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Impact et limites de l'apprentissage implicite

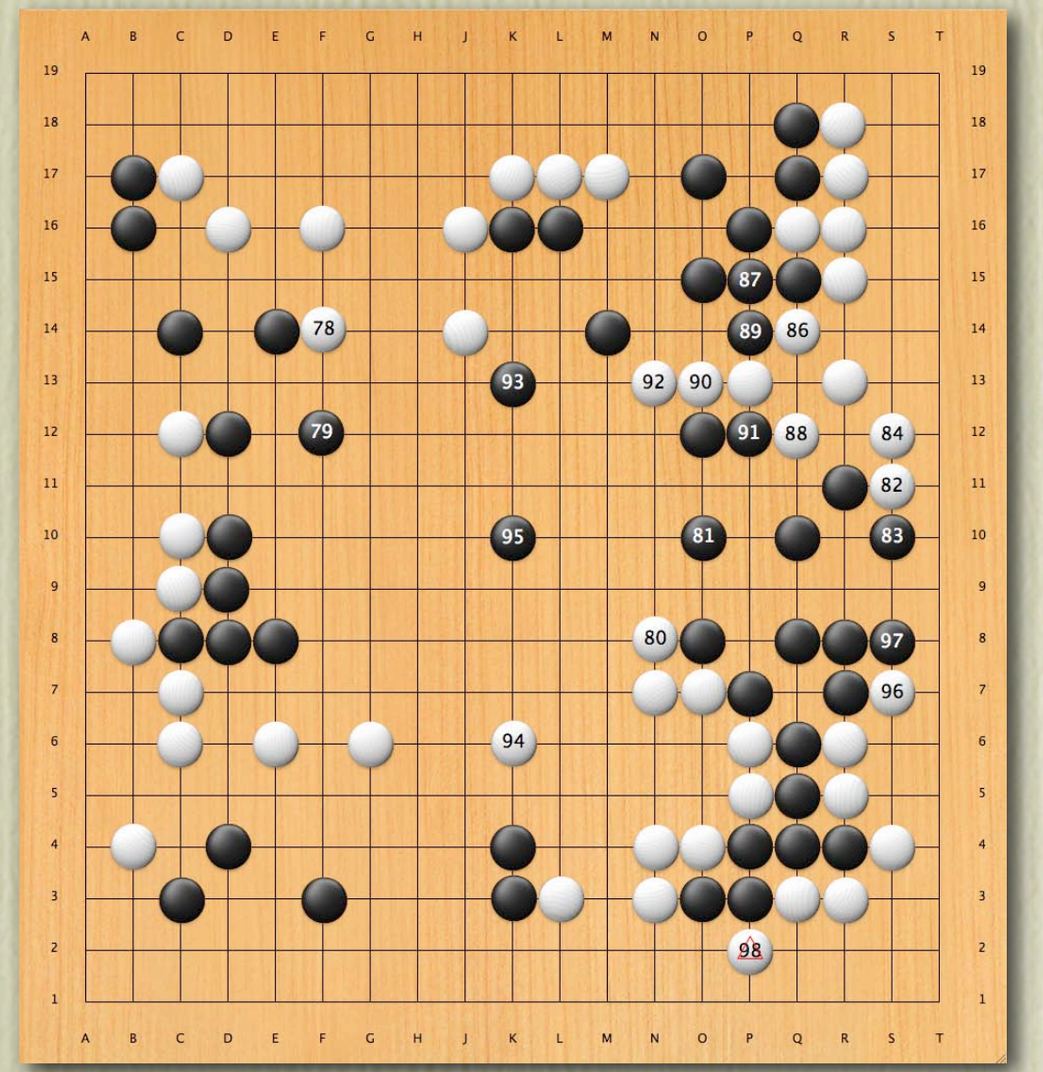
axel cleeremans

Consciousness, Cognition & Computation Group

What is shared?

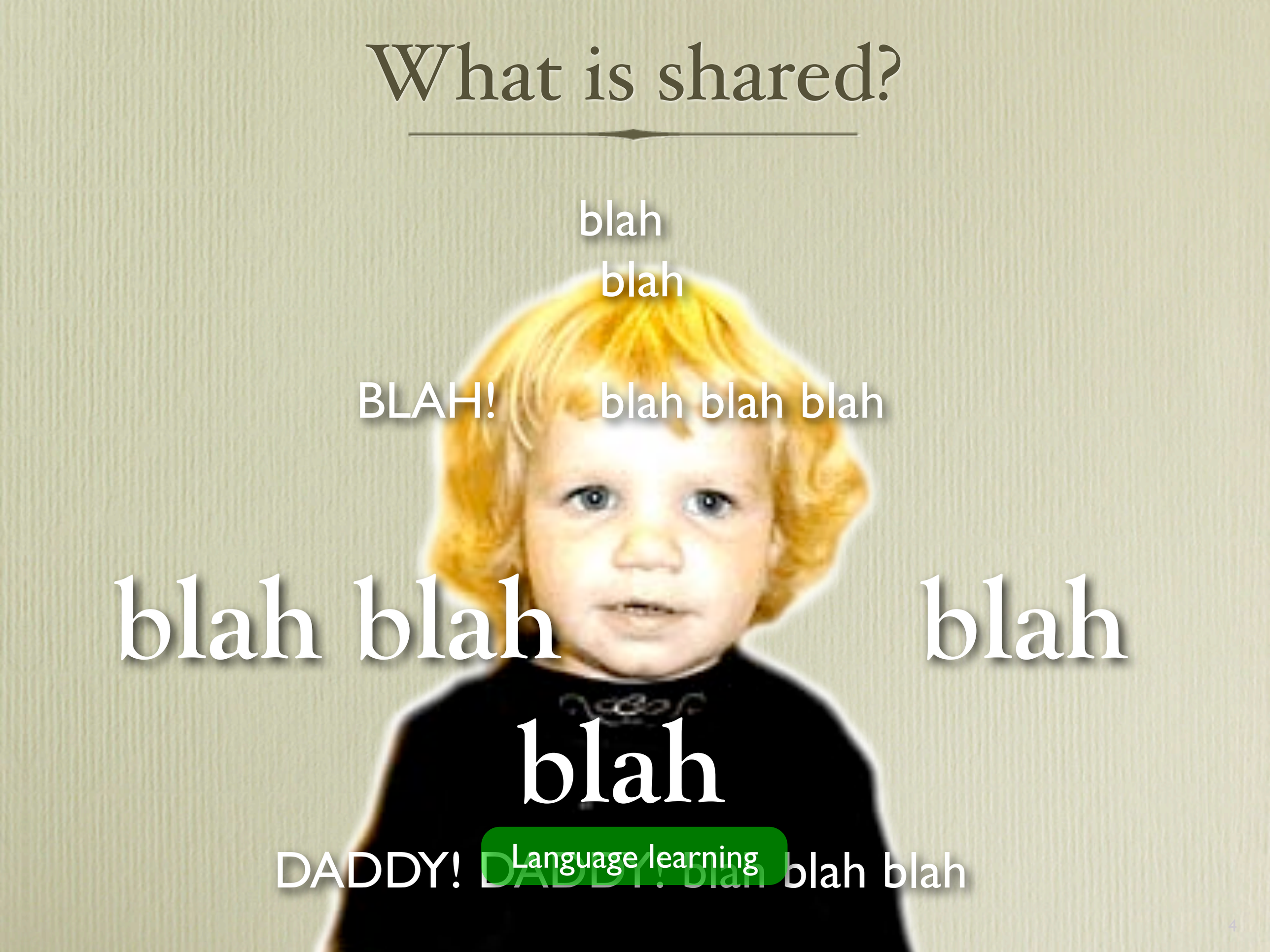
Athletic skills

What is shared?

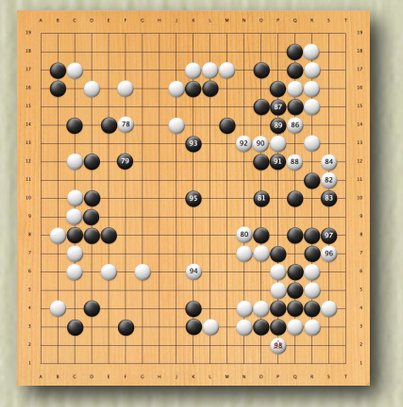


Game playing

What is shared?



Implicit knowledge



Many of the things we learn to do:

- are learned without intention,
- without verbalizable knowledge of what was learned,
- and sometimes without knowledge that we learned anything

IMPLICIT LEARNING:

A change in performance that is not accompanied by a corresponding change in the ability to describe the acquired knowledge

Memorize this!

TSSXS

TXXVPXVV

PTTVV

TXXVVPS

PTVPXVV

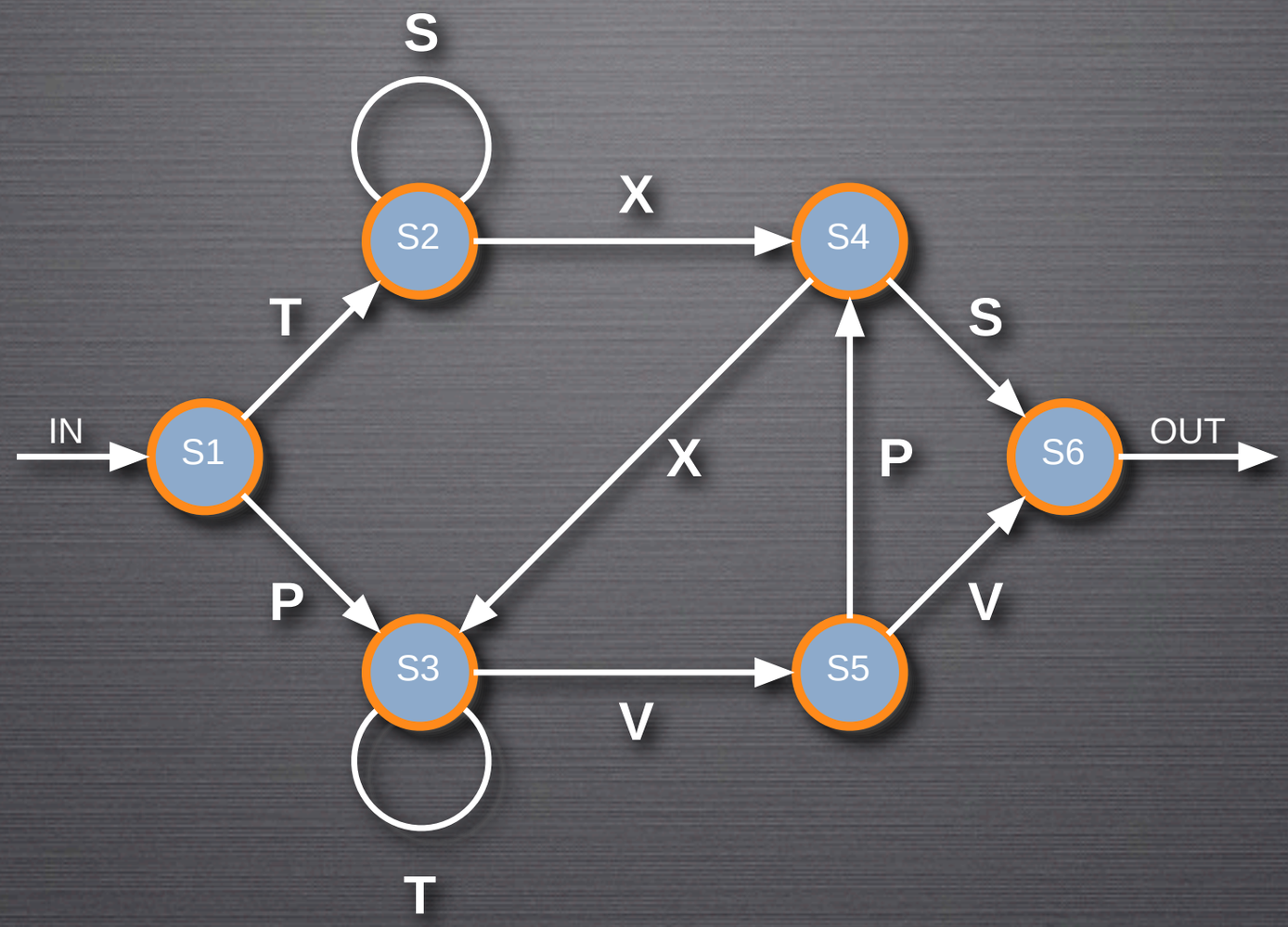
PTVPXVPS

Grammatical or Not?

TXXVPXVV	✔
PTTVVV	✘
VTVPXVV	✘
PVPS	✔
TXXTVV	✔
TVPSTX	✘

- All the strings you have seen have been generated according to specific grammar rules
- Now you have to decide, for each string, whether it is grammatical or not

Analyze that!



- Reber (1967) used this grammar in the first artificial grammar learning experiment
- The grammar is a simple finite-state automation: Strings of letters are generated by entering the grammar at node S1, moving from node to node and concatenating the labels of the traversed arcs until the end node is reached.

SEQUENCE LEARNING

© Pour La Science

Task is choice reaction

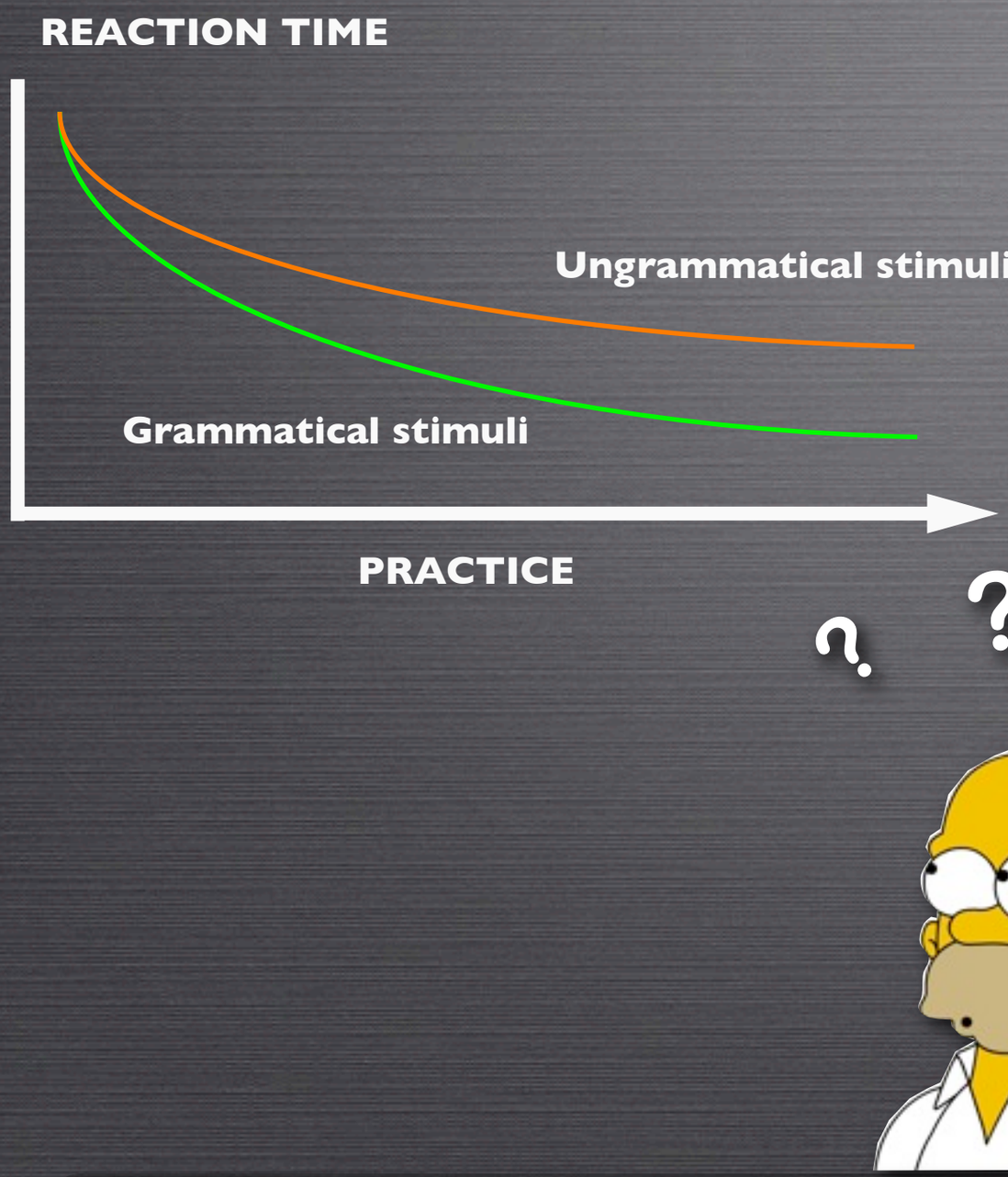
Unknown to subjects, stimuli follow a repeating sequence

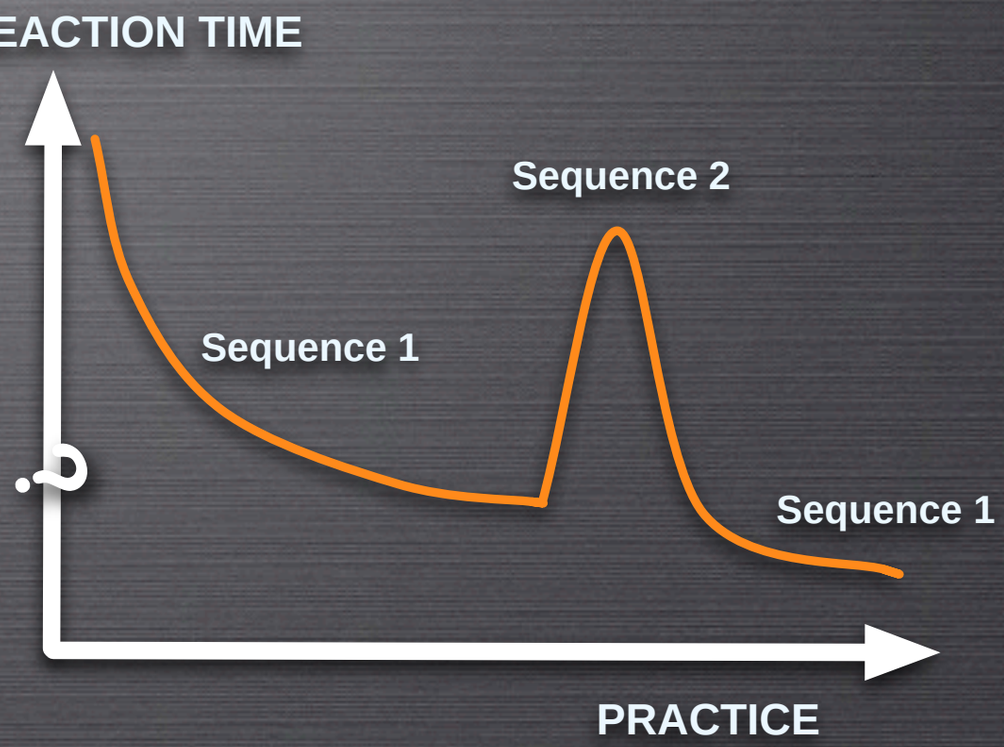
People exhibit sensitivity to the sequential structure in the absence of verbalizable knowledge about the sequence

342312143241 342312143241 ... (training)

341243142132 341243142132 ... (transfer)

Typical Results



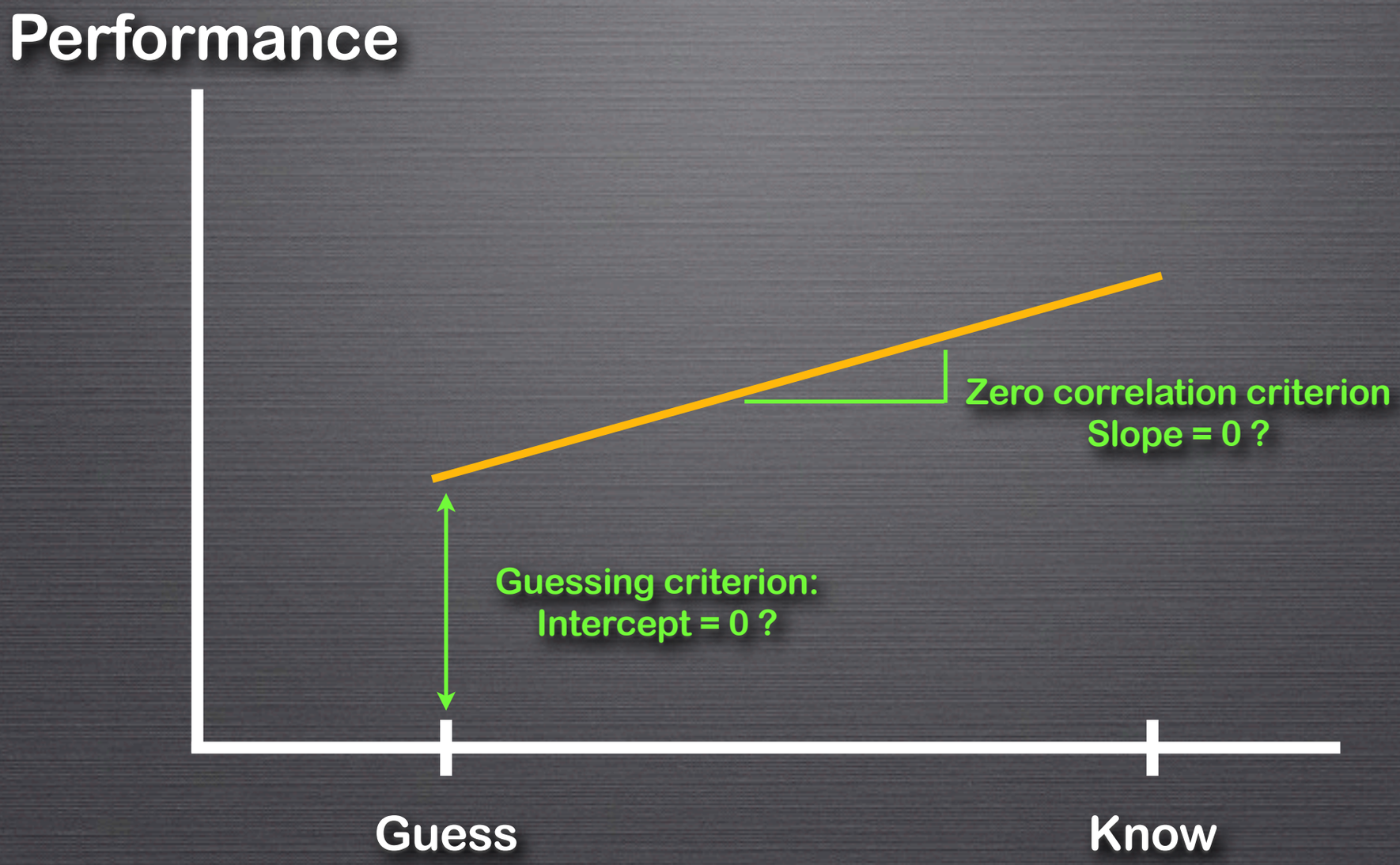


IMPLICIT LEARNING:

A change in performance that is not accompanied by a corresponding change in the ability to describe the acquired knowledge

Subjective measures

Z. Dienes



Confidence (or other measures of meta-knowledge)

Implicit learning

- Reber (1967 & 1989) :

  "The process by which knowledge about the rule-governed complexities of the stimulus environment are acquired independently of conscious attempts to do so."

