Functional decomposition of spoken word production and its control

Ardi Roelofs

Max Planck Institute for Psycholinguistics
F.C. Donders Centre for Cognitive Neuroimaging
Nijmegen Institute for Cognition and Information
nici

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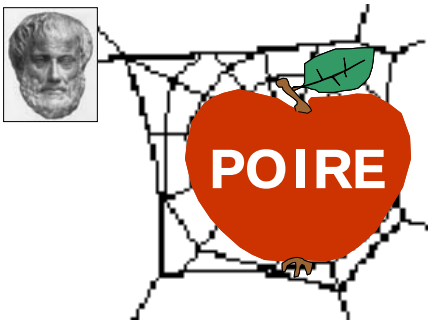
A few numbers

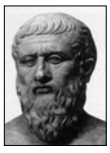
We produce about **2** to **5** words per second.

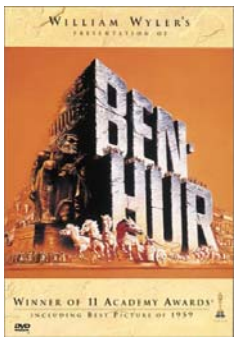
Vocabulary of more than **30,000** words.

About **1** error per **1,000** words.

With **1** hour talking per day, one produces about **4.000.000** words per year, about **200.000.000** words in half a century, i.e., each word, on average, about **6500** times.







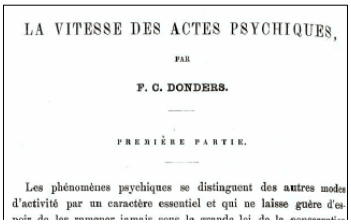
"I can resist everything except temptation."

Oscar Wilde

"Une distraction, à l'instant où l'irritation agit, est toujours punie par une prolongation de durée de l'acte."

F. C. Donders (1868)

Subtraction method



LA VITESSE DES ACTES PSYCHIQUES,

PAR

F. C. DONDERS.

PREMIÈRE PARTIE.

Les phénomènes psychiques se distinguent des autres modes d'activité par un caractère essentiel et qui ne laisse guère d'es-

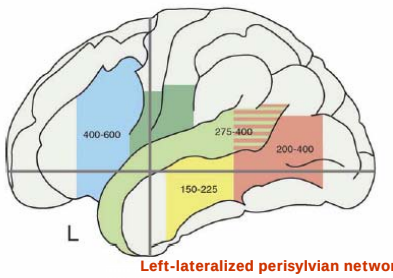
(*Archives néerlandaises des sciences exactes et naturelles*, 1868)

"[One] discovers in comparing the incoming and outflowing blood that oxygen has been consumed [by the brain]."

F. C. Donders (1868)

1868

2006



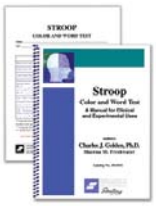
Left-lateralized perisylvian network

ELSEVIER COGNITION

The spatial and temporal signatures of word production components

P. Indefrey*, W.J.M. Levelt (2004)

J. Ridley Stroop (1935)



CAFÉ

CLÉ

TANGO

BLEU

VERT

ROUGE

Stroop asymmetry

Task: Name ink color!

BLEU ROUGE XXX

J. Ridley Stroop (1935)

Task: Read word aloud!

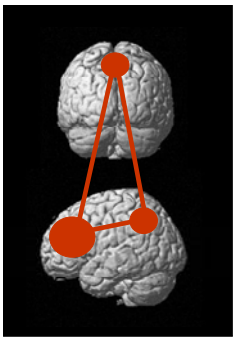
BLEU ROUGE VERT

J. Ridley Stroop (1935)

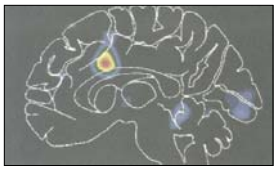
Two accounts of Stroop asymmetry

1. **Pathway strength** (GRAIN)
2. **Functional architecture** (WEAVER++)

Prefrontal-parietal control network



Anterior Cingulate Cortex



Two accounts of ACC function

1. **Conflict detection** (GRAIN)
2. **Top-down regulation** (WEAVER++)

Outline of the remainder

1. Structure of lexical memory.
2. Stroop asymmetry and its time course.
3. Control processes.

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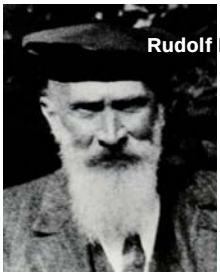
Slips of the tongue



