before the task: the interest of the document to be studied (or watched, etc.) should be highlighted in a precise and detailed manner.
- Agents should be encouraged to express the cognitive goal have in performing a specific digital activity
- the document should not be too easy to read: leaving it to readers to "repair" missing connections encourages deep processing. (McNamara et al., 1996)
- The digital document should signal the importance of specific aspects in contents. (Sidi et al., 2017)

Self-checking on screen: exercises for students

At key steps in the activity: readers should be asked to

- **explain in their own words** the content read on screen.
- **write on paper** short summaries of a paragraph or section (copy/paste forbidden!)
- Choose **between two summaries**, or two diagrams, the one that better recaps a section in the text.
- At the end of the action, whenever possible: ask agents **to fill-in an incomplete**
  - **diagram,**
  - **conceptual map**, with the option of returning to the digital text.

Müller & Oppenheimer, (2014).

5. Conclusion

Implications regarding artificial quasi-agentive programs

- The INTERSELF project means to explore the contrast between social interactions Human-Human versus Human-Artificial Agents, and its impact on our sense of self and self-identity.

- This presentation defended that human cognitive agents tend to select **different goals** according a cost-benefit trade-off.

Our conclusions

- Cognitive goals always reflect a trade-off between resources and expected benefits.

- The default trade-off is biased to **routine impulsivity** in numerical matters, except when serious risks are associated with the activity (see tax report)

Consequences for collective agency

- Collective agency can be based on **impulsive, routine, or strategic** forms of interaction, whether cooperative or competitive.
- Social networking, which is known to include a number of digital quasi-agents, proximally relies on recipients' **impulsive goals** to achieve **strategic private goals:** influencing votes, good consumption, or enhancing one's own fame.
- Artificial chess players prime **strategic thinking**.
- Siri style artificial "agents" (search and control mechanisms) prime **routine cognitive agency** and enhance its metafluency.

The challenge for INTERSELF

- consists in associating AI-based communication technology **with strategic cognitive collective goals, able to elicit and enhance deep thinking**.
- **How is deep thinking connected to self-identity?** The answer is not obvious, because self-identity and related **affiliative** representations and goals tend to generate **emotion-based coalitions (i.e. impulsive group acceptances)**.
- **From the viewpoint of AI technology**, the challenge is to **resist recruiting** ever newer and more efficient ways of eliciting agents' impulsive decision-making, **at the expense of** the kind of collective strategic thinking required to ensure social equity and solve environmental problems.

Thank you for your attention !

This presentation is available for download on

http://joelleproust.org