- Lewicki (1987) :

  " [...] subjects are able to acquire specific procedural knowledge (i.e. processing rules) not only without being able to articulate what they have learned but even without being aware that they had learned anything."

- Perruchet & Vinter (1998):

  "The term implicit learning designates an adaptive mode in which subject's behavior is sensitive to the structural features of an experienced situation, without that adaptation being due to an intentional exploitation of subject's explicit knowledge about these features.

Psychological Review
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VOLUME 84 NUMBER 3 MAY 1977

Telling More Than We Can Know: Verbal Reports on Mental Processes

Richard E. Nisbett and Timothy DeCamp Wilson
University of Michigan

Evidence is reviewed which suggests that there may be little or no direct introspective access to higher order cognitive processes. Subjects are sometimes (a) unaware of the existence of a stimulus that importantly influenced a response, (b) unaware of the existence of the response, and (c) unaware that the stimulus has affected the response. It is proposed that when people attempt to report on their cognitive processes, that is, on the processes mediating the effects of a

biology letters

Biol. Lett. (2006) **2**, 412–414
doi:10.1098/rsbl.2006.0509
Published online 27 June 2006

Cues of being watched enhance cooperation in a real-world setting

Melissa Bateson*, Daniel Nettle and Gilbert Roberts

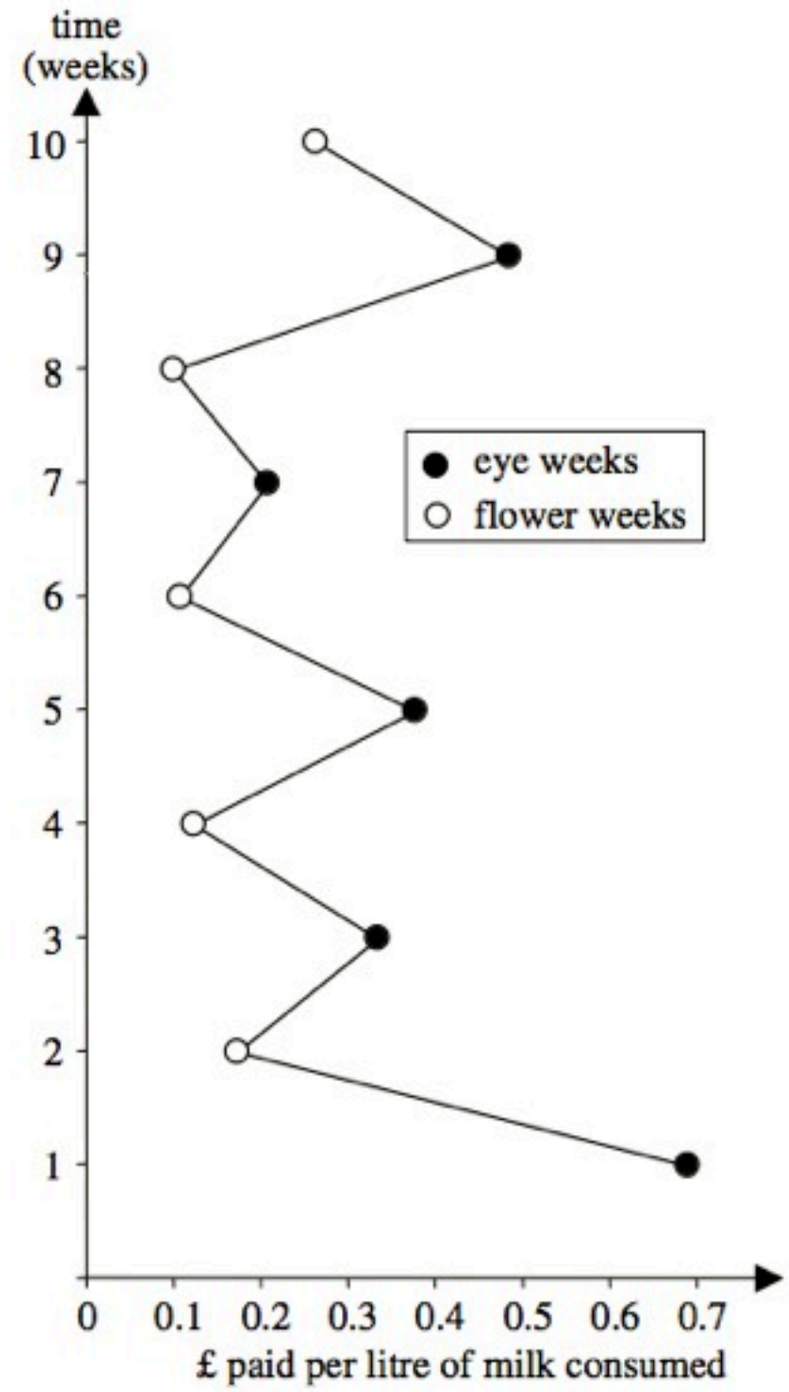
COFFEE CLUB

Prices:

Coffee (with or without milk): 50p
Tea (with or without milk): 30p
Milk only (in your own coffee or tea): 10p
Full cup of milk: 30p

Please put your money in the blue tin.

Thanks, Melissa

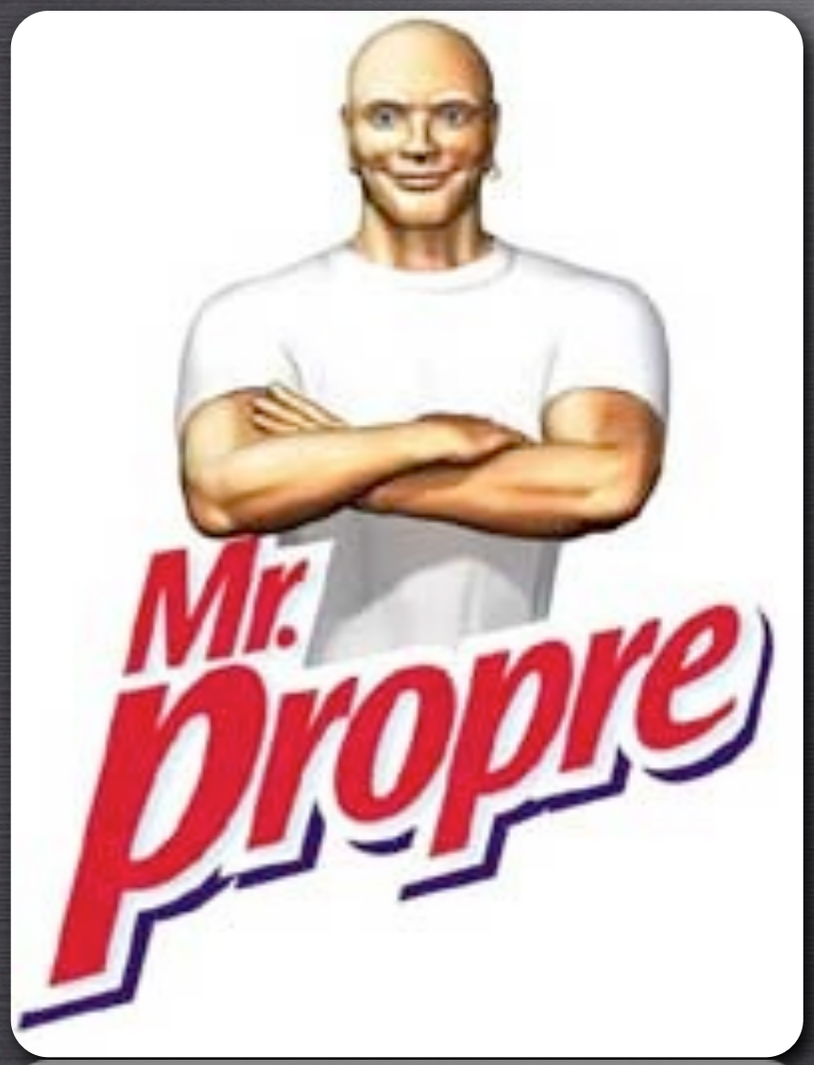


Research Report

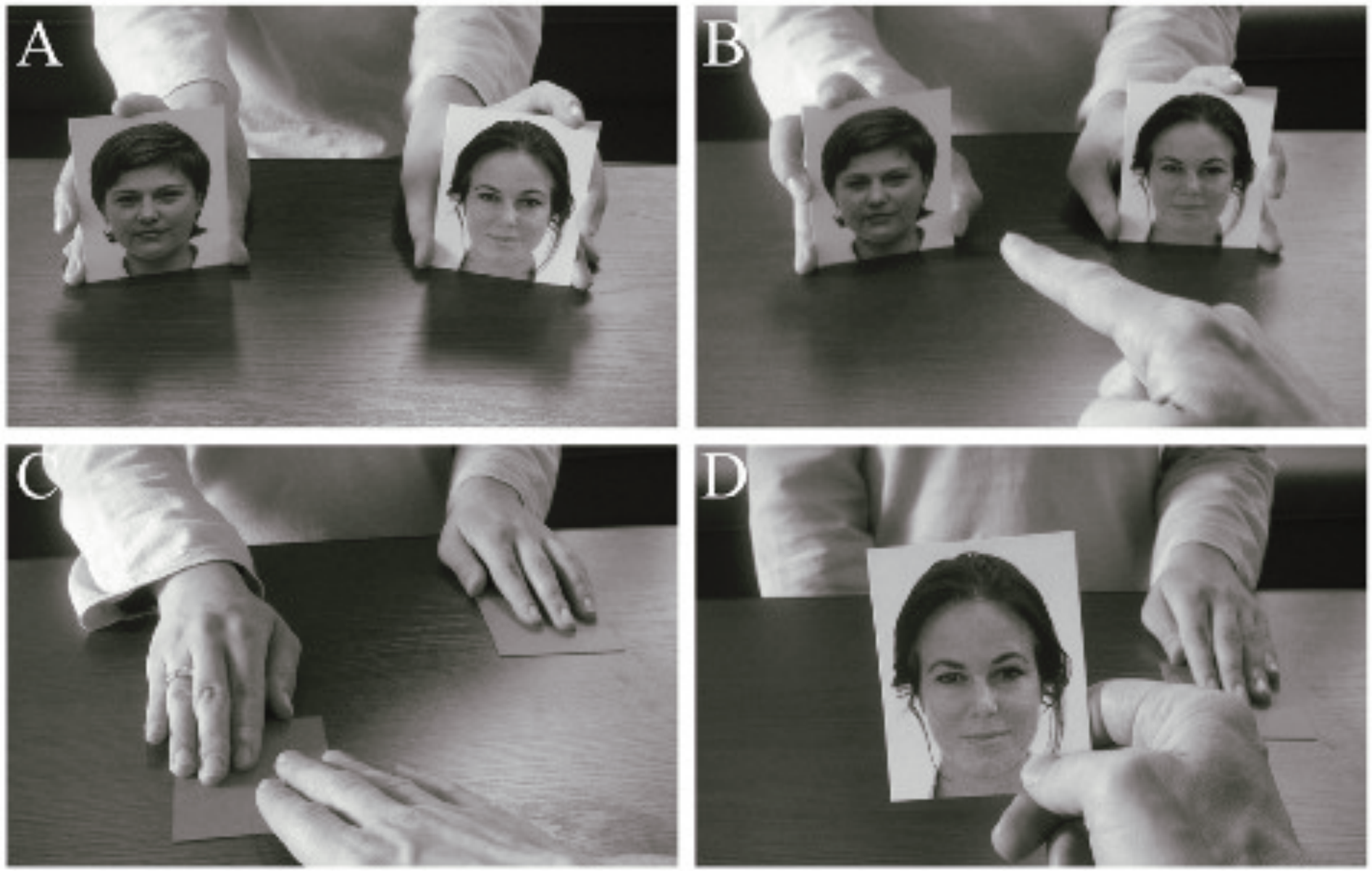
Smells Like Clean Spirit

Nonconscious Effects of Scent on Cognition and Behavior

Rob W. Holland,[1] Merel Hendriks,[1] and Henk Aarts[2]



Choice Blindness



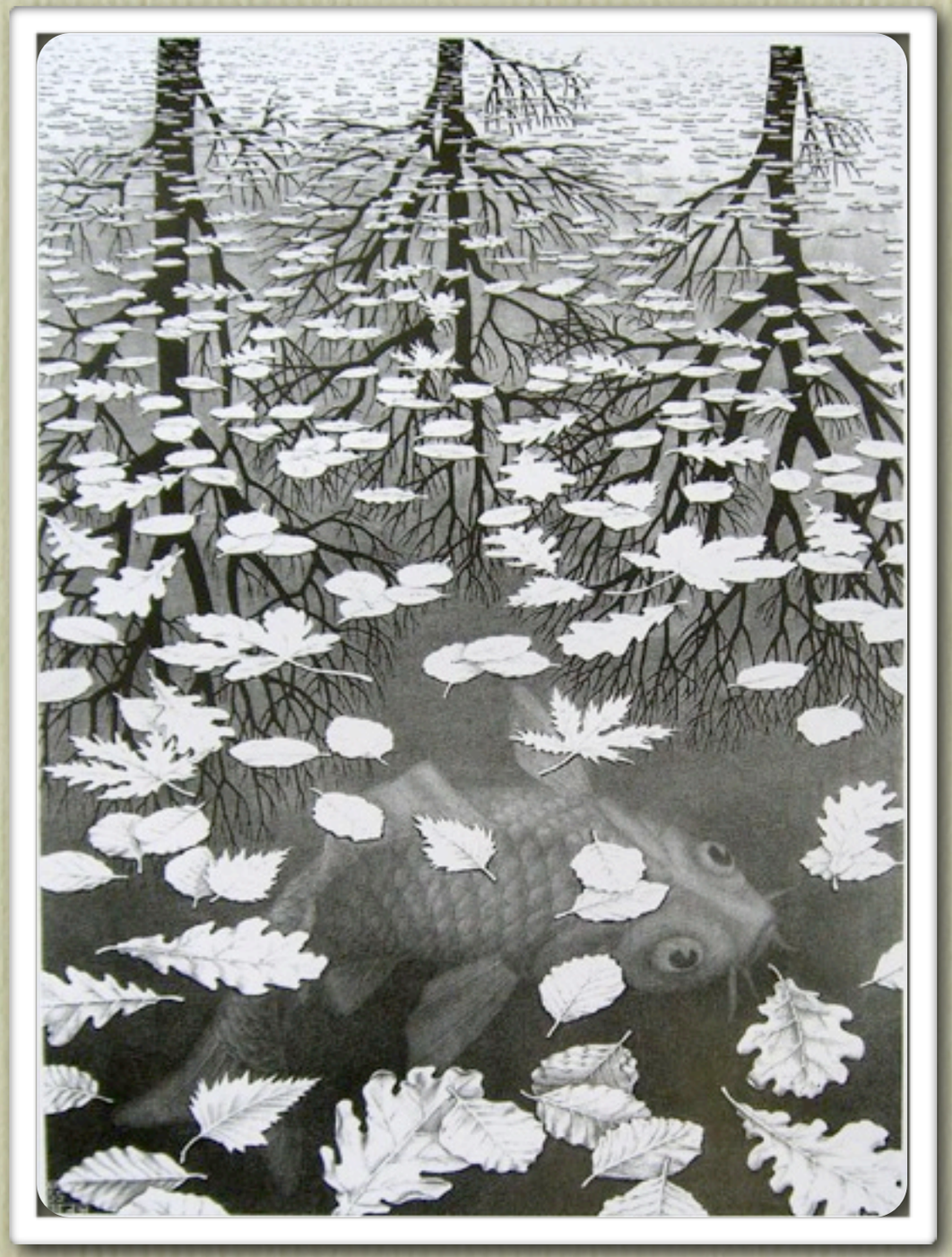
Johansson, Hall, Sikstrom, & Olsson (2005)

Theories of Implicit learning

Raf Cleeremans

The unconscious is very powerful!

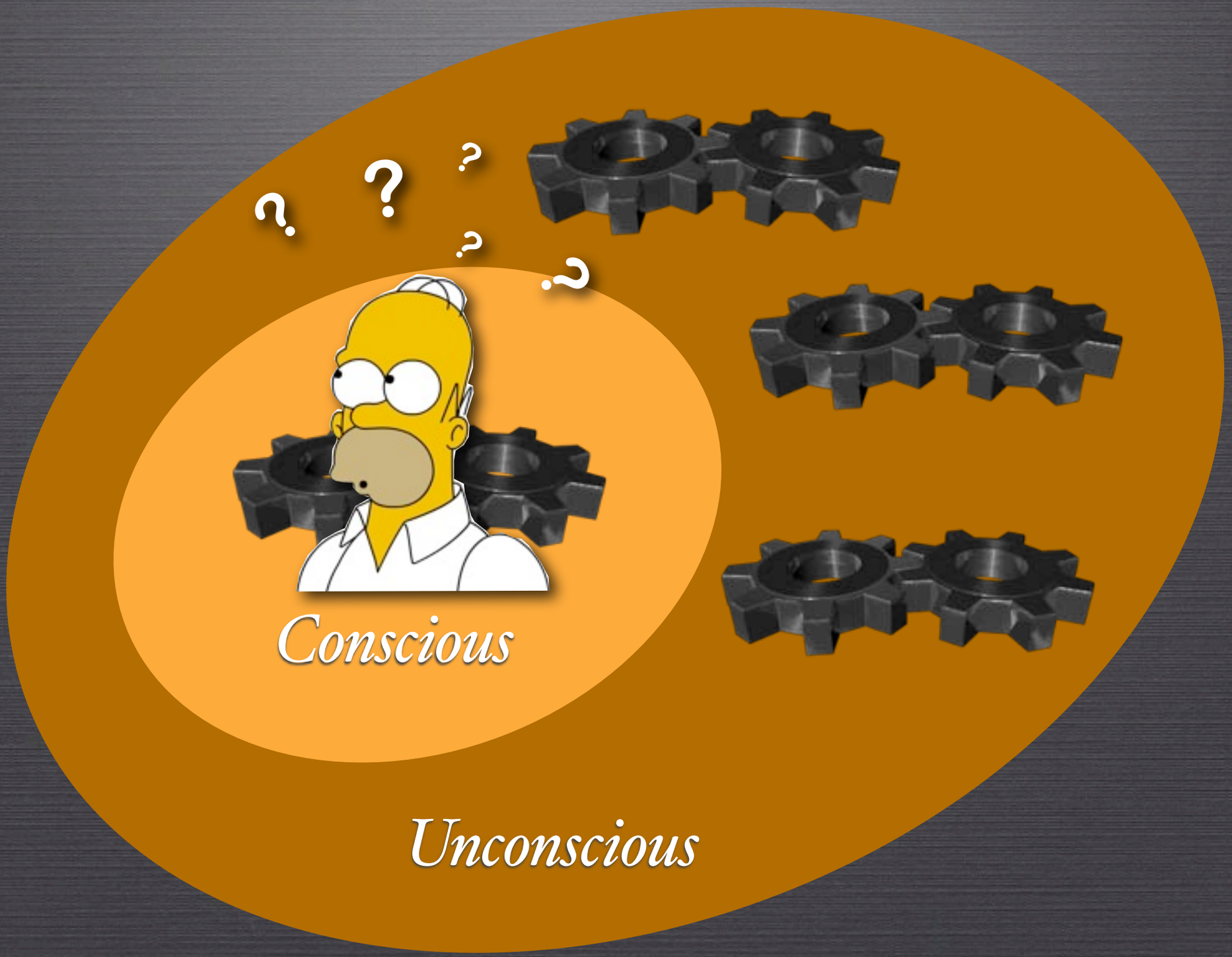
Consciousness is king



M.C. Escher, “Three Worlds, 1955

Searle:“At its most naive, our picture [of the unconscious] is something like this: Unconscious mental states in the mind are like deep fish in the sea.The fish that we can’t see under neath the surface have exactly the same shape they have when they surface.The fish don’t lose their shapes by going under water”

Searle, Rediscovery of the Mind, p. 152


Conscious
Unconscious

$$F_G = \frac{G m_1 m_2}{r^2}$$

Two central issues

- *The role of consciousness in learning*
  - *Is cognition without consciousness possible? In what sense? What are the limits of unconscious cognition?*
- *Knowledge representation*
  - *How is abstract knowledge represented?*

	Abstract rules	Associations
Conscious knowledge		
Unconscious knowledge		

Where is implicit learning?