Rudolf Meringer & Karl Mayer

Versprechen und Verlesen (1895)

Slips of the tongue

Rossi & Defare (*Int. J. Psycholing.*, 1995)

Meaning

"Il faut faire grossir les gros obèses"

maigrir

Syntax

"sur la femme de leurs genoux"

les genoux de leur femme

"une contusion à la chambre"

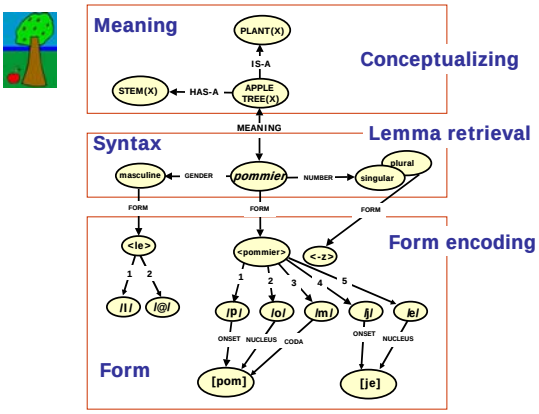
jambe

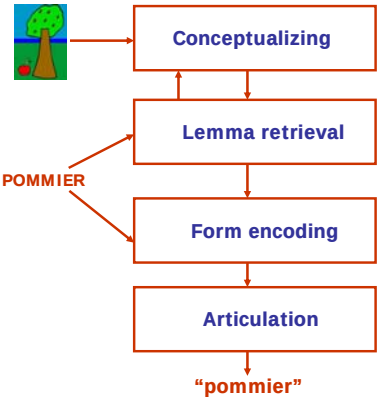
"Franche Dimance"

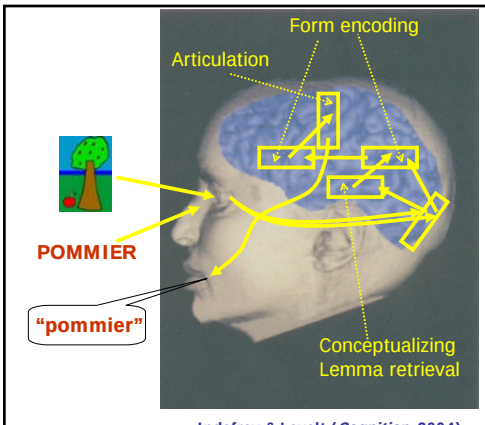
c ch

Form

WEAVER++
Levelt, Roelofs, & Meyer (*BBS*, 1999)







Indefrey & Levelt (*Cognition*, 2004)

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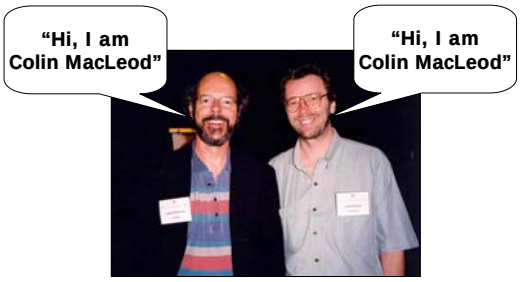
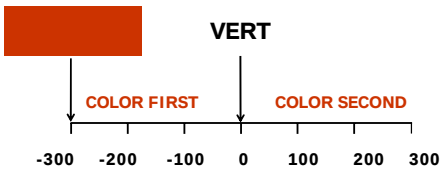


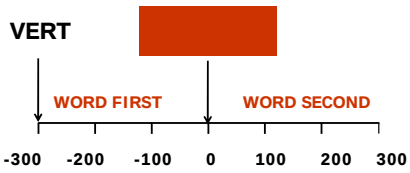
Stroop asymmetry

J. M. Cattell (1886)

"Reading is faster than color naming."



