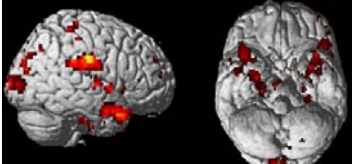


2006 Summer School, Sofia, Bulgaria
July 6, 2006

Cognitive Neuroscience of Thought
Kalina Christoff

Spontaneous Aspects of Thought



Thinking outside the prefrontal cortex

Spontaneous thought processes

Thinking that occurs in an undirected way, without deliberately trying to reach particular mental goal

<u>Goal-directed thought</u>	<u>Spontaneous thought</u>
- directed	- undirected
- deliberate	- not deliberate
- effortful	- effortless
- degree of control	- degree of automaticity

Kinds of thought that tend to include spontaneous components

mind-wandering (Antrobus et al., 1970)
daydreaming (Singer, 1966; Giambra, 1979)

insight problem solving (Maier, 1931; Duncker 1945)
creative thinking

task-unrelated thought (Giambra, 1989)
stimulus-independent thought (Antrobus, 1968; Teasdale et al., 1993)

Spontaneous thoughts: Noise or signal?

Sign of the imperfections of human thinking or An essential part of thought flow

Spontaneous thoughts are known to

- decrease with increasing task demands (Antrobus, 1968; Filler and Giambra, 1973; Teasdale et al., 1993)
- decrease with increasing age (Giambra, 1989)

Distractibility ↑ with age (REF)

Executive processes ↓ with age (REF)
(eg. Reasoning, Problem solving)

Mind-wandering ~~↑~~ with age (Giambra, 1989)

Distractibility ↑ with age (REF)

Executive processes ↓ with age (REF)
(eg. Reasoning, Problem solving)

Mind-wandering ↓ with age (Giambra, 1989)

Mind-wandering follows life time course similar to executive processes

How do we study mind-wandering?

Behavioural procedures

Questionnaires
 subjects answer a series of questions
 retrospective (Giambra, 1977; Giambra, 1979)
 immediate (Klinger and Cox, 1987)

Dual-task interference paradigms
 primary task + monitor and report spontaneous thoughts
 press a button when a thought occurs (Giambra, 1989)
 report number of thoughts at the end of an interval (Antrobus, 1968; Giambra, 1995)

Implicit dual task interference paradigm

(Teasdale et al., 1993; Teasdale et al., 1995)

- a single primary task, no mention of second task
- generation of spontaneous thoughts treated as a second, implicit task
- no continuous self-monitoring requirement

thought-sampling procedure
 subjects are probed, at unpredictable intervals, to report their thought content at that instant

Spontaneous thought depends on central executive resources

Teasdale et al. (1995)

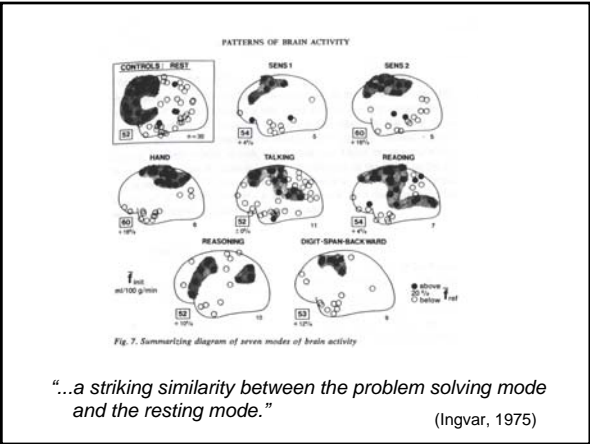
- a random-number generation task
- degree of randomness indicates the extent of executive recruitment (Baddeley, 1986)
- **degree of randomness was lower when task-unrelated thoughts were reported**

Tasks interfere with the production of spontaneous thoughts to the extent that they make continuous demands upon central executive resources.