Two central issues

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  - *How is abstract knowledge represented?*

	Abstract rules	Associations
Conscious knowledge	explicit learning	
Unconscious knowledge		

Where is implicit learning?

Two central issues

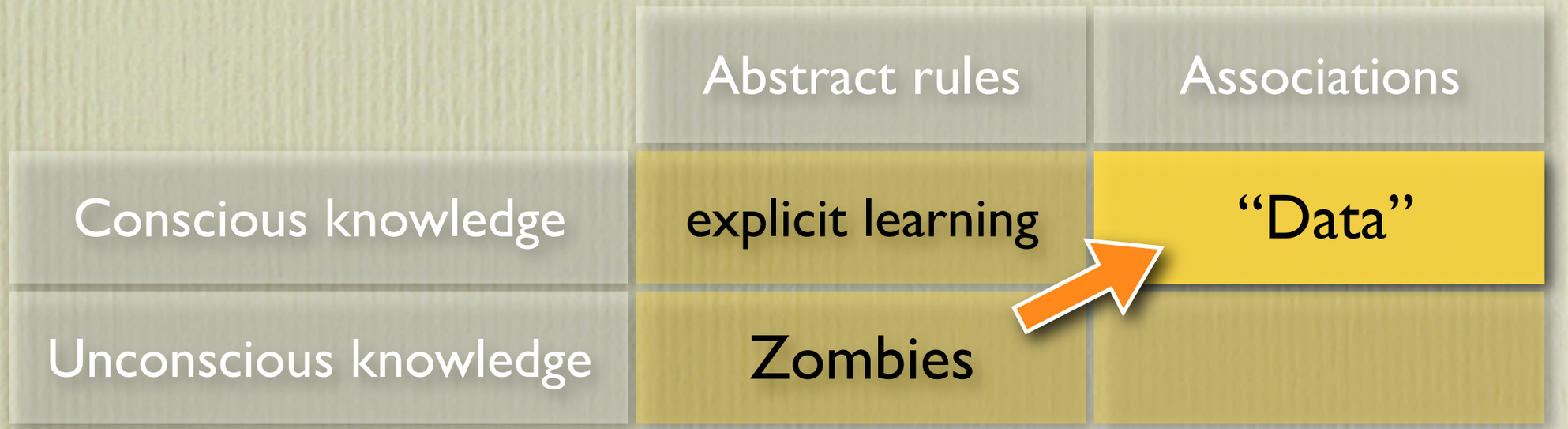
- *The role of consciousness in learning*
  - *Is cognition without consciousness possible? In what sense? What are the limits of unconscious cognition?*
- *Knowledge representation*
  - *How is abstract knowledge represented?*

	Abstract rules	Associations
Conscious knowledge	explicit learning	
Unconscious knowledge	Zombies	

Implicit learning is unconscious symbol manipulation

Two central issues

- *The role of consciousness in learning*
  - *Is cognition without consciousness possible? In what sense? What are the limits of unconscious cognition?*
- *Knowledge representation*
  - *How is abstract knowledge represented?*



Implicit learning is conscious learning of associations

Two central issues

- *The role of consciousness in learning*
  - *Is cognition without consciousness possible? In what sense? What are the limits of unconscious cognition?*
- *Knowledge representation*
  - *How is abstract knowledge represented?*

	Abstract rules	Associations
Conscious knowledge	explicit learning	"Data"
Unconscious knowledge	Zombies →	Priming+

Implicit learning involves relational priming based on functional similarity

Computational objectives of learning

- Distinction and complementarity between "model" learning and "task" learning (O'Reilly, 1998):

  - **Model learning** involves activity-based hebbian plasticity and is a prime candidate for implicit learning in that it does not require intentions, goals, or error information and is highly sensitive to correlational structure. Conditioning is an example of the operation of such mechanisms. The goal is to build detailed, internal, predictive models of the world is like.
  - **Task learning** involves error-based plasticity and is a prime candidate for explicit learning in that it is most appropriate for learning specific tasks, that is, learning complex input-output mappings that require specific actions to be related to specific goals.
  - An important goal of current research is to determine exactly how and where in the brain these learning mechanisms combine.

Plasticity

We learn all the time, whether we intend to or not

- ★ Expert string players exhibit larger-than-normal areas of the somatosensory cortex dedicated to representing input from the fingering digits (Elbert et al., 1995)
- ★ Posterior hippocampus is enlarged in experienced taxi drivers compared to subjects who do not have extensive experience in memorizing complex maps (Maguire et al., 2000)
- ★ The very organization of the somatosensory cortex (the famous Penfied homonculus) might depend on pre-natal sensory experience (Farah, 1997)
- ★ Evidence for neurogenesis was also found in humans, overturning decades of unquestioned — but, as it turns out, erroneous — assumptions about the lack of regenerative cellular processes in the adult brain.
- ★ Evidence for fetal learning (van Helteren et al., 2000)
- ★ Evidence for memory consolidation during REM sleep (Maquet et al., 2000)

What is learned?

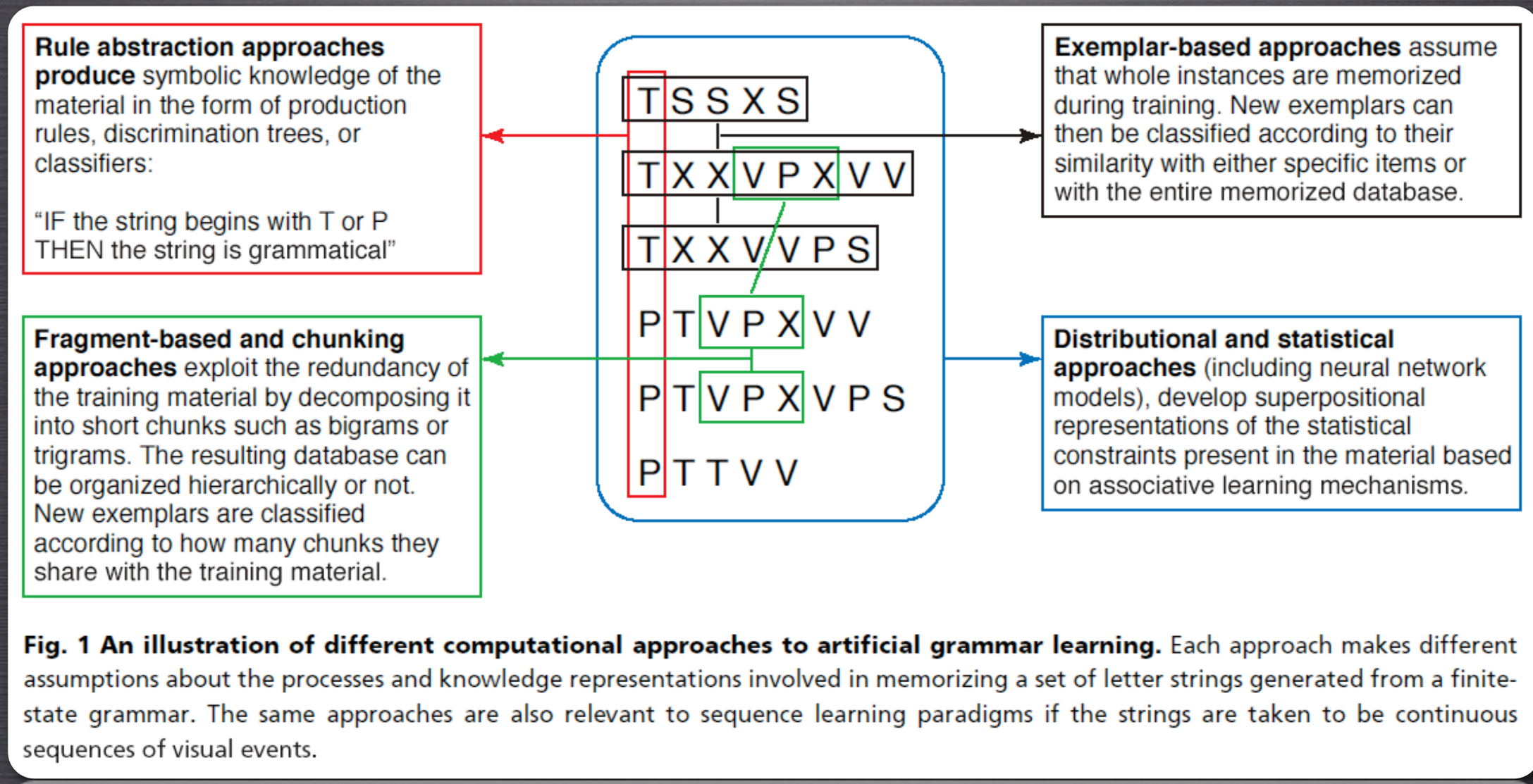


Fig. 1 An illustration of different computational approaches to artificial grammar learning. Each approach makes different assumptions about the processes and knowledge representations involved in memorizing a set of letter strings generated from a finite-state grammar. The same approaches are also relevant to sequence learning paradigms if the strings are taken to be continuous sequences of visual events.

Many possibilities exist. Which one is right? Might several be right at the same time?
Does the nature of what is learned correlate with availability to conscious awareness?

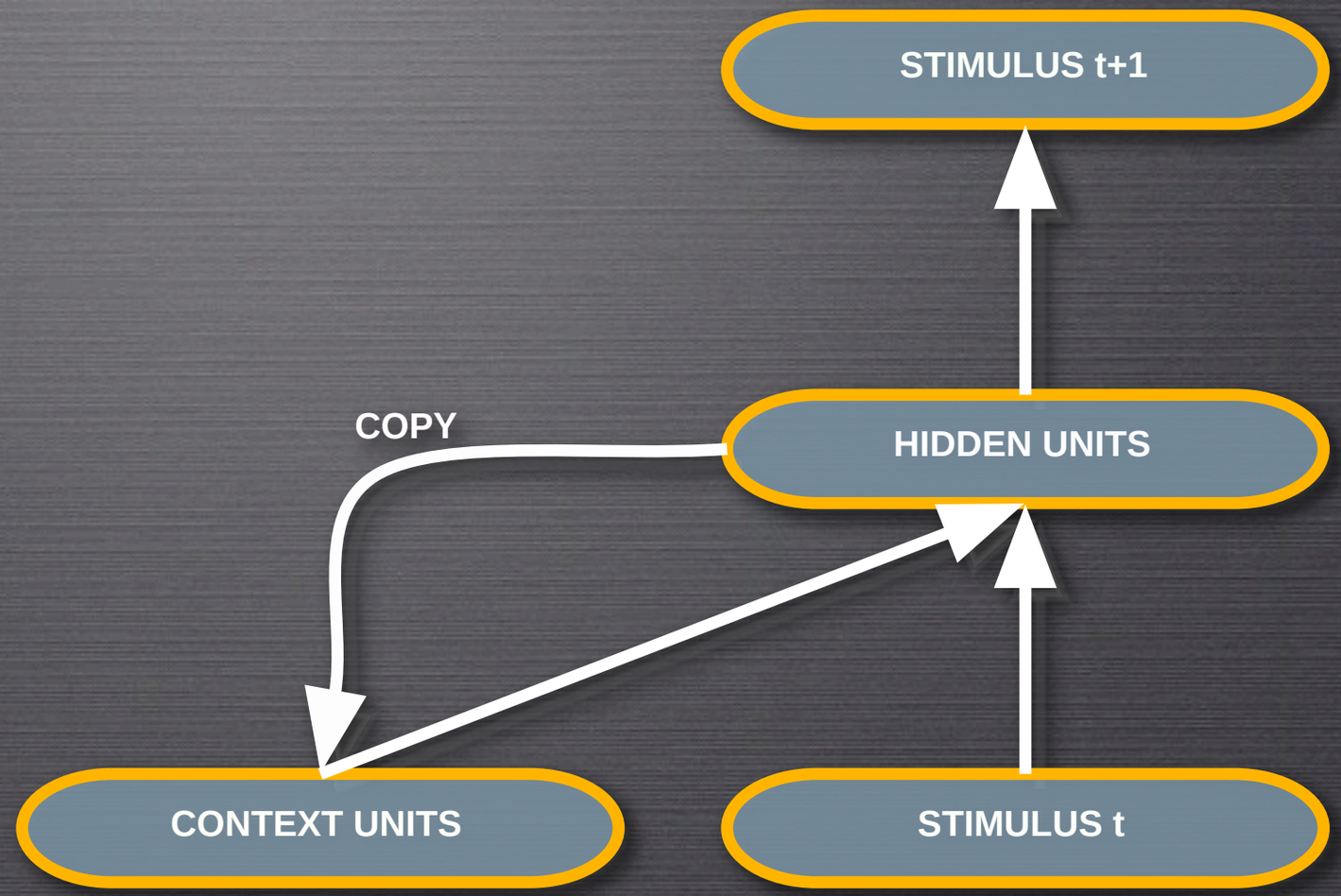
The simple recurrent network

Elman 1990

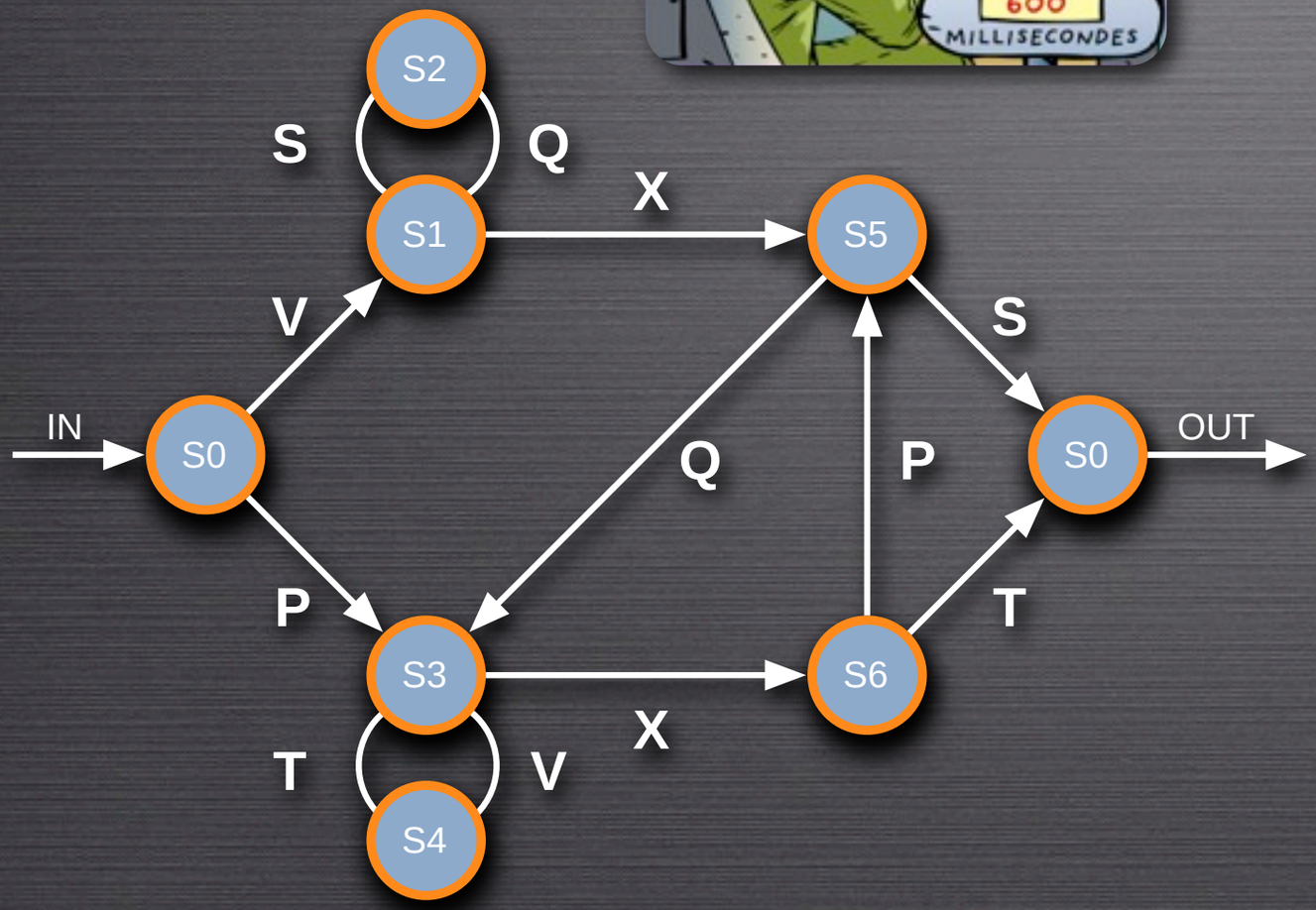
TASK IS PREDICTION

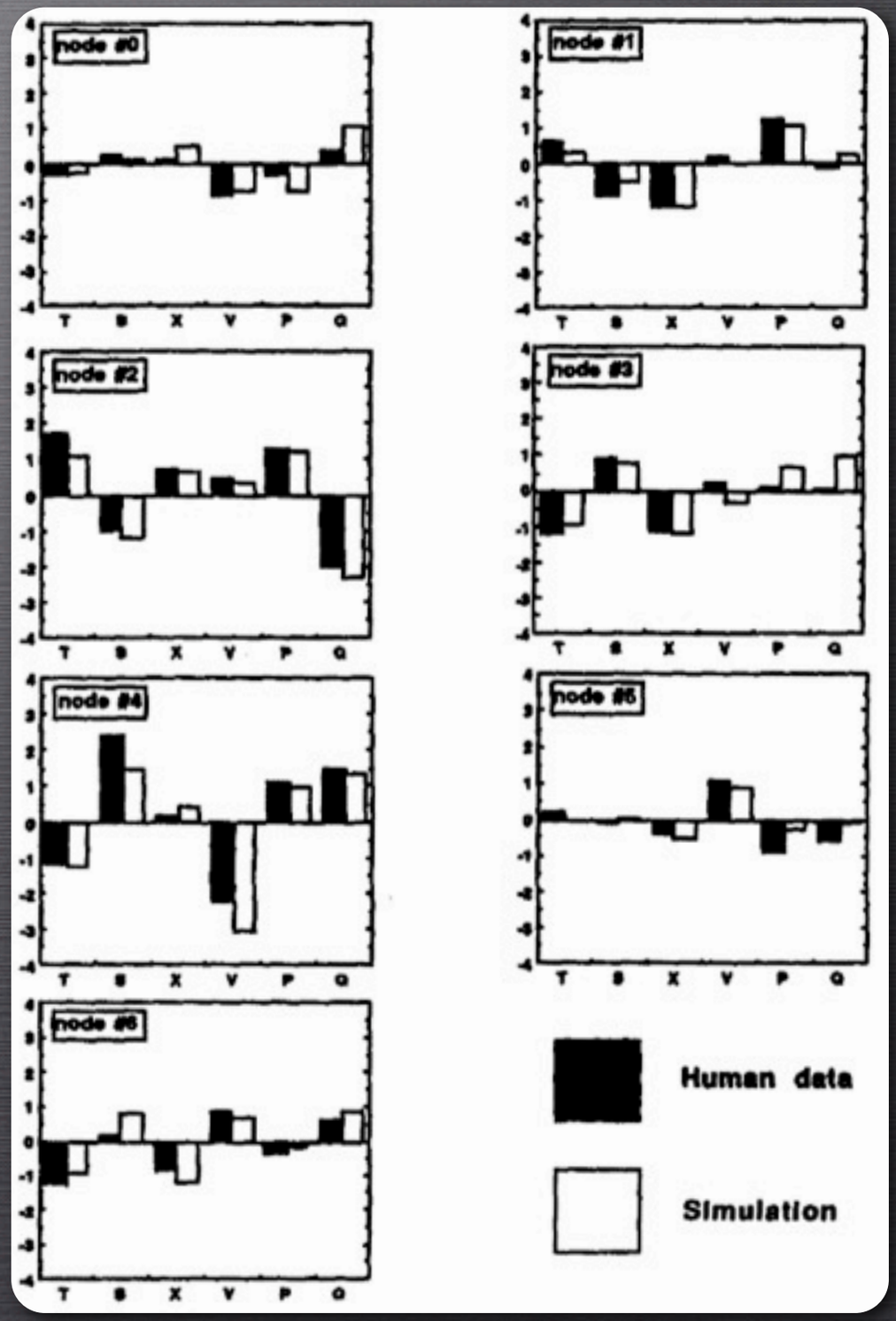
On each time step:

- Present Element t over input units
- Copy hidden units activation onto context units
- Let activation propagate
- Compare response and actual successor ➡ error
- Modify the weights using back-propagation