SOA (in milliseconds)



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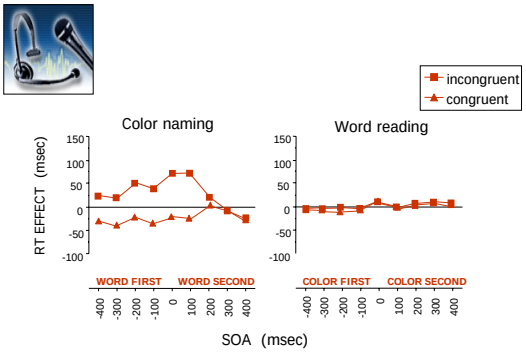


Glaser & Glaser (*JEP:HPP*, 1982)

VERT

VERT

Melara & Algom (*Psych. Rev.*, 2003)

Melara & Mounts (*Mem. & Cogn.*, 1993)

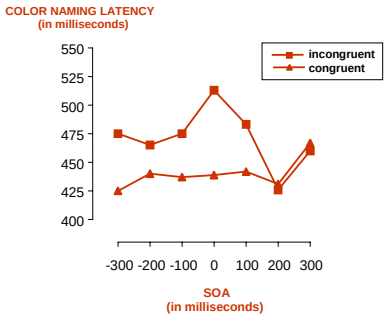
Repeating is as fast as color naming

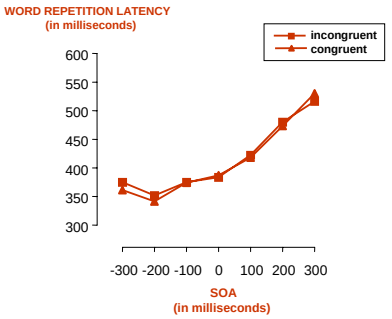
(hear: bleu) incongruent

(hear: rouge) congruent

control task: keypress

Roelofs (*Mem. & Cogn.*, 2005)





Two accounts of Stroop asymmetry

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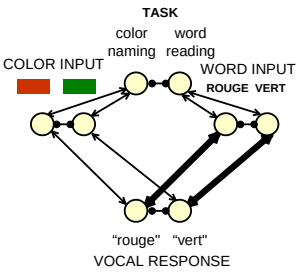
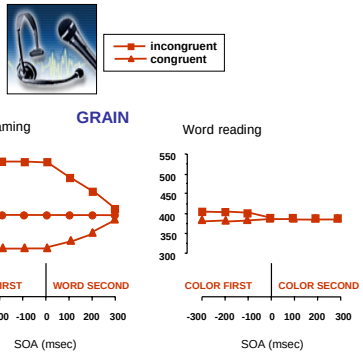
2. **Functional architecture** (WEAVER++)

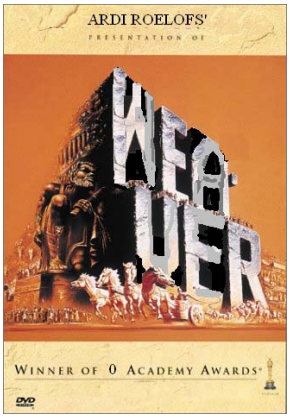
GRAIN



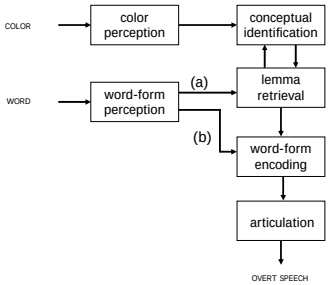
Cohen et al. (1990, *Psych. Rev.*), Botvinick et al. (2001, *Psych. Rev.*)



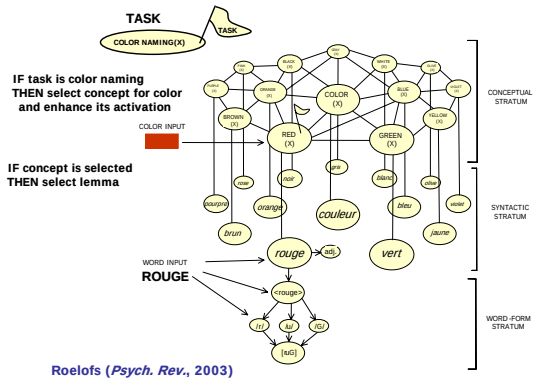
Cohen & Huston (1994, *Att. & Perf.*)



WEAVER++ model of spoken word production



Levelt et al. (*BBS*, 1999),
Roelofs (*Cognition*, 1992, 1997; *Psych. Rev.*, 2003, 2004)