Cognitive and neural basis

Spontaneous and task-related thought share common

- cognitive resources
- but also...
- neural mechanisms



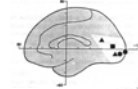
The use of resting baselines

remained a common practice
 rest eyes closed, resting with eyes open, fixation, etc
 frequently justified by the assumption that
 mental processes during rest are unsystematic and unorganised
 neural activation is non-localised and negligible
 has been
 unfortunate (may have obscured activations)
but also...
 fortunate (revealed systematic effects of rest)

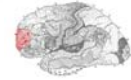
Absence of task-related activation

Noted for a number of brain regions when a resting baseline is used:

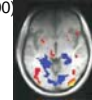
early visual cortex
 (Kosslyn et al., 1995)



rostrolateral prefrontal cortex
 (Christoff and Gabrieli, 2000)



medial temporal lobe
 (Stark and Squire, 2001)



Spontaneous thought during REST

- James (1890)
- Singer (1966)
- Antrobus et al. (1970)
- Ingvar (1975)
- Giambra (1979)
- Klinger & Cox (1987)
- Andreasen et al. (1995)
- Kosslyn et al. (1995)
- Raichle (1998)
- Binder et al. (1999)
- Christoff & Gabrieli (2000)
- Stark & Squire (2001)
- Gusnard et al. (2001)

Random
 Episodic and
 Semantic
 Thinking

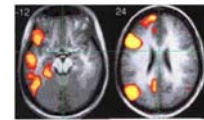
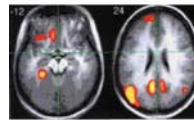
Overlapping network of regions

REST & episodic retrieval (Andreasen et al., 1995)

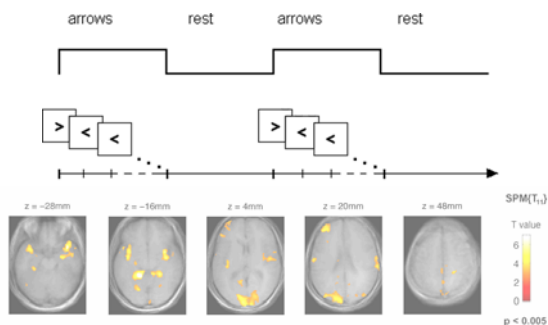
rest > semantic retrieval & episodic > semantic retrieval
prefrontal and parietal association cortices

REST & semantic processing (Binder et al., 1999)

rest > tone discrimination & semantic task > tone discrimination

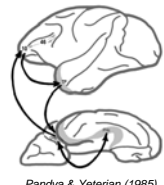
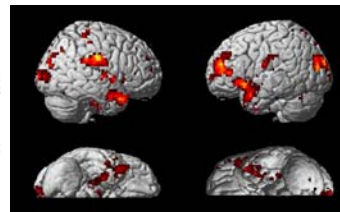