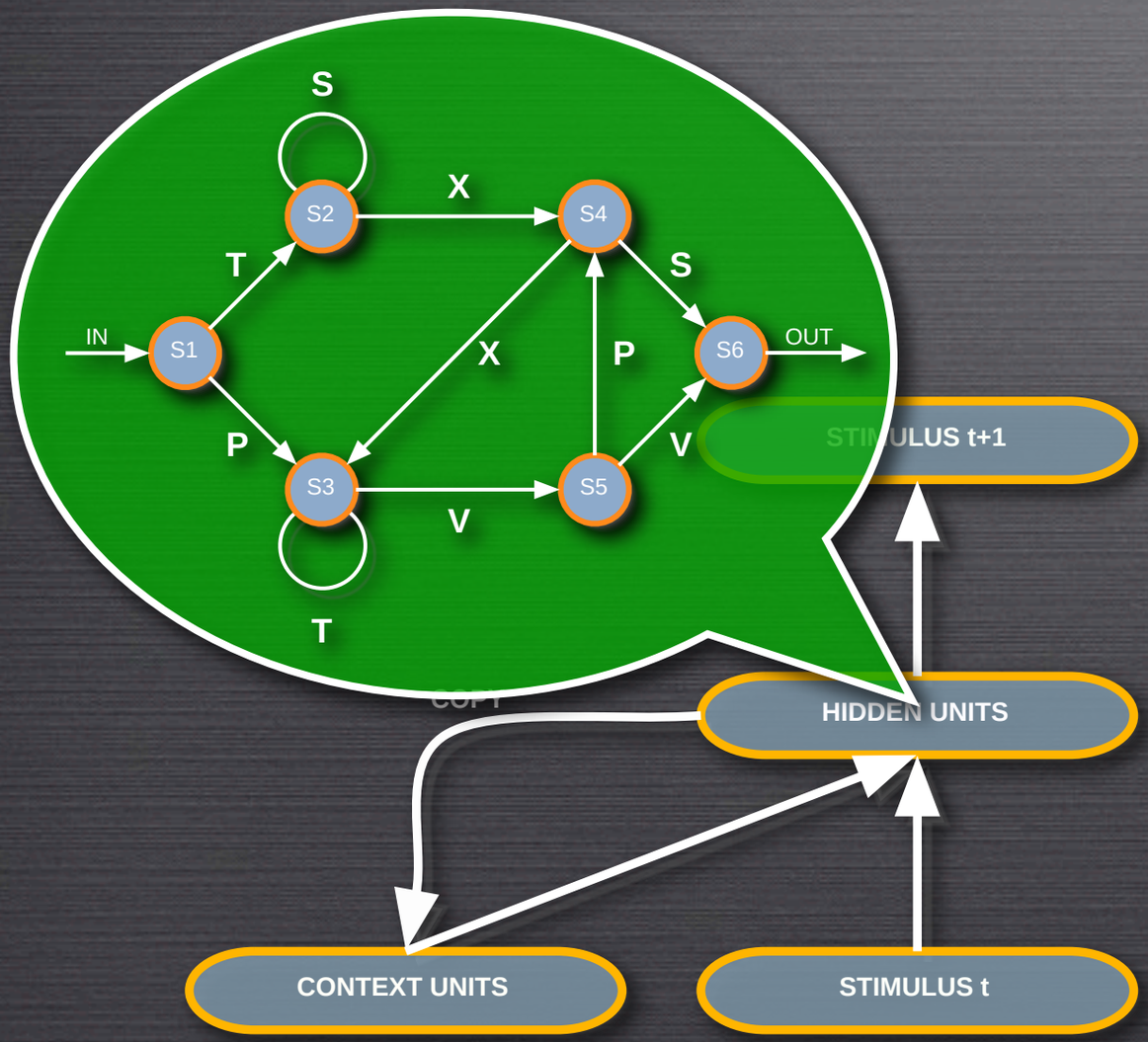
Sensitivity to sequential structure





Cleeremans & McClelland, 1991

Emergent representation



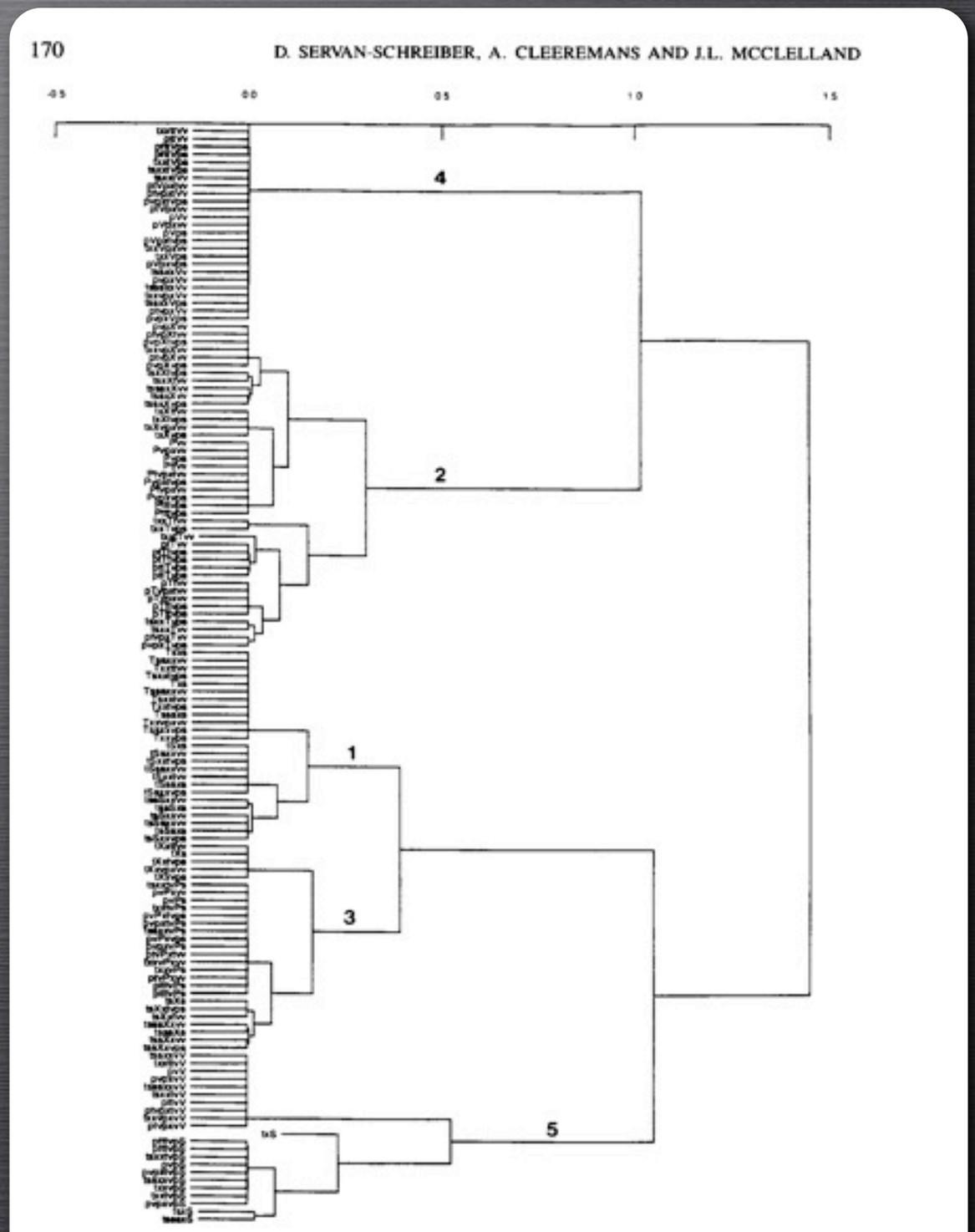
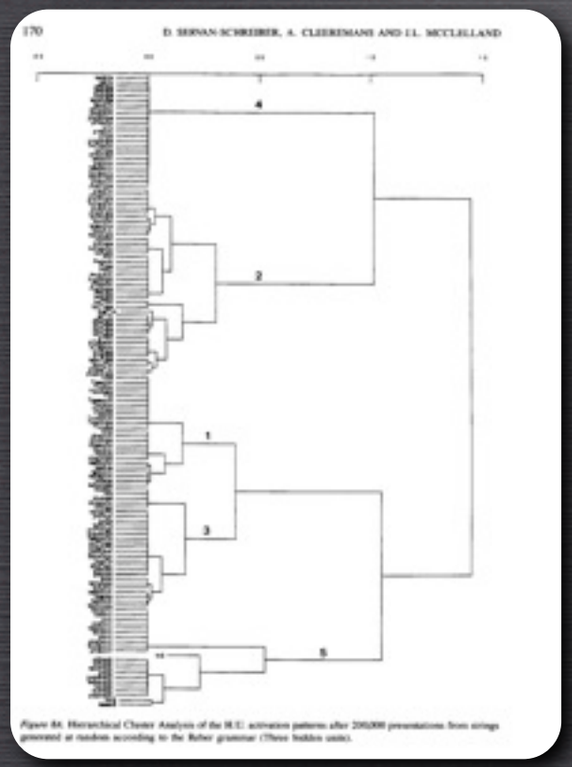
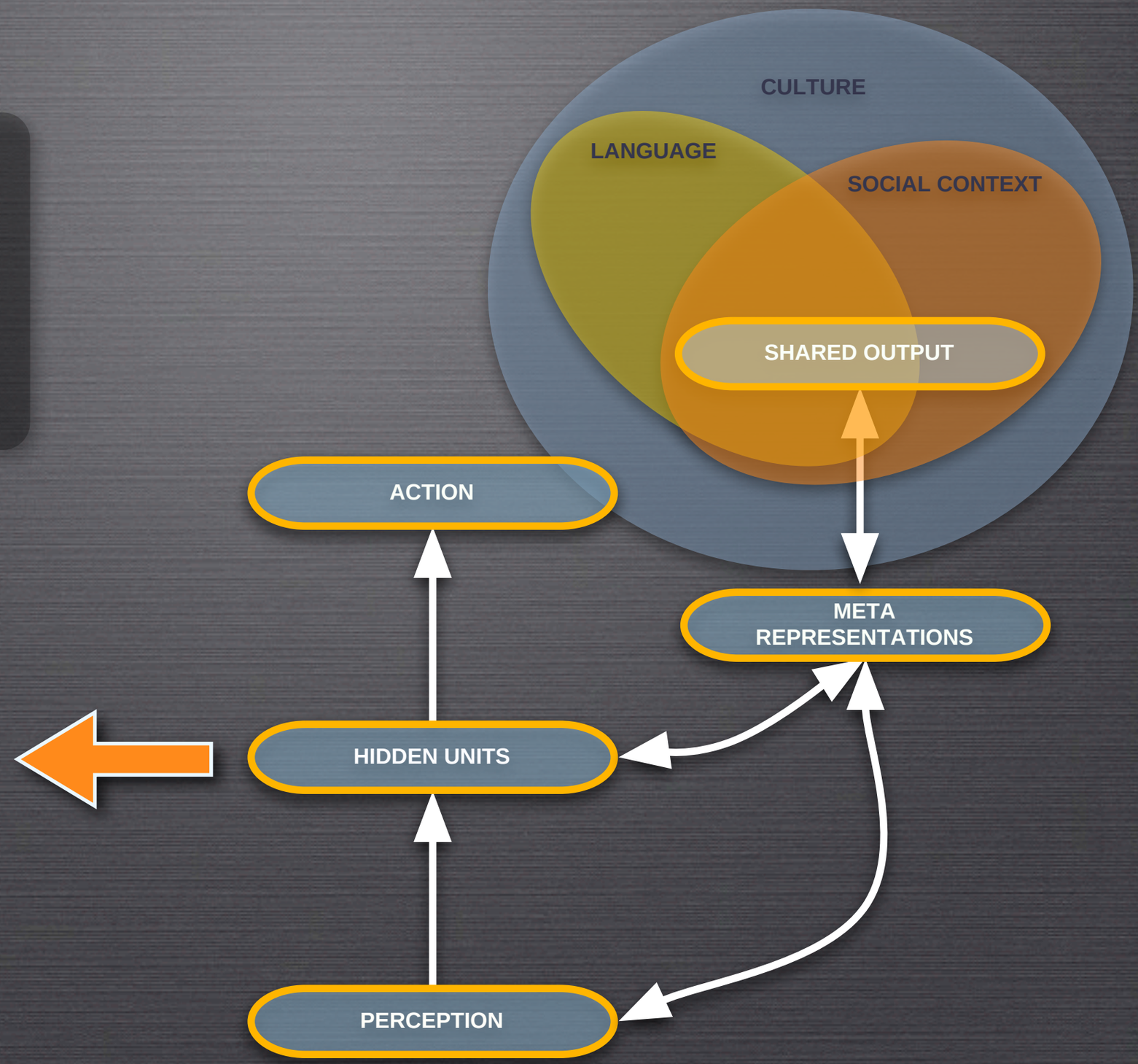


Figure 84. Hierarchical Cluster Analysis of the H.U. activation patterns after 200,000 presentations from strings generated at random according to the Reber grammar (Three hidden units).

Meta Representations

Knowledge “in the network” vs. knowledge “for the network” (Clark & Karmiloff-Smith)





What functions for M-reps?

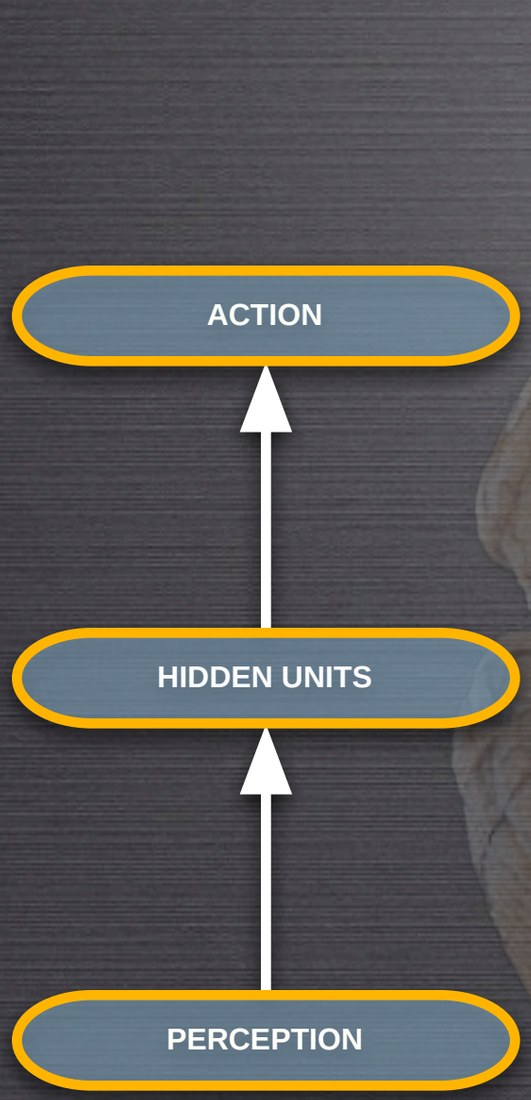
To indicate “mental attitude”, that is, the manner in which the first-order representations are known: Truth, belief, hope, fear, want, &c.

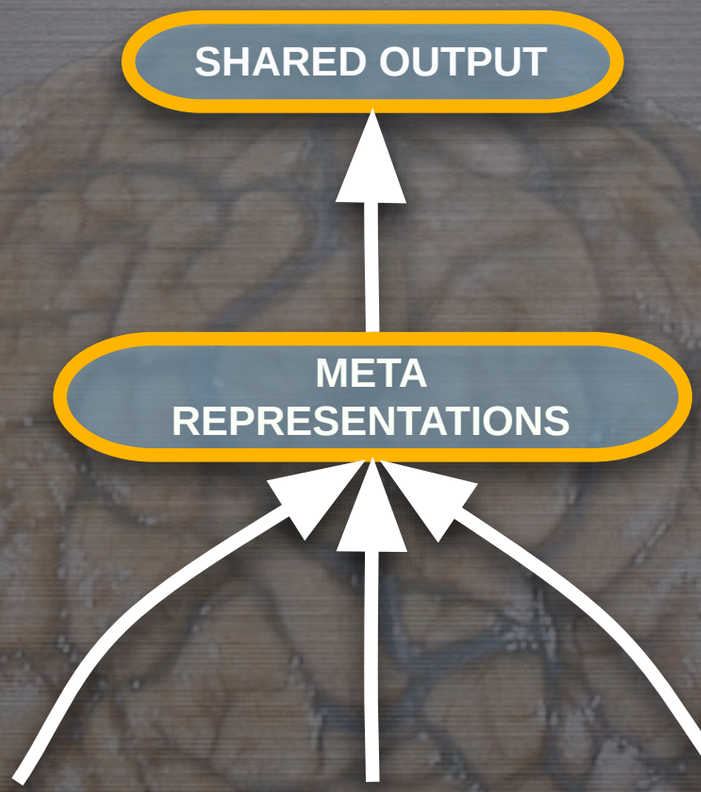
Metarepresentations so make it possible for an agent to know the geography of its own representations: Signal detection on the mind

This is something that the brain learns about unconsciously

Metarepresentations are also representations: “Fame in the brain” ideas also apply to metarepresentations

Signal Detection on the Mind





The brain learning about itself: Signal detection on your own representations

The brain learning about the world

From implicit to explicit

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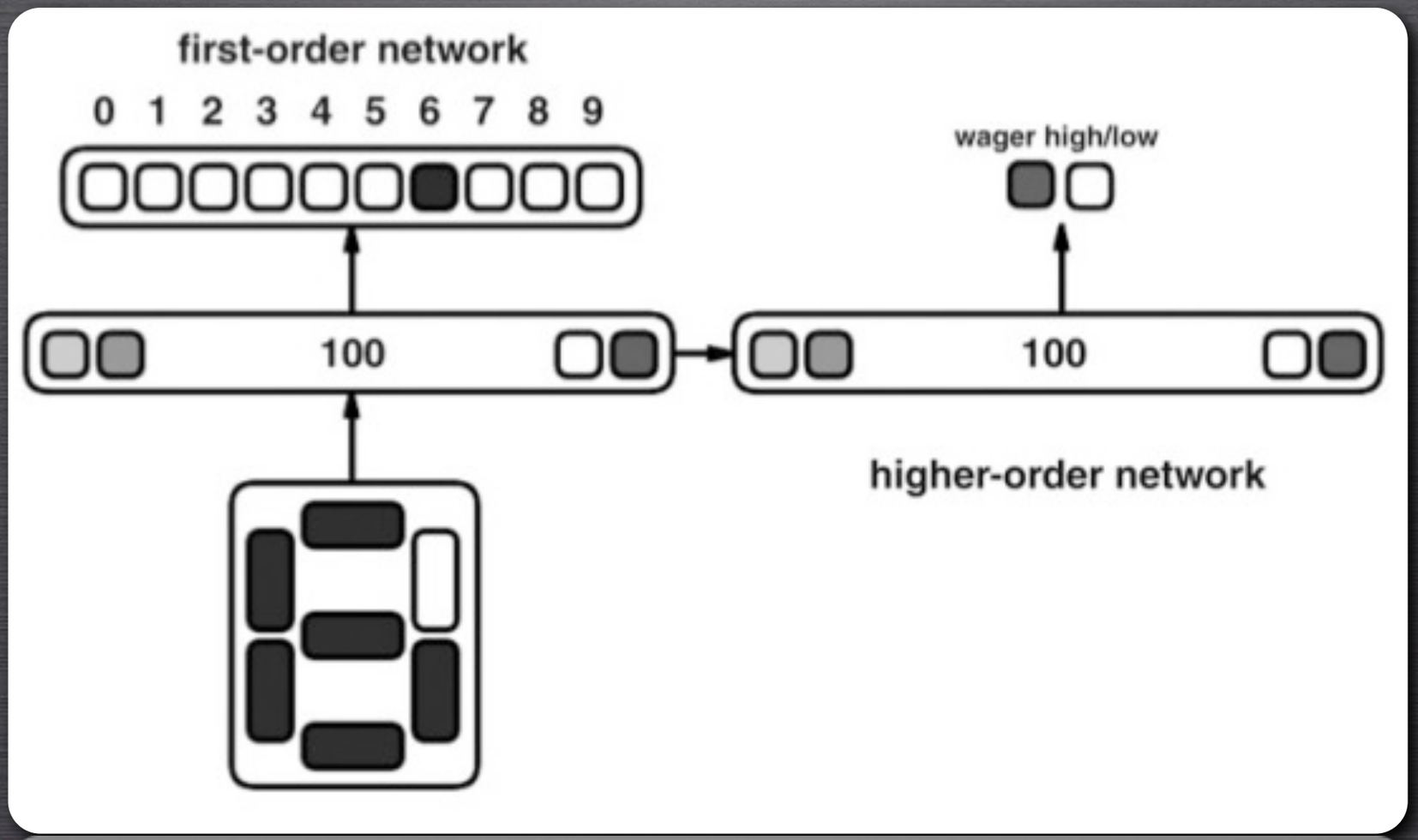
2007 Special Issue