Rest vs Arrows



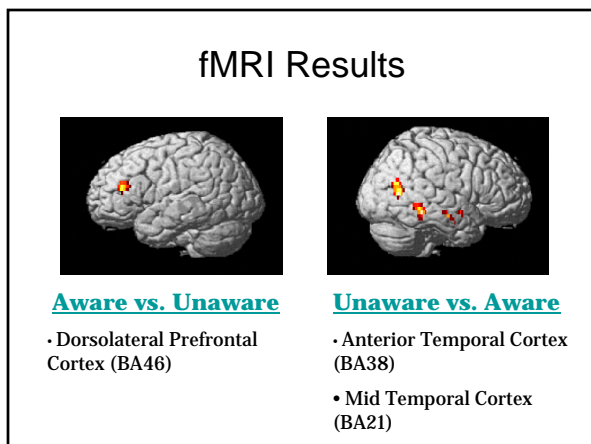
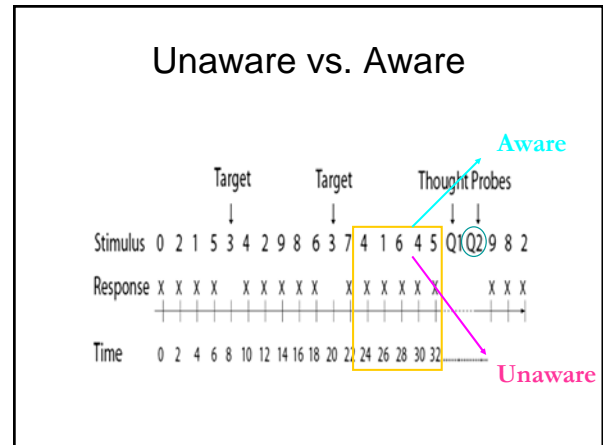
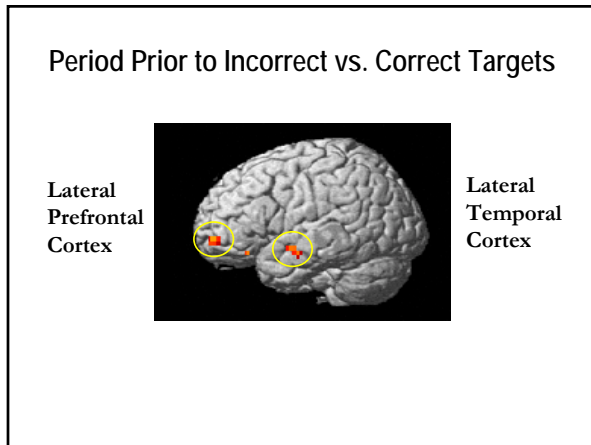
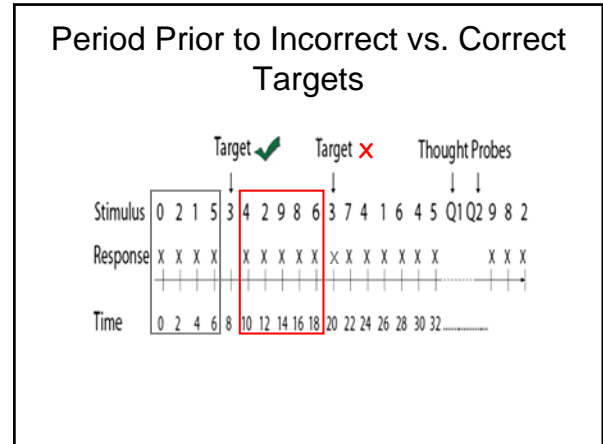
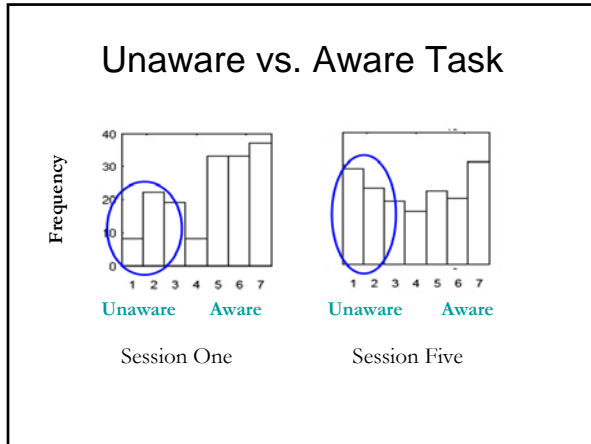
Christoff et al. (2004) Cortex

Activations during rest



Pandya & Yeterian (1985)

- RL PFC (BA10)
- Temporopolar cortex (BA38)
- Parahippocampus (BA36)



Temporal cortex may serve to generate spontaneous thoughts

Awareness of these thoughts activates prefrontal cortex

Insight problem solving

People sometimes solve problems with a unique process called insight, accompanied by an “Aha!” experience.

Insight and non-insight solutions involve, in part, different cognitive and neural processes (although they may share many others processes).

Or

The “aha” experience is epiphenomenal insight and noninsight solutions differ only in subsequent emotional intensity, and are attained with precisely the same cognitive and neural mechanisms.

- ### Characteristics of insight problem solving
- Solvers first come to an impasse, no longer progressing toward a solution (Duncker 1945)
 - There is no conscious access to the process of overcoming the impasse (Maier 1931)
 - Insight often occurs when people are not aware they are thinking of the problem
 - Solutions are experienced as arising suddenly (Metcalfe and Wiebe 1987; Smith and Kounios 1996)
 - The correctness of the solution (or solution path) is recognized immediately
 - Performance on insight problems is associated with creative thinking (Schooler and Melcher 1997)