Consciousness and metarepresentation: A computational sketch

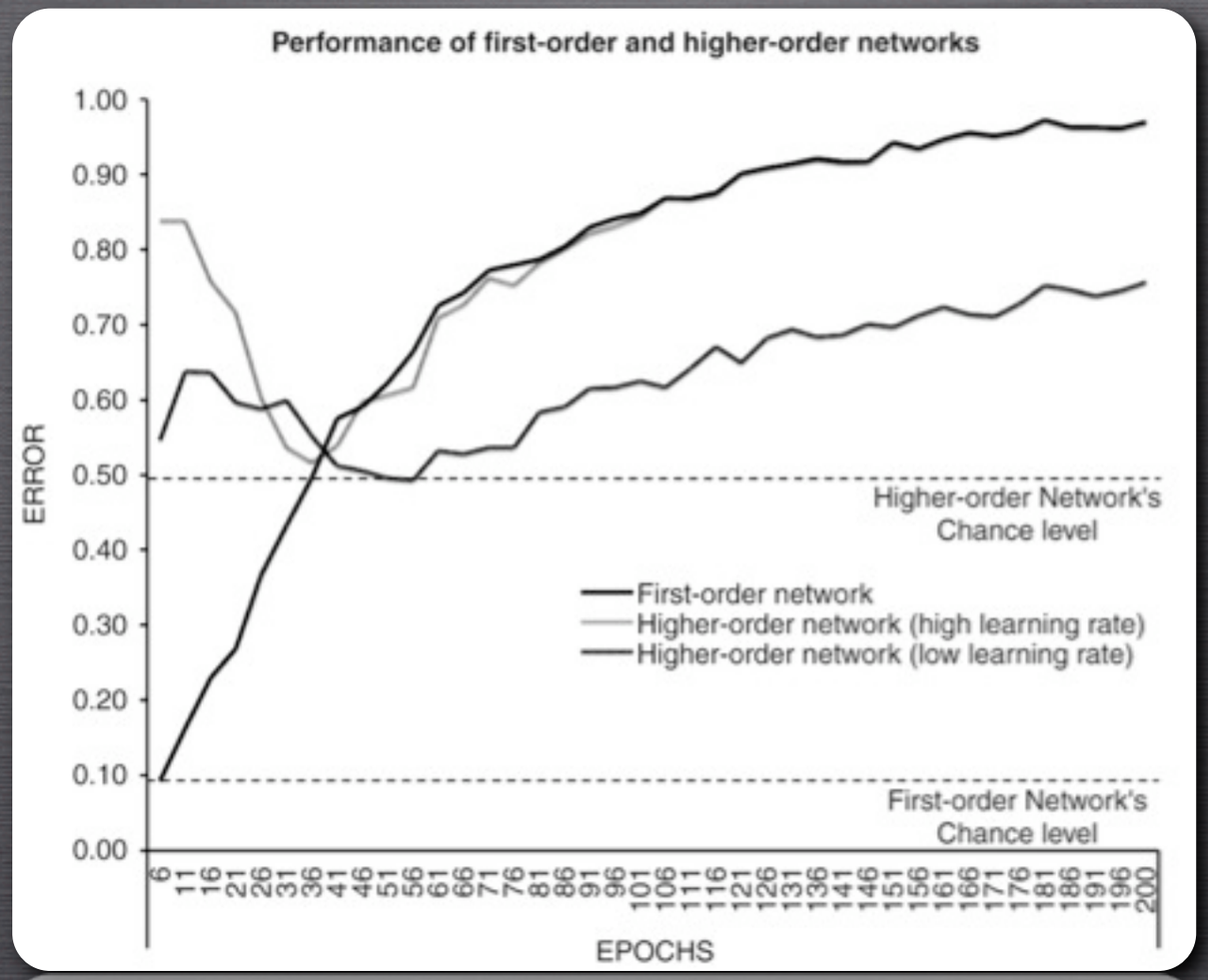
Axel Cleeremans*, Bert Timmermans, Antoine Pasquali

Cognitive Science Research Unit, Université Libre de Bruxelles CP 191, 50 ave. F.-D. Roosevelt, B1050 Bruxelles, Belgium

Wagering in the digits task



Wagering in the digits task

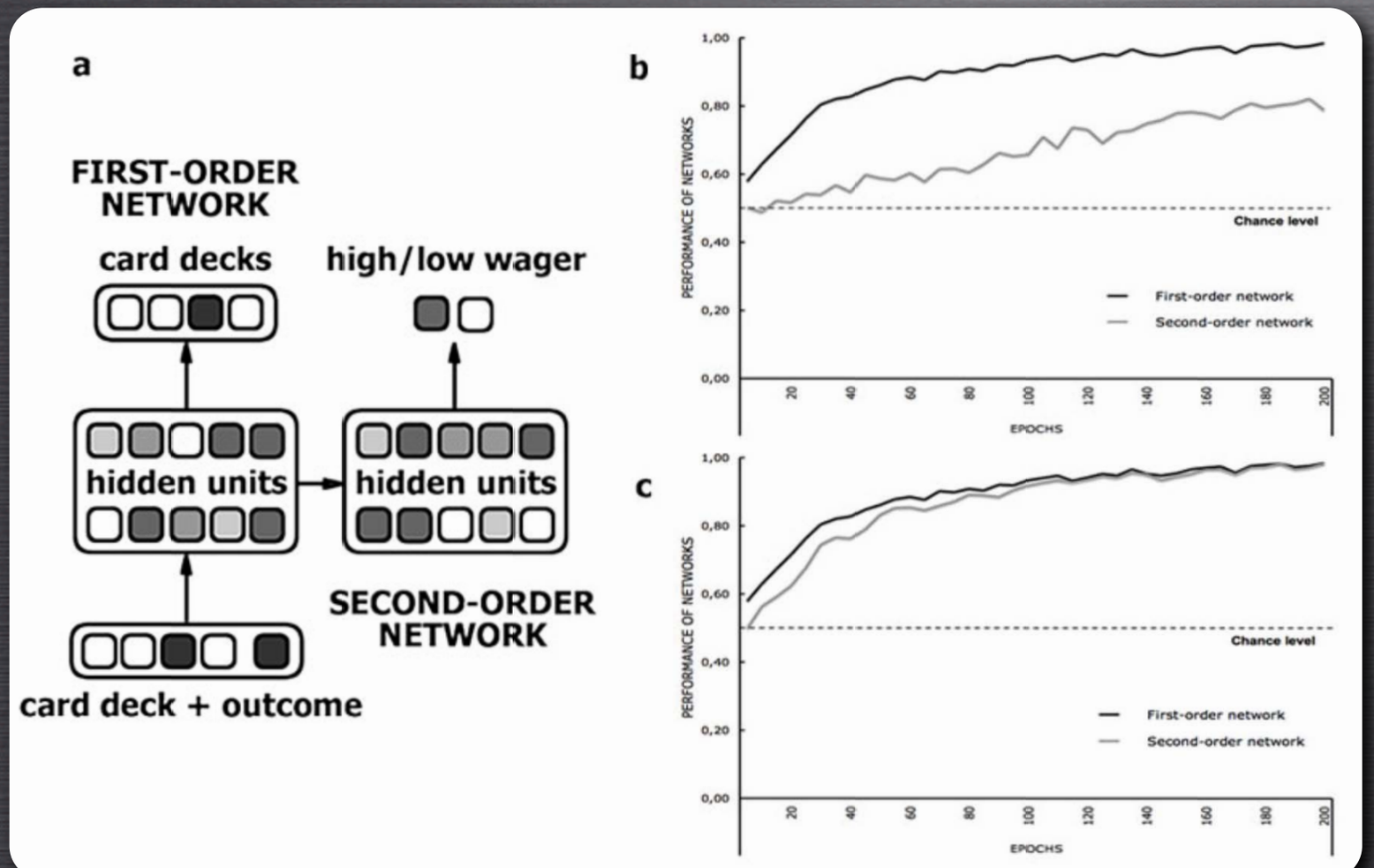


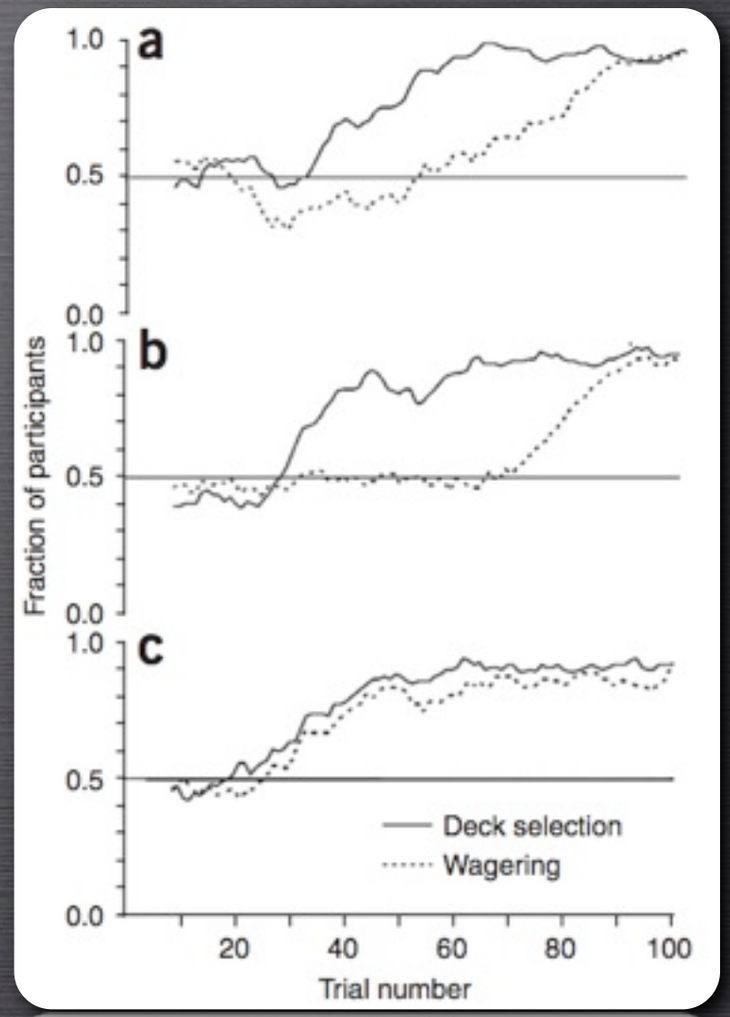
Different training conditions result in different patterns of relationship between the performance of the first-order network and that of the second-order (wagering) network

The Iowa Gambling task

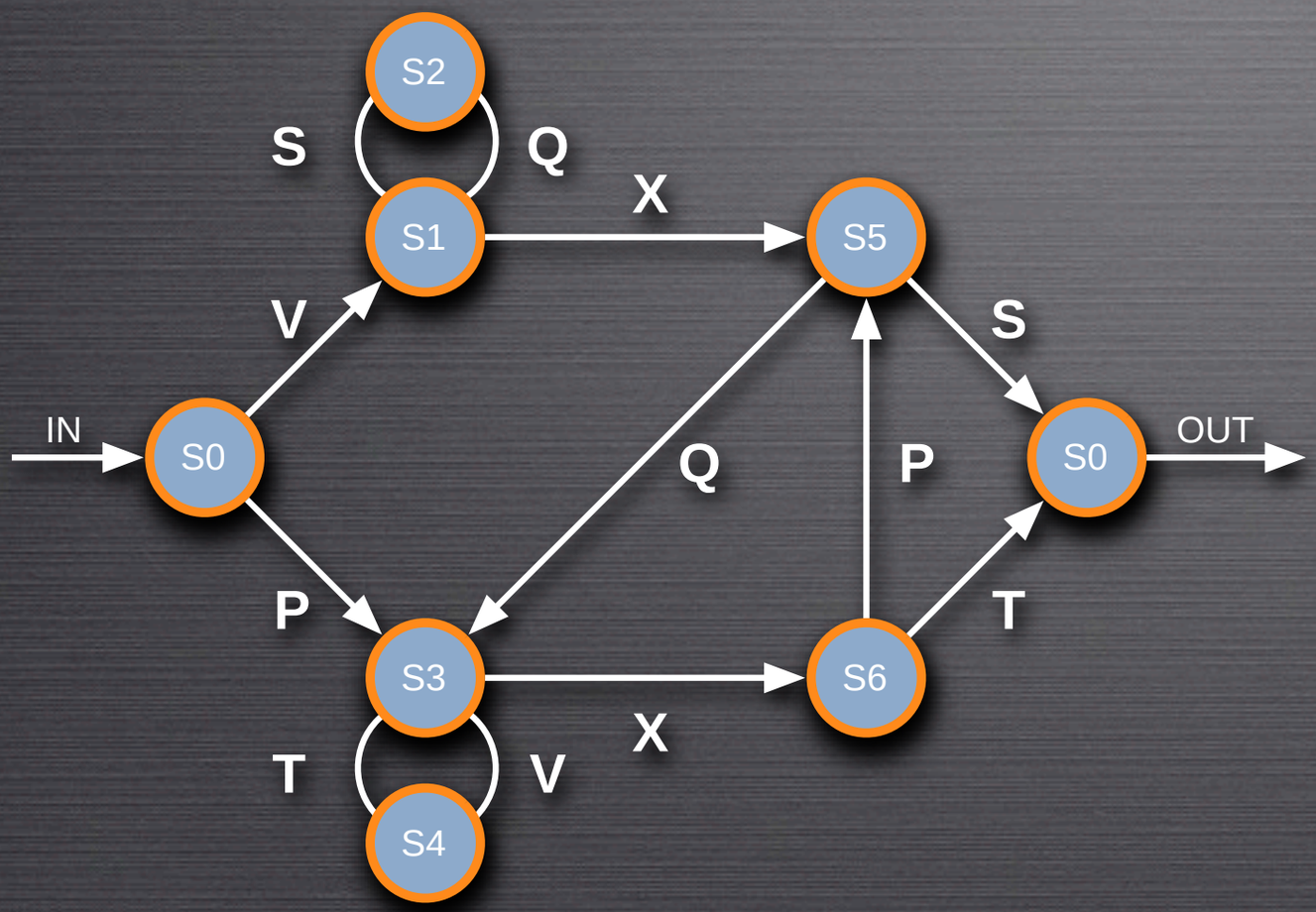
	Bad Decks		Good Decks	
	A	B	C	D
Gain/Deck:	$100	$100	$50	$50
Loss/10 cards:	$1250	$1250	$250	$250
Net/10 cards:	-$250	-$250	$250	$250
Rewards/10 cards:	5	1	5	1

The Iowa Gambling task





Artificial Grammar Learning



Reber 1967

Memorize:

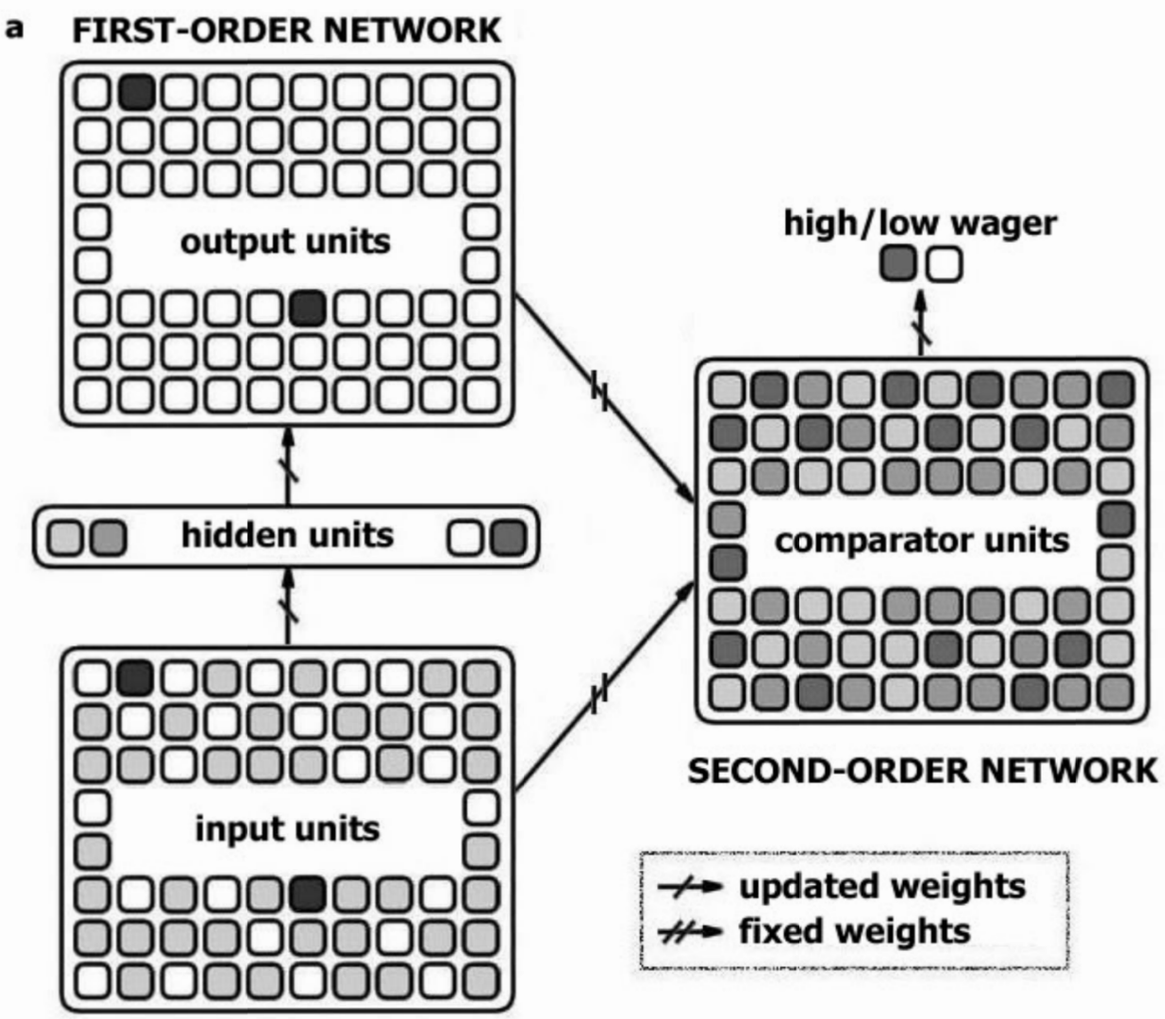
VSQXS
PTVTVXT
PXPQXT
(…)

Test (no feedback):

G vs. NG strings

Artificial Grammar Learning

a



b

Blindsight (noisy vision)	Correct	Incorrect	Total
High Wager	29,10	1,77	30,87
Low Wager	49,63	19,50	69,13
Total	78,73	21,27	100,00
Normal vision	Correct	Incorrect	Total
High Wager	50,57	4,67	55,23
Low Wager	29,43	15,33	44,77
Total	80,00	20,00	100,00

c

Incidental learning	Correct	Incorrect	Total
High Wager	36,33	8,78	45,11
Low Wager	35,44	19,44	54,89
Total	71,78	28,22	100,00
Explicit learning	Correct	Incorrect	Total
High Wager	63,44	0,33	63,78
Low Wager	34,78	1,44	36,22
Total	98,22	1,78	100,00

Moral

Finding sensitivity to some regularity does not necessarily imply that the regularity itself is represented in the cognitive system as an object of representation.

There is real challenge involved in figuring out how symbolic representations emerge out of sub-symbolic processing

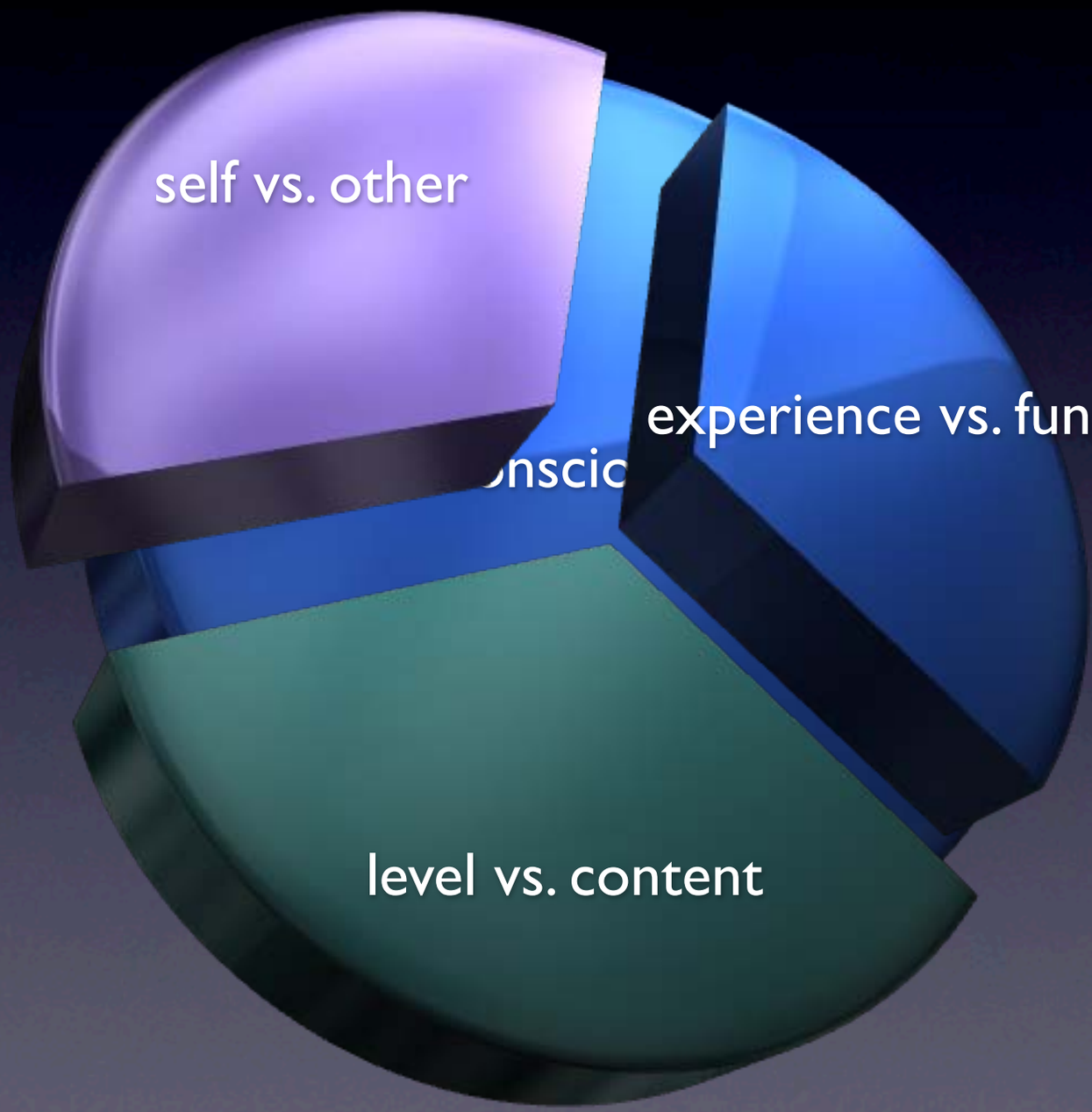
Challenges

Raf Cleeremans

Three challenges

- *Definitional challenge*
- *Methodological challenge (measurement)*
- *Conceptual challenge (intepretation)*

Consciousness is not a single thing!



The definitional challenge

- **Consciousness is not unitary:**
  - awareness of the presence or absence of a stimulus
  - awareness of one's intentions / awareness of action
  - awareness of the fact that behavior is influenced by a previous processing episode

- **Different paradigms engage different aspects of consciousness**
  - Subliminal perception, change detection: awareness of the stimulus
  - Implicit memory: awareness of the influence of previous stimuli
  - Implicit learning: awareness of the relationships between stimuli

The methodological challenge

- **How do we devise an appropriate measure of awareness?**
  - **Quantitative dissociation logic:** Compare the sensitivity of two different measures to some relevant information: A measure **C** of subjects' awareness of the information, and a measure **P** of behavioral sensitivity to the same information.
  - Unconscious processing is then demonstrated whenever **P** exhibits sensitivity to some information in the absence of correlated sensitivity in **C**.

- **Three problems:**
  - **Retrospective assessment problem:** C & P cannot be obtained concurrently: Forgetting & Observer paradox
  - **Information problem**: Does C measure knowledge necessary to perform the task?
  - **Sensitivity problem**: Are C and P equally sensitive to the relevant information?

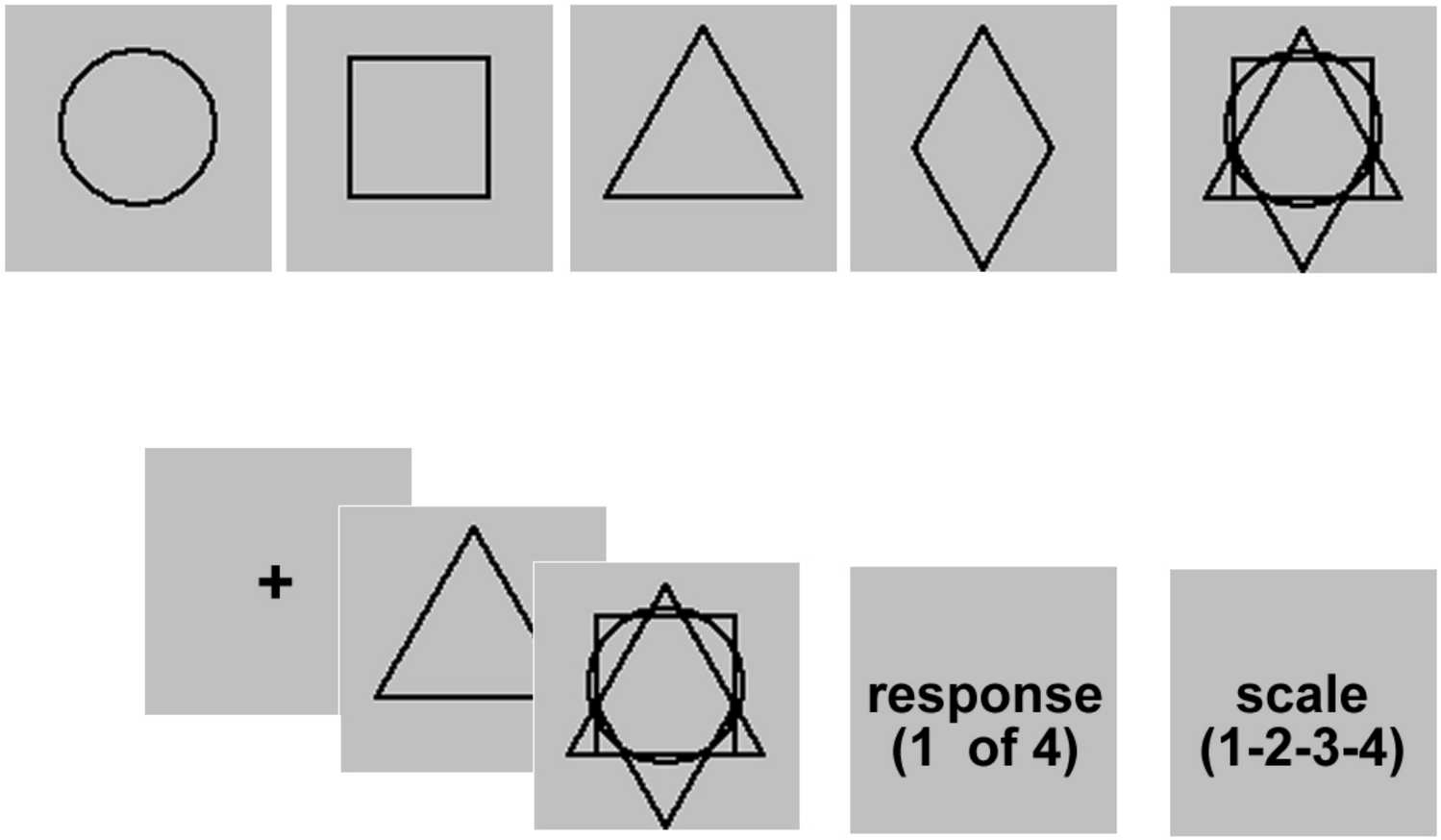
The conceptual challenge

- **Even if we obtain good dissociation results, how should we interpret them?**
  - **Double dissociations do not imply dissociable systems (Dunn & Kirsner (1988)!**
- **Numerous demonstrations that single-system accounts can in fact account for dissociations:**
  - **e.g., Plaut (1995) on dyslexia**
  - **the memory debate**

Three illustrations

- **Perceptual (un)awareness**
  - **Subliminal perception**
- **Implicit learning & memory**
  - **Sequence learning**
- **Decision making**
  - **Unconscious Thought Theory**

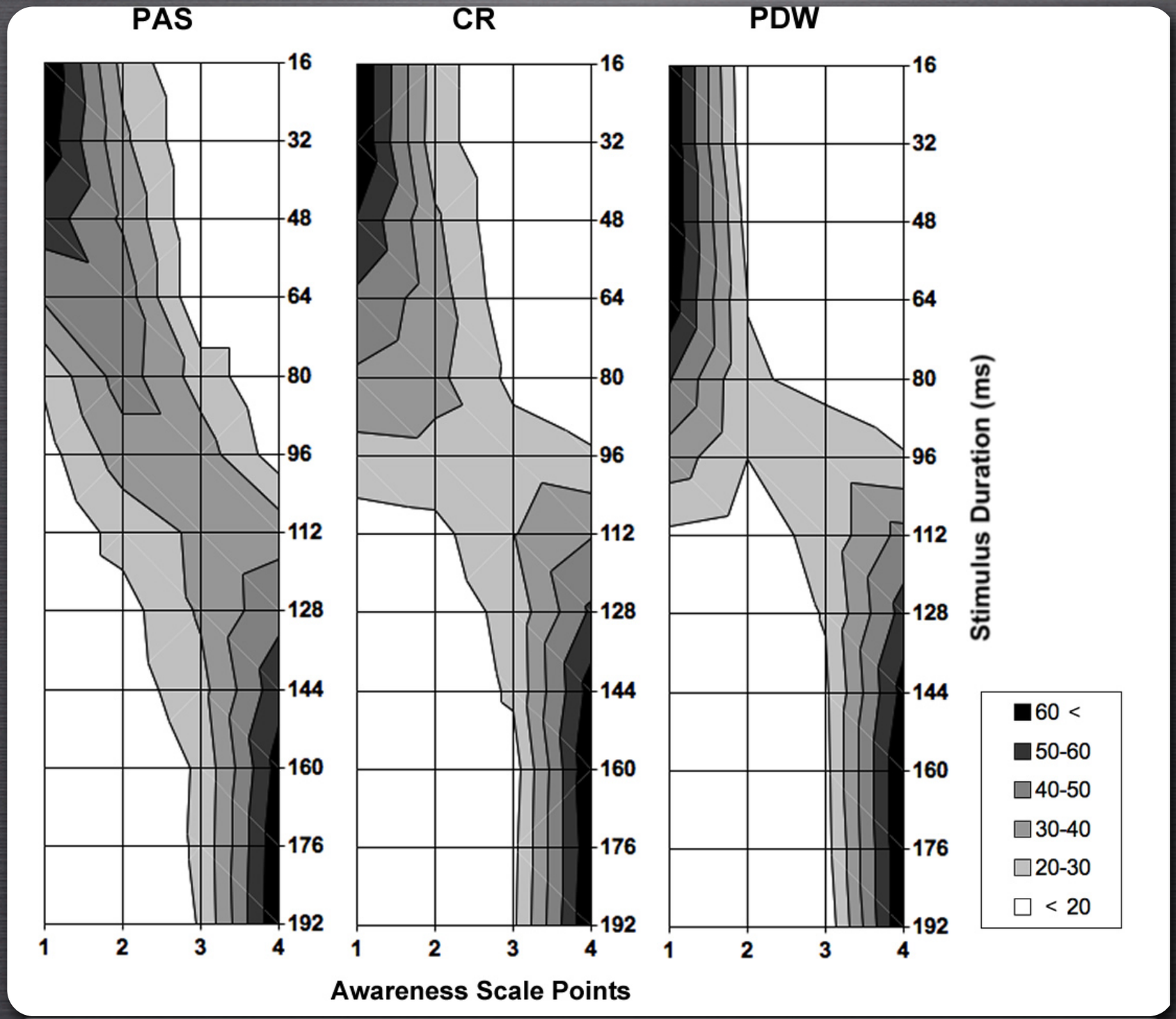
PARADIGM



Three scales: PAS, CR, and PDW, all with 4 points

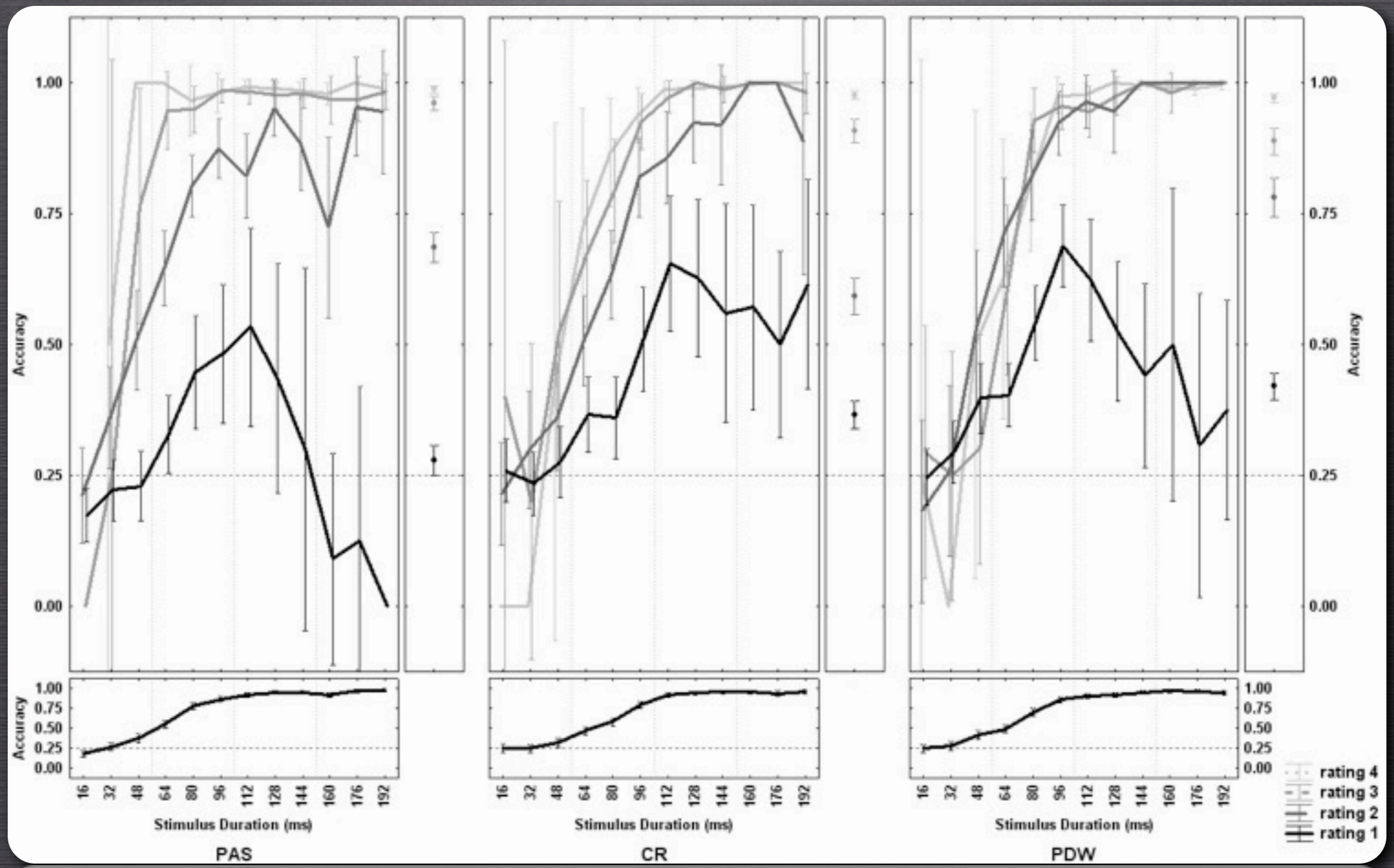
Sandberg, Timmermans et al (in revision)

SCALE POINTS DISTRIBUTION



Sandberg, Timmermans et al (in revision)

Performance vs. awareness



Sandberg, Timmermans et al (in revision)

Moral

The observed relationship between performance and awareness depends on your measures of each...

This has implications for our concept of consciousness

Implicit learning

Raf Cleeremans

The Process Dissociation Procedure
(Jacoby, 1991)

- Any task always involves both implicit and explicit components
- After training on the serial reaction time task, participants perform two direct tests that differ with respect to the instructions:

➡ the inclusion condition:

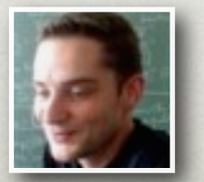
- Participants are asked to recollect and reproduce the training sequence. If they cannot recollect the location of a stimulus, they are told to use their intuition and to guess
- Explicit and implicit influences can both contribute to performance improvement

➡ the exclusion condition:

- Participants are told to generate a sequence of stimuli that differs from the training sequence: They must try to avoid reproducing the training sequence
- Explicit and implicit influences are set in opposition

Temporal effects

- In a series of experiments, we manipulated the extent to which learning is implicit or explicit by varying the response-stimulus interval (RSI)
  - Preparation for the next event in choice reaction time tasks involve both (unconscious) priming and conscious preparation
  - Reducing the RSI to zero might prevent the development of conscious expectations about the next stimulus, and hence selectively impair explicit sequence learning (see also Squire et al. on conditioning)
  - Increasing the RSI might promote the development of strong, conscious representations



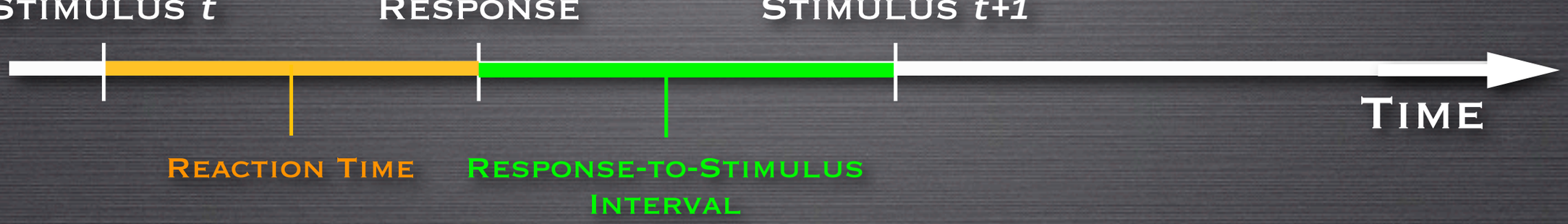
Arnaud Destrebecqz

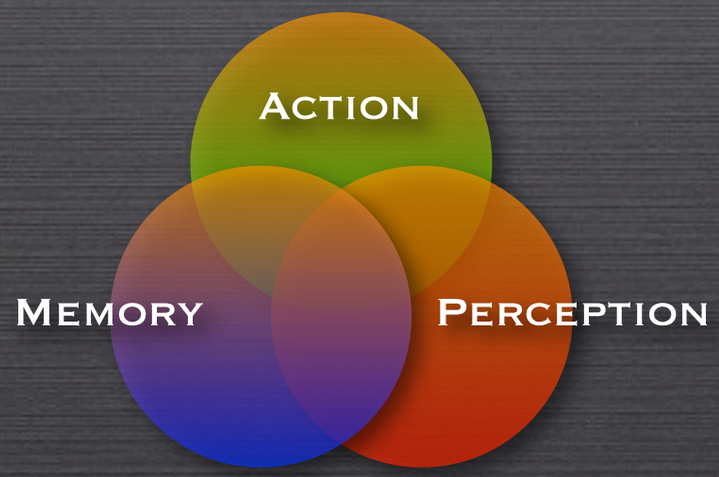
Destrebecqz & Cleeremans, PBR 2001, CBR 2003, L&M 2005