Insight problems solving

Jung-Beeman et al. (2004) PLoS Biology

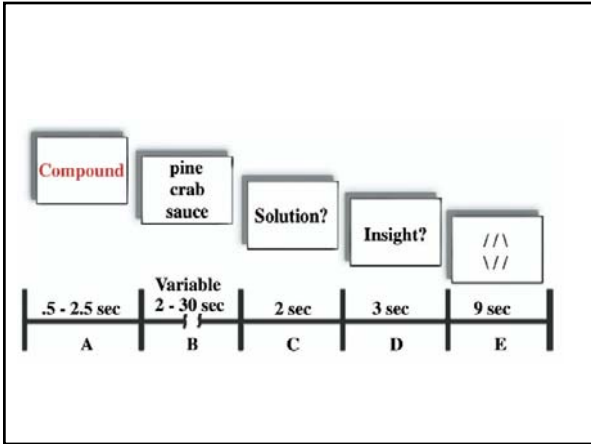
Subjects solved verbal problems

Compound remote associate problems (Bowden & Jung-Beeman 2003) adapted from a test of creative cognition (Mednick 1962).

Subjects saw three problem words:
pine, crab, sauce

and attempted to produce a single solution word that can form a familiar compound word or phrase with each of the three problem words

Answer: APPLE (pineapple, crab apple, applesauce).



Instructions

“A feeling of insight is a kind of ‘Aha!’ characterized by suddenness and obviousness.

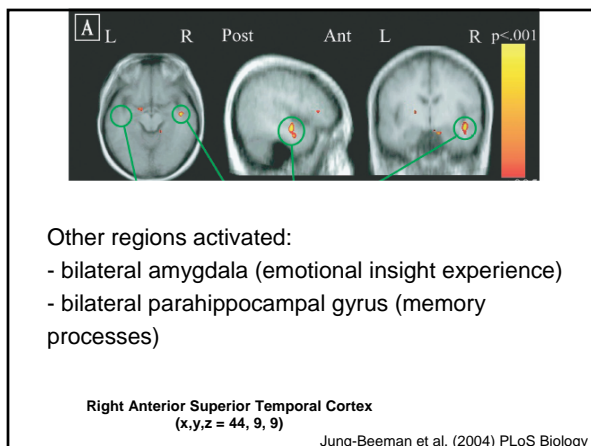
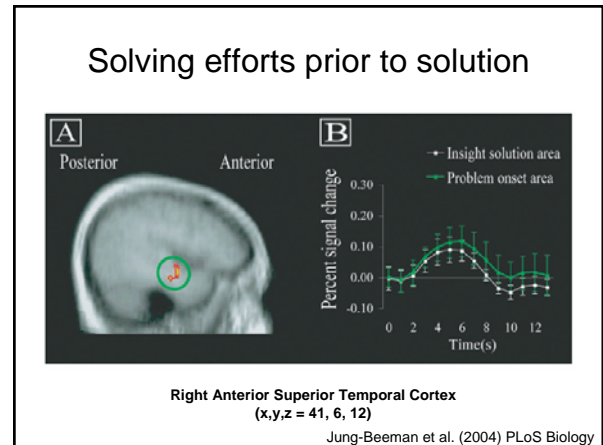
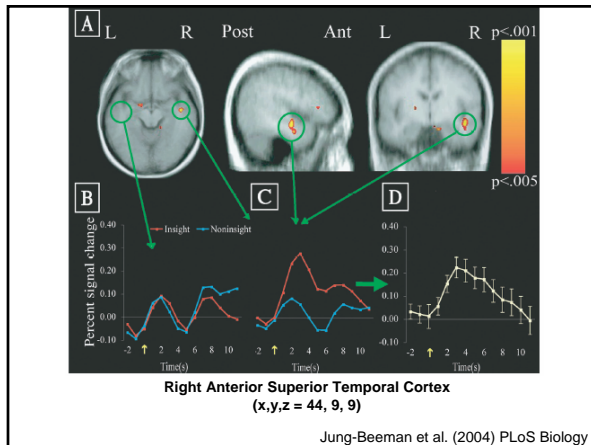
“You may not be sure how you came up with the answer, but are relatively confident that it is correct without having to mentally check it.

“It is as though the answer came into mind all at once—when you first thought of the word, you simply knew it was the answer.”

Advantages

relied on solvers’ reports to sort solutions into insight solutions and noninsight solutions, avoiding the complication that presumed insight problems can sometimes be solved without insight

made use of the most important defining characteristic of insight problems: the subjective conscious experience—the “Aha!”



Piaget’s “object permanence” stage in the child’s thinking

A similar “thought permanence” stage in scientific thinking