Time course of a single trial

RSI = 250ms

Standard condition

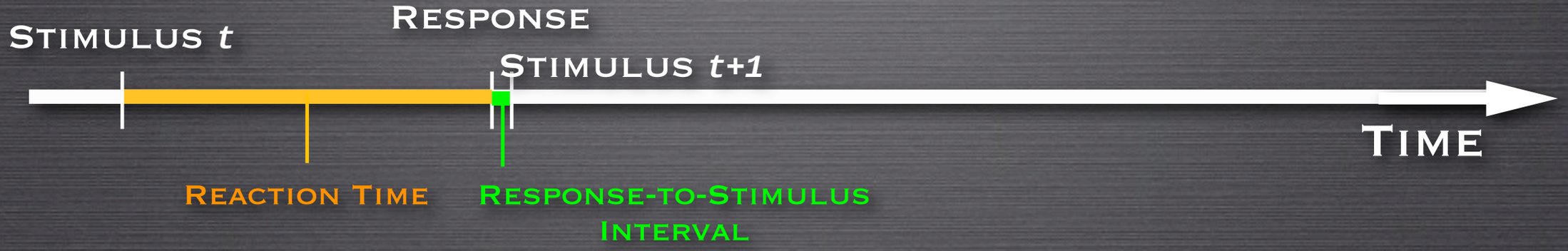


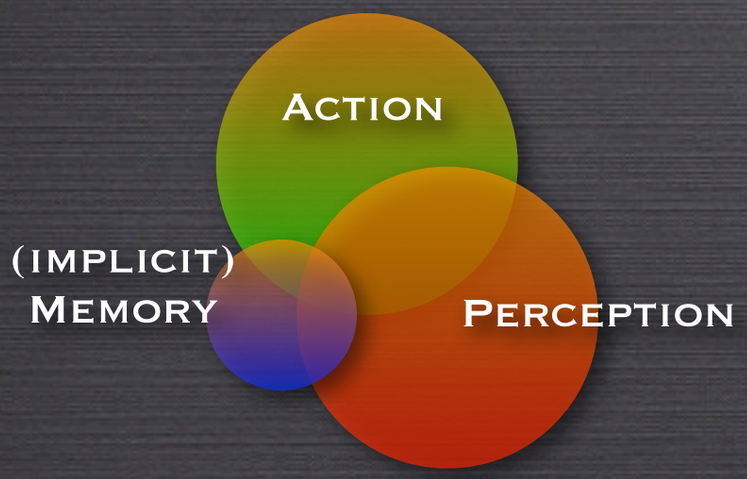


RSI 250

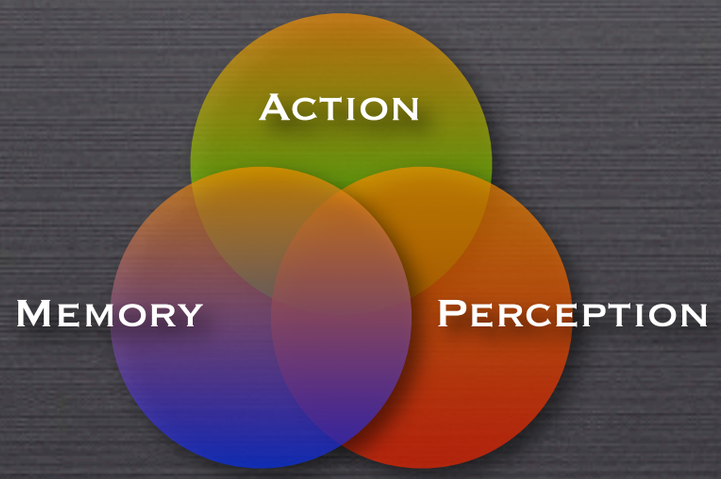
Time course of a single trial

RSI = 0ms
"No RSI" condition





RSI 0

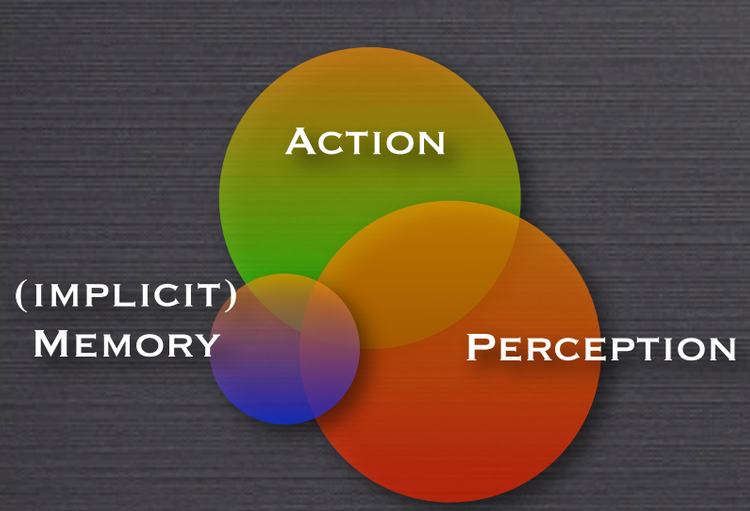


RSI 250

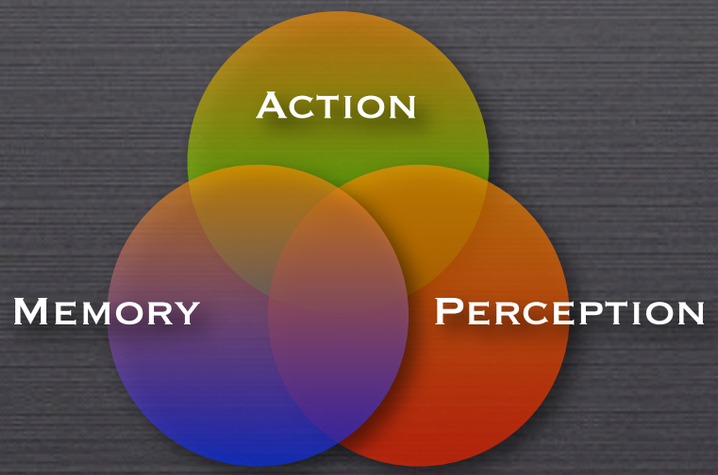
Time course of a single trial

RSI = 1500ms

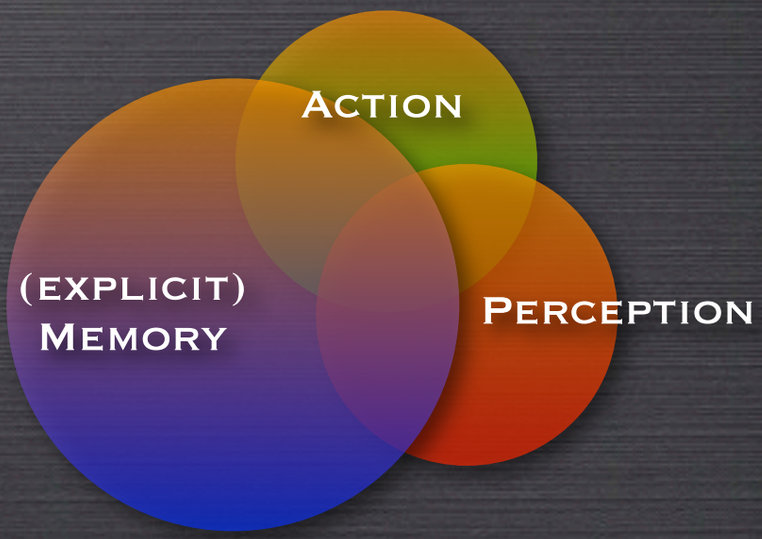
"Long" condition



RSI 0

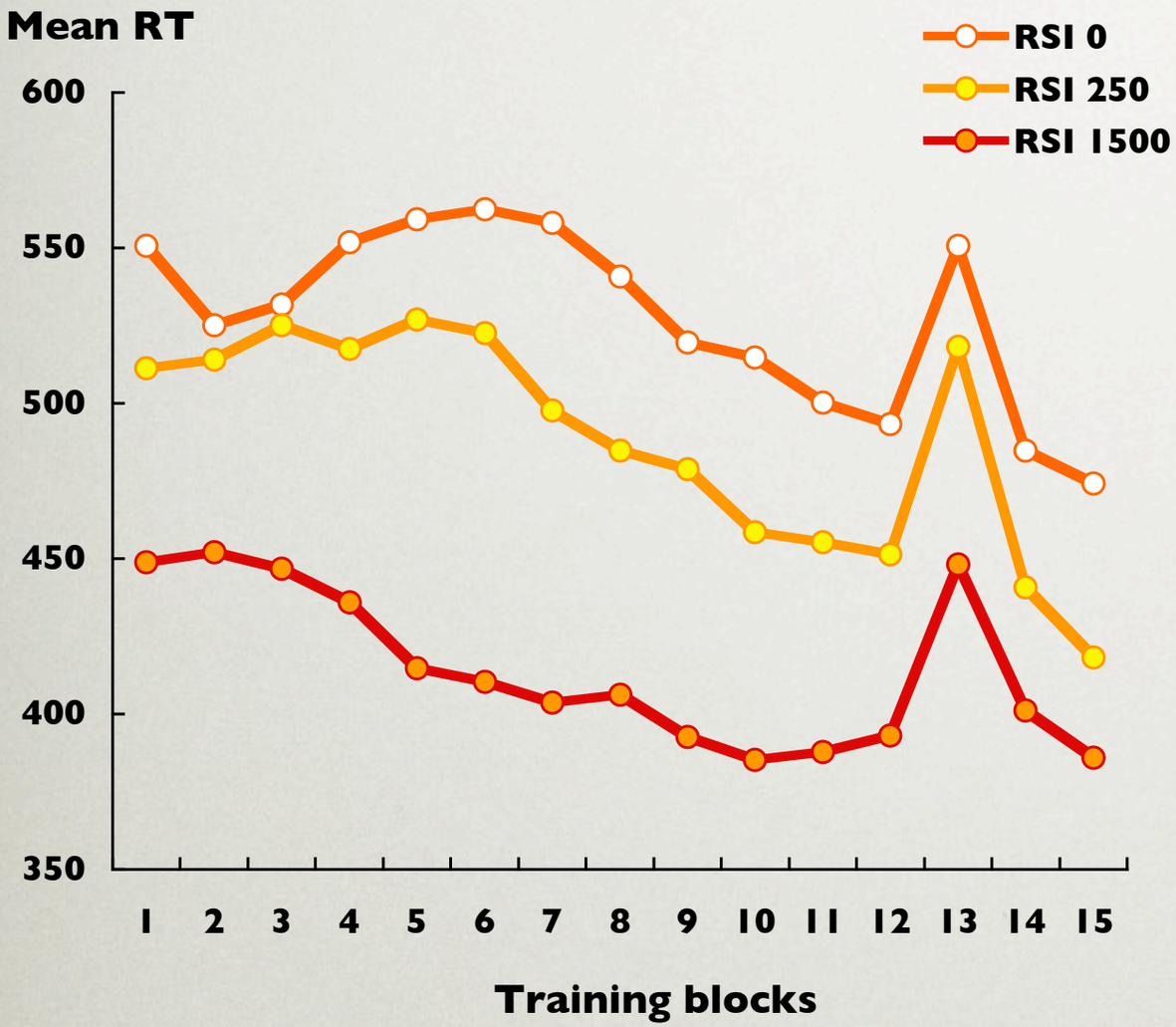


RSI 250



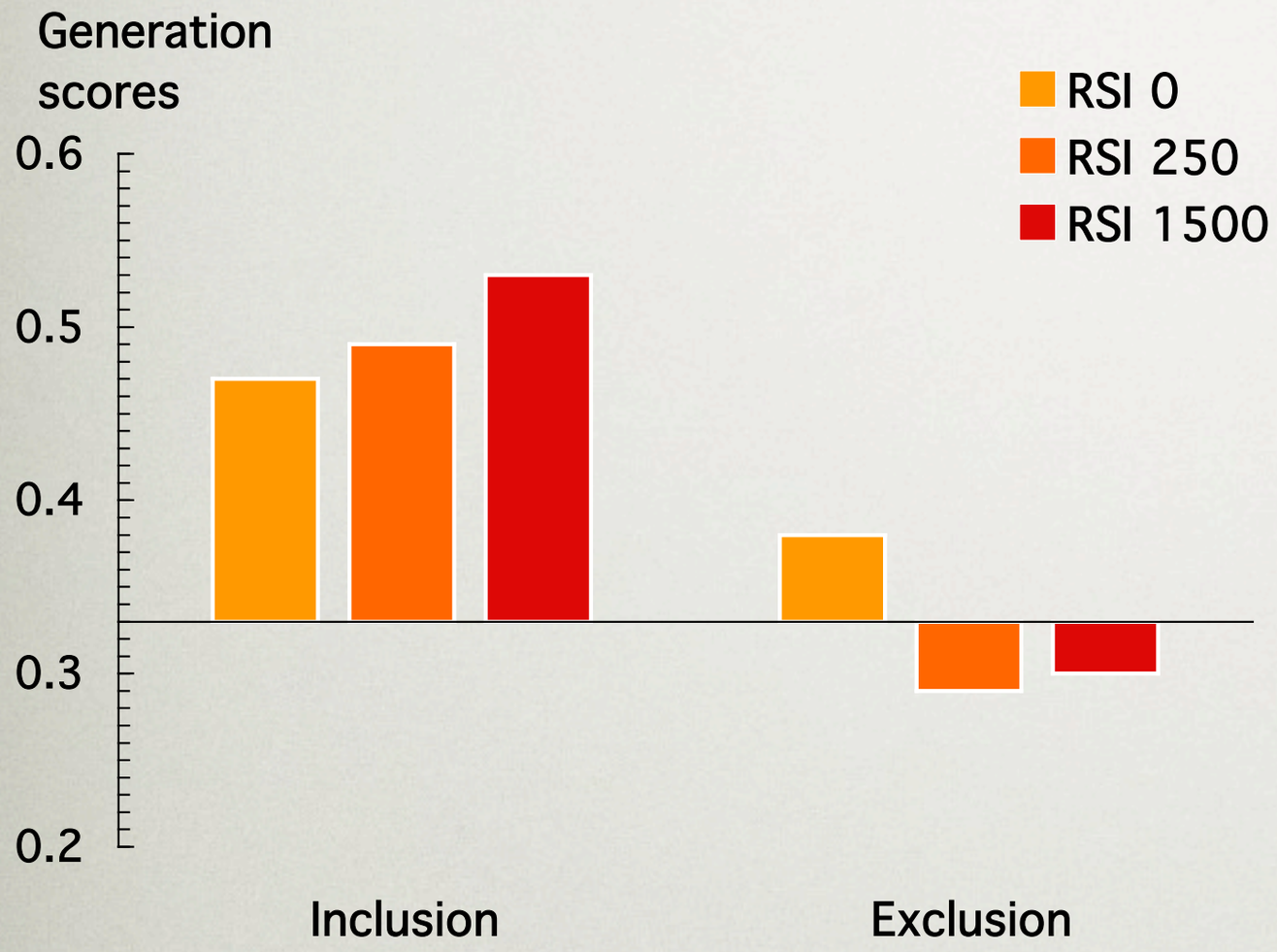
RSI 1500

Choice Reaction Time



- The same 12-element sequence is presented on blocks 1-12 and 14-15
- A different 12-element sequence is presented on block 13
- Higher values of RSI are associated with faster reaction times
- Subjects learn in all three conditions

Generation



- Generation scores represent the proportion of generated triplets that are part of the training sequence
- Inclusion scores do not differ from each other and are significantly above chance level in all three conditions
- Exclusion scores are above chance level in the RSI 0 condition only
- Inclusion scores are higher than exclusion scores but this difference is only marginally significant in the RSI 0 condition

Moral

Tasks are not process-pure: they always involve a mixture of conscious and unconcious processes. It's impossible to turn awareness "off"

This has implications for our concept of consciousness

Decision making

Raf Cleeremans

Need a New Car?

Right, but which one?

On Making the Right Choice: The Deliberation-Without-Attention Effect

Ap Dijksterhuis,* Maarten W. Bos, Loran F. Nordgren, Rick B. van Baaren

Contrary to conventional wisdom, it is not always advantageous to engage in thorough conscious deliberation before choosing. On the basis of recent insights into the characteristics of conscious and unconscious thought, we tested the hypothesis that simple choices (such as between different towels or different sets of oven mitts) indeed produce better results after conscious thought, but that choices in complex matters (such as between different houses or different cars) should be left to unconscious thought. Named the "deliberation-without-attention" hypothesis, it was confirmed in four studies on consumer choice, both in the laboratory as well as among actual shoppers, that purchases of complex products were viewed more favorably when decisions had been made in the absence of attentive deliberation.

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Results

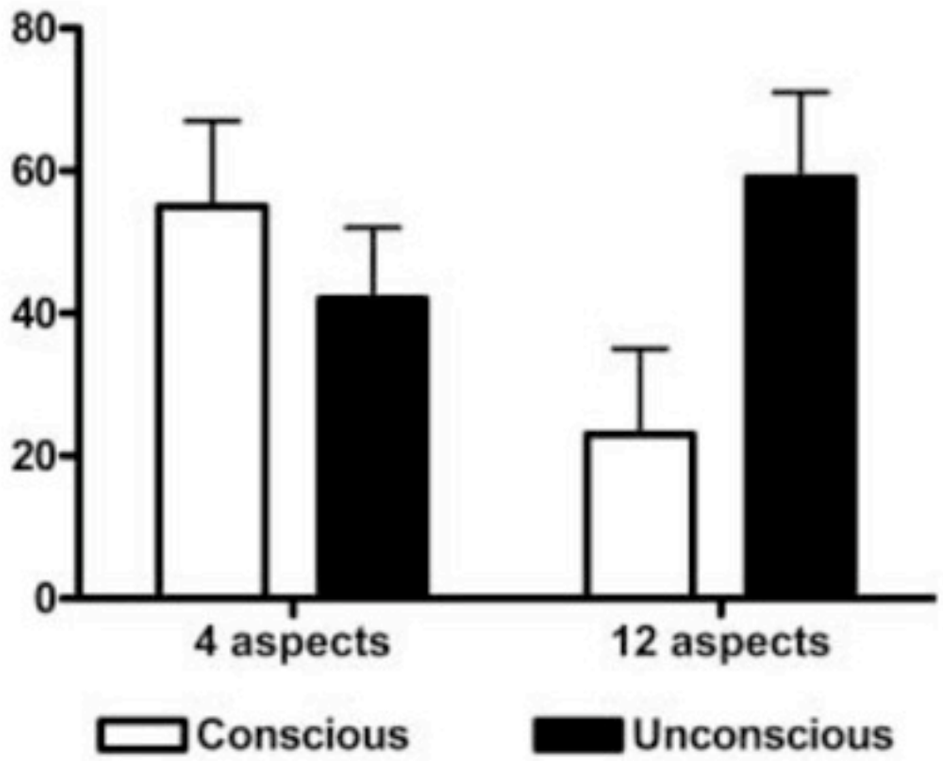

Fig. 1. Percentage of participants who chose the most desirable car as a function of complexity of decision and of mode of thought (n = 18 to 22 in each condition). Error bars represent the standard error.

Trust your gut instinct when those shopping decisions get tough, say scientists

By Roger Highfield, Scienc
Published: 12:01AM GMT

Don't think too hard about major decisions

Big decision time? Best to sleep on it

Megan Rauscher
Reuters

Friday, 17 February 2006

When faced with a major decision, such as buying a car or a house, it's best to do your homework, then forget about it for a while and let your unconscious churn through the options.

According to the results of a novel study published today in the journal *Scienc*
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Conscious deli
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BBC NEWS

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News Front Page

Last Updated: Friday, 17 February 2006, 11:07 GMT

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Sleep on it, decision-makers told

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options.

Scientists said the conscious brain could only cope with small decisions

PERSPECTIVES ON PSYCHOLOGICAL SCIENCE

A Theory of Unconscious Thought

Ap Dijksterhuis and Loran F. Nordgren

Social Psychology Program, University of Amsterdam, Amsterdam, The Netherlands

ABSTRACT—*We present a theory about human thought named the unconscious-thought theory (UTT). The theory is applicable to decision making, impression formation, attitude formation and change, problem solving, and creativity. It distinguishes between two modes of thought: unconscious and conscious. Unconscious thought and conscious thought have different characteristics, and these different characteristics make each mode preferable under different circumstances. For instance, contrary to popular belief, decisions about simple issues can be better tackled by conscious thought, whereas decisions about complex matters can be better approached with unconscious thought. The relations between the theory and decision strategies, and between the theory and intuition, are discussed. We end by discussing caveats and future directions.*

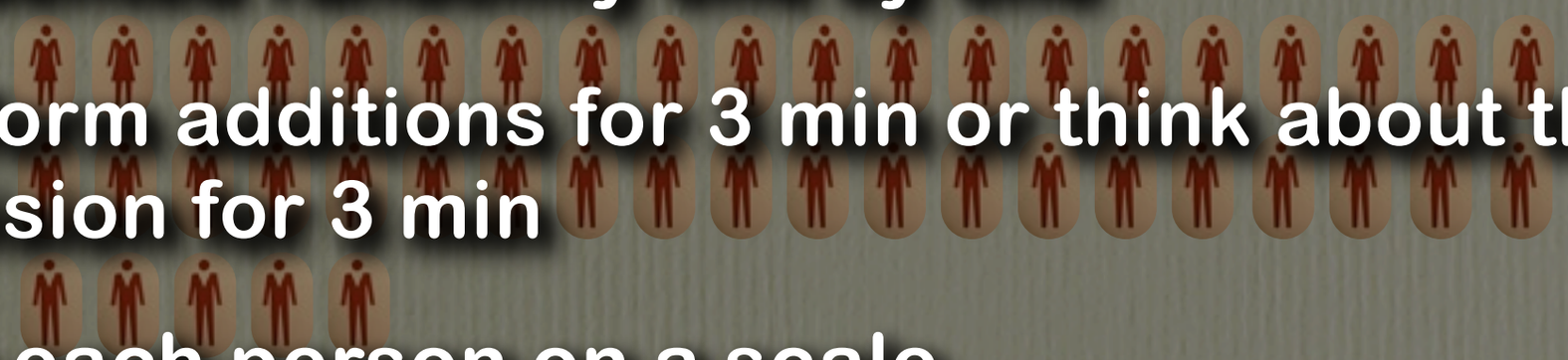
Can we replicate?

- *7 studies involving over > 700 participants*
- *Conceptual & exact replications*
- *Methodological improvements*
- *Manipulation of new factors*

Study 1

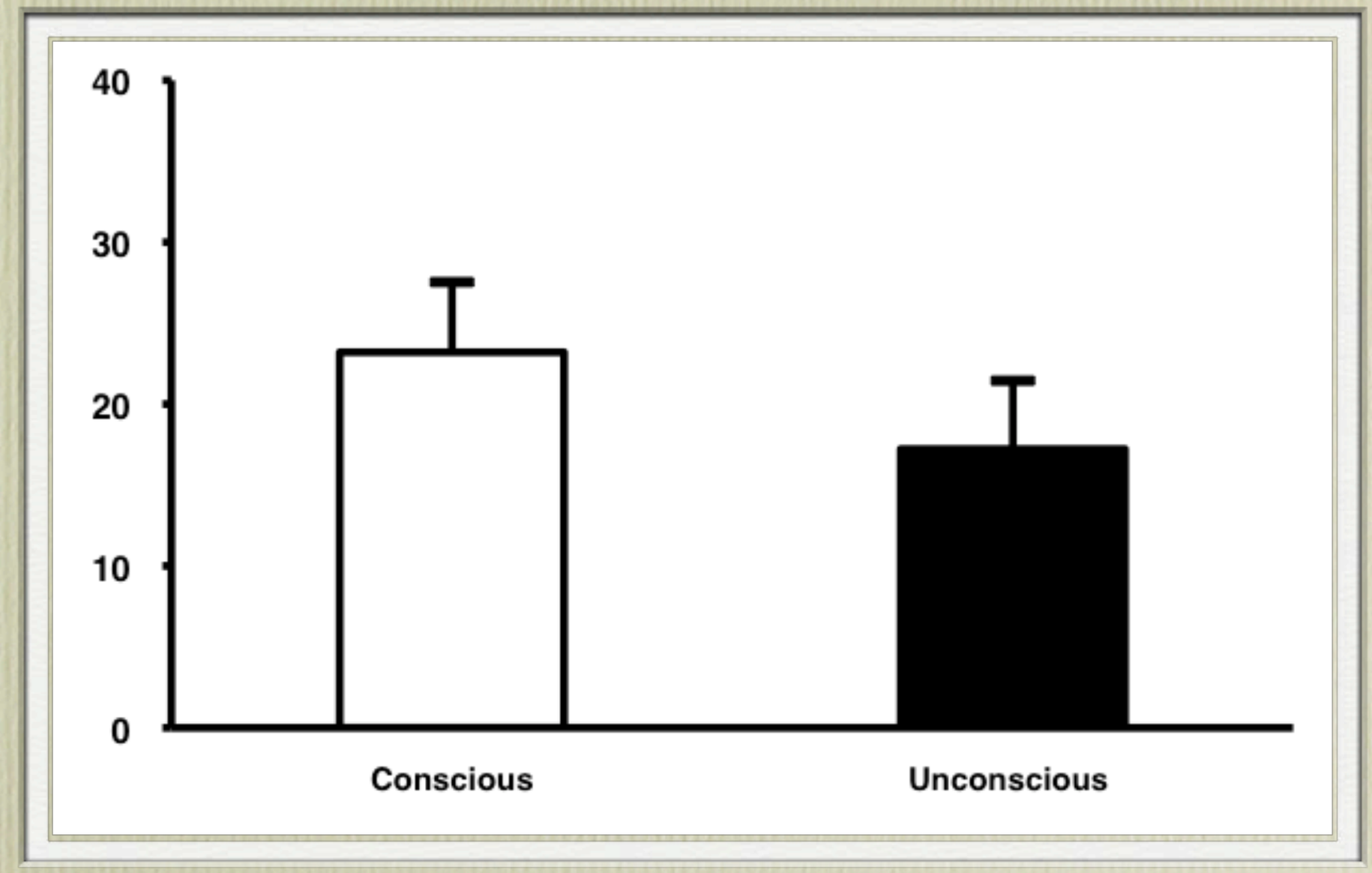
choose the best engineer

- 45 participants
- choose the best engineer amongst 4 candidates each characterized by 12 pre-tested attributes presented randomly one by one



- perform additions for 3 min or think about the decision for 3 min
- rate each person on a scale
- Decision quality: Rating given to the normatively “best” candidate - average of ratings given to the other candidates, converted on a 0-100 scale

Results



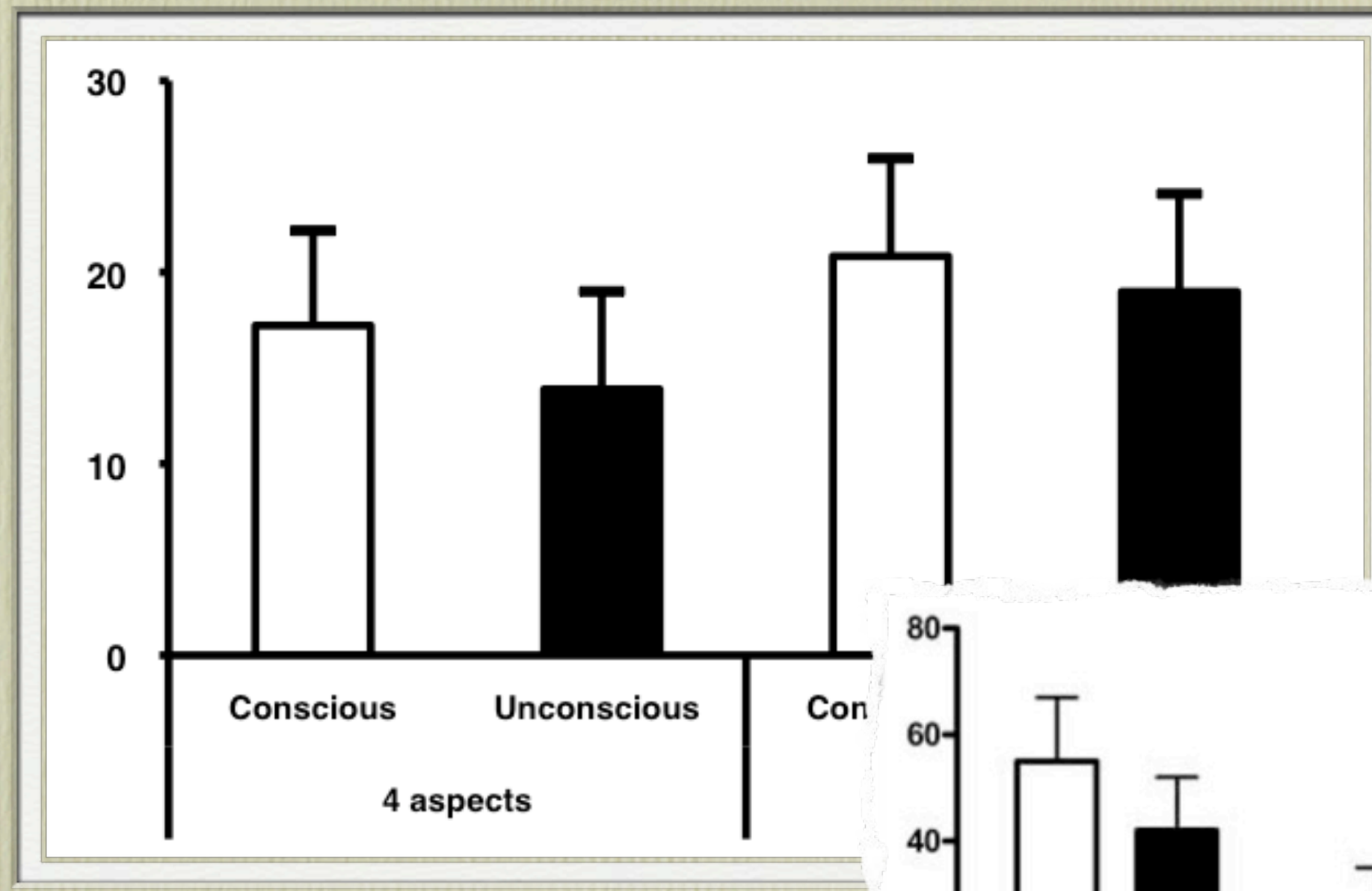
Difference in attitude (on a scale of 0 to 100) toward the desirable and other candidates as a function of Mode of Thought.

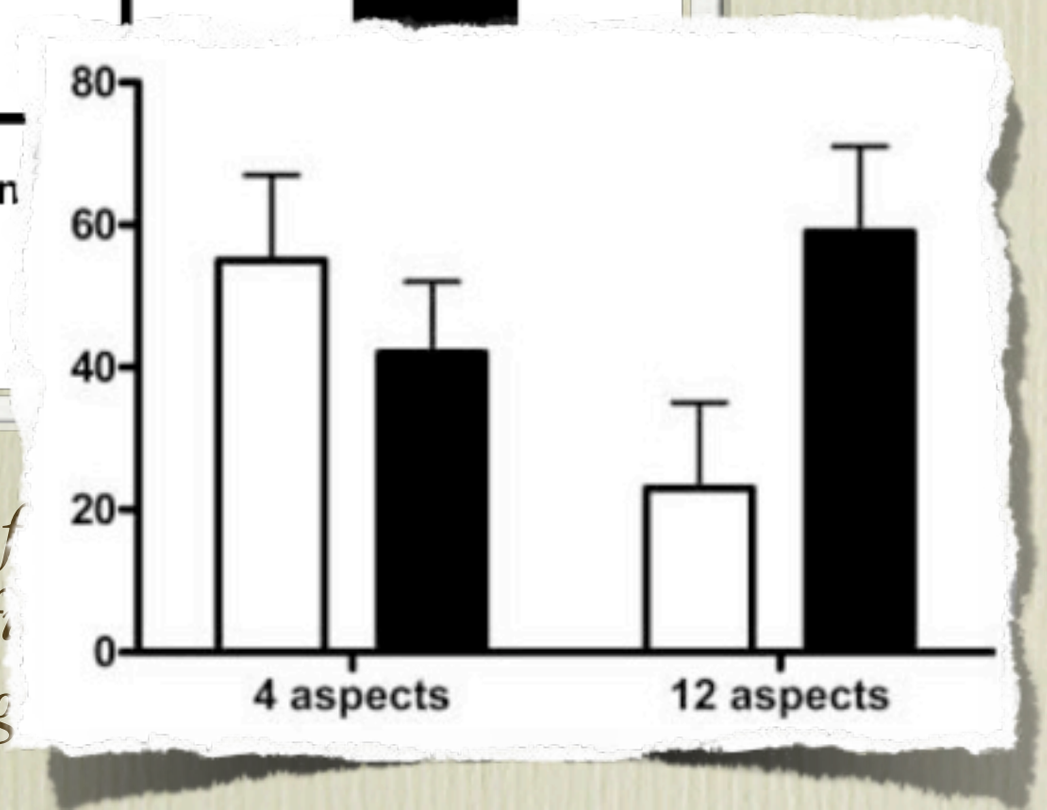
Study 2

choose the best car

- 65 participants
- exact replication of Dijksterhuis et al. (2006): Solve anagrams vs. think about the decision for 4 minutes
- two factors: Complexity (4 vs. 12 attributes) vs. Mode of Thought.

Results





Difference in attitude (on a scale of
desirable and other candidates as a f
Mode of Thoug

The plot thickens...

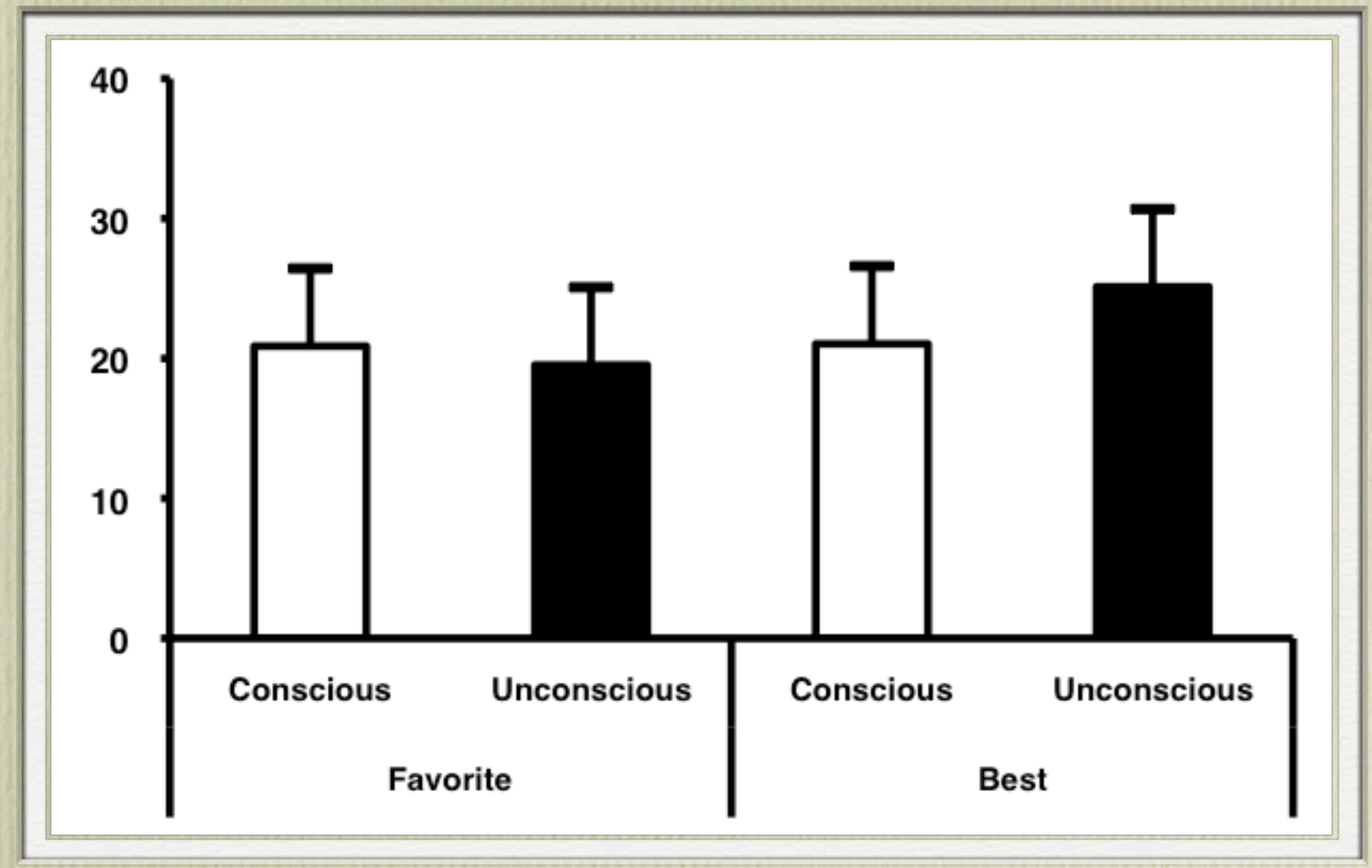
- No difference between conscious and "unconscious" thought
- More worrisome: No correlation between # of attributes taken into account and decision quality

Study 3

choose the best or the favorite car

- 100 participants
- pretest attributes so that they are judged equally important
- “Complex decision” only: 12 attributes
- explore the effects of type of decision
- two factors: Type of decision (“favorite car” - “best” car) vs. Mode of Thought.

Results



Difference in attitude (on a scale of 0 to 100) toward the desirable and other candidates as a function of Type of decision & Mode of Thought.

Study 4

choose the best car: Identify relevant moderators

- 118 participants: 59 men, 59 women, 50% with driving licence
- ask participants about decision timing, about perceived difficulty, & about motivation
- test memory for attributes through recognition
- three factors: Gender X Driving Licence X Mode of Thought.

Results

69.5 % of participants report making a decision during information presentation

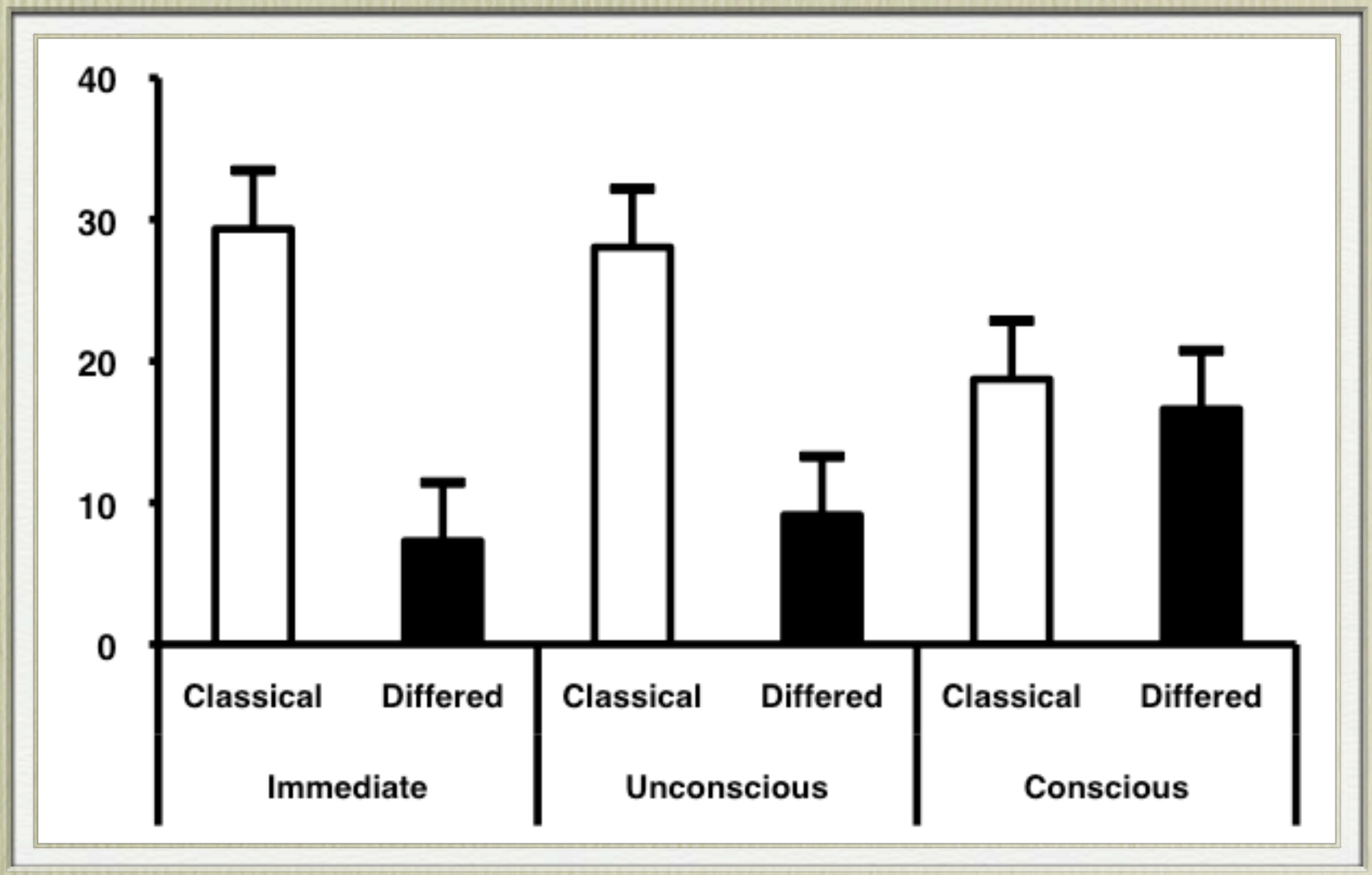
The data have nothing to do with "unconscious thinking": There simply is no thinking going on, conscious or otherwise, for people have already made their decision online

Study 5

choose the best appartment

- 294 participants (!)
- manipulate the task: “memory” (differed) and “impression formation” (classical) conditions
- manipulate the nature of the decision: “immediate”, “conscious” (think about it), “unconscious” (solve anagrams)

Results



Difference in attitude (on a scale of 0 to 100) toward the best and other apartments as a function of Task (impression formation vs. memorization) & Decision Type

Moral

Finding dissociations between performance and awareness does not always entail that performance was driven by unconscious contents...

This has implications for our concept of consciousness

Conclusions

Raf Cleeremans

Conclusions

- *We learn all the time, whether we intend to or not.*
- *All tasks involve both implicit and explicit processes.*
- *Sensitivity to some regularity does not necessarily imply that the regularity itself is represented in the cognitive system as an object of representation.*
- *There is a real challenge in figuring out how symbolic knowledge emerges out of subsymbolic processing*

Radical Plasticity!?!

Brain of a white-collar worker

Lionel Feuillet, Henry Dufour, Jean Pelletier

Lancet 2007; 370: 262

Department of Neurology (L Feuillet MD, J Pelletier PhD), **and Department of Neurosurgery** (H Dufour PhD), **Faculté de Médecine de Marseille, Université de la Méditerranée, Assistance Publique hôpitaux de Marseille—Hôpital de la Timone, Marseille, France**

Correspondence to:
Dr Lionel Feuillet, Department of Neurology, Faculté de Médecine de Marseille, Université de la Méditerranée, Assistance Publique hôpitaux de Marseille—Hôpital de la Timone, Marseille, France
lionel.feuillet@mail.ap-hm.fr

A 44-year-old man presented with a 2-week history of mild left leg weakness. At the age of 6 months, he had undergone a ventriculoatrial shunt, because of postnatal hydrocephalus of unknown cause. When he was 14 years old, he developed ataxia and paresis of the left leg, which resolved entirely after shunt revision. His neurological development and medical history were otherwise normal. He was a married father of two children, and worked as a civil servant. On neuropsychological testing, he proved to have an intelligence quotient (IQ) of 75: his verbal IQ was 84, and his performance IQ 70. CT showed severe dilatation of the lateral ventricles (figure); MRI revealed massive enlargement of the lateral, third, and fourth ventricles, a very thin cortical mantle and a posterior fossa cyst. We diagnosed a non-communicating hydrocephalus, with probable stenosis of Magendie's foramen (figure). The leg weakness improved partly after neuroendoscopic ventriculocisternostomy, but soon recurred; however, after a ventriculoperitoneal shunt was inserted, the findings on neurological examination became normal within a few weeks. The findings on neuropsychological testing and CT did not change.

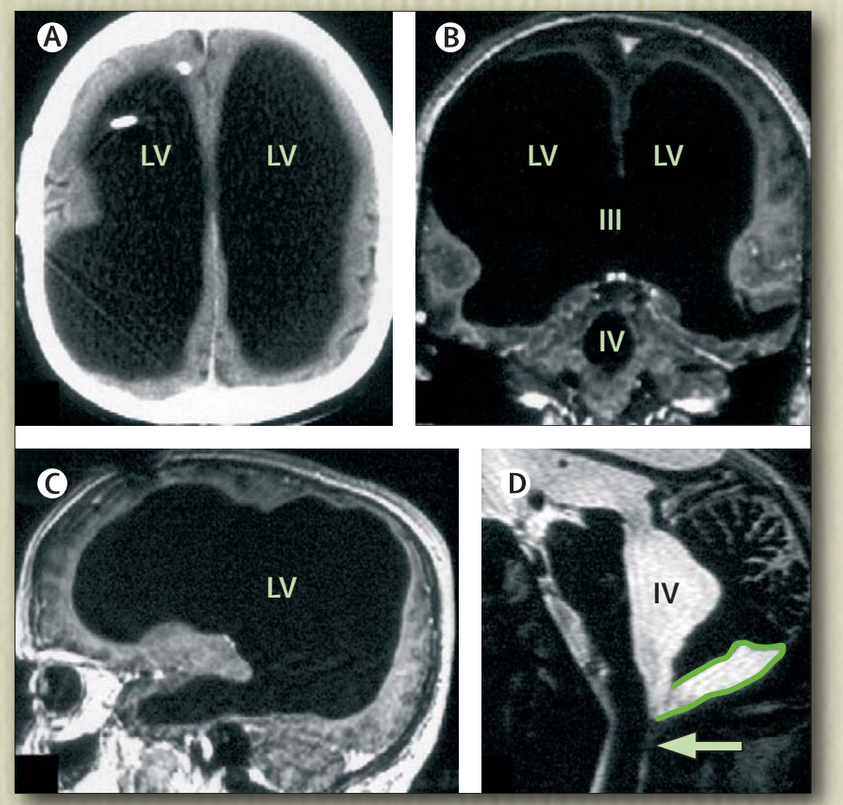
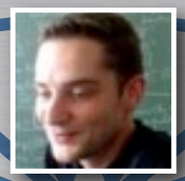
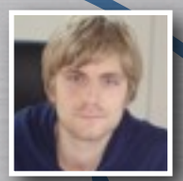


Figure: **Massive ventricular enlargement, in a patient with normal social functioning**
(A) CT; (B, C) T1- weighted MRI, with gadolinium contrast; (D) T2-weighted MRI. LV=lateral ventricle. III=third ventricle. IV=fourth ventricle. Arrow=Magendie's foramen. The posterior fossa cyst is outlined in (D).

Arnaud Destrebecqz



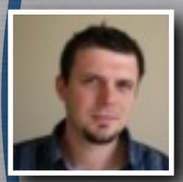
Stéphanie Chambaron



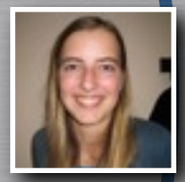
Damien Brevers

Julie Bertels

Vinciane Gaillard



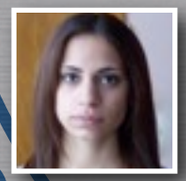
Stéphane Doyen



Astrid Vermeiren

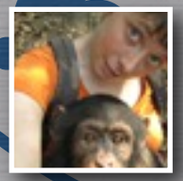
Axel Cleeremans

Anne Atas



Cora-Lise Pichon

Laure Legrain



Ana Franco

Pedro Magalhaes

http://co3.ulb.ac.be