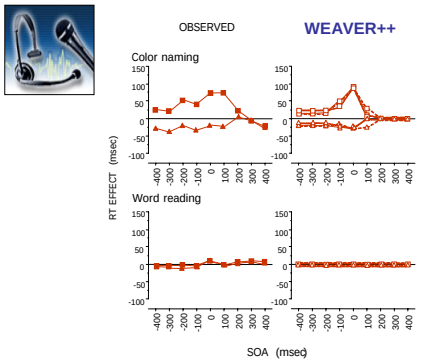


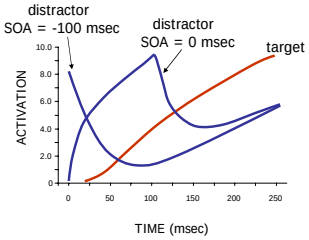
Roelofs (*Psych. Rev.*, 2003)

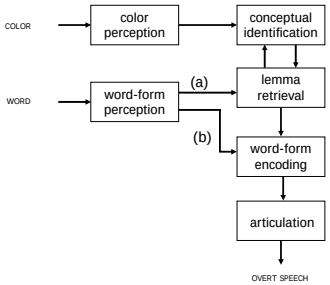
Colin MacLeod's (1991) top-16

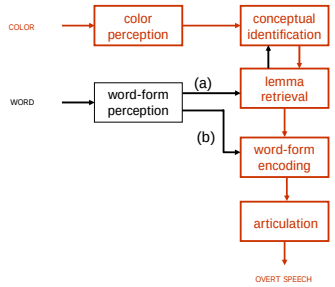
incongruency, congruency, reverse Stroop, response set, semantic gradient, time course, stimulus, spatial, multiple task, manual, bilingual, training, age, and pathological effects.

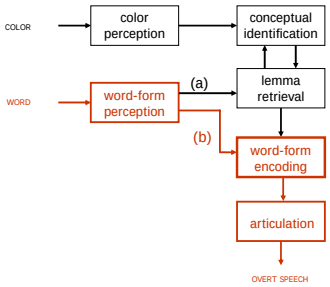
250 data points from 16 classic studies
3 free parameters taking 2 values each.
r(model-data) = .98
WEAVER++ explains 96 percent of the variance.

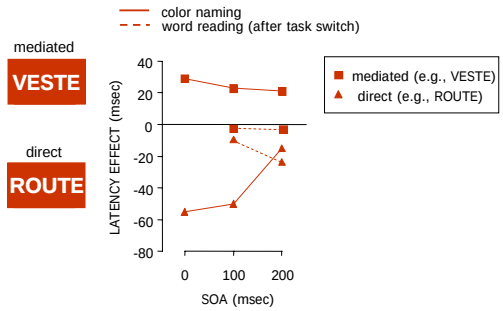




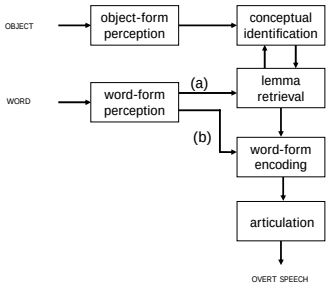


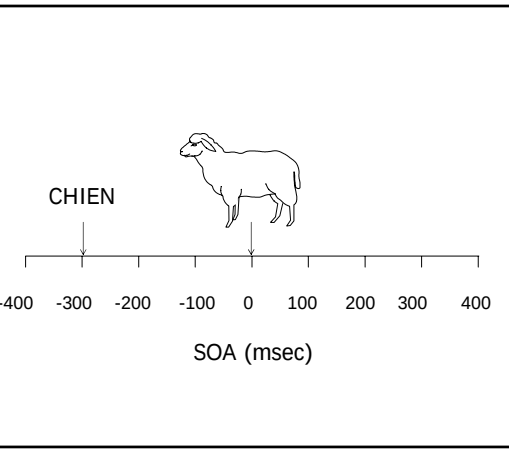


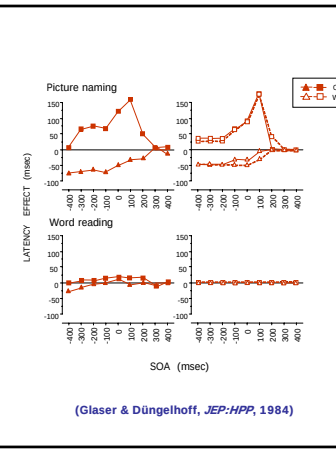




Roelofs (*Psych. Rev.*, 2003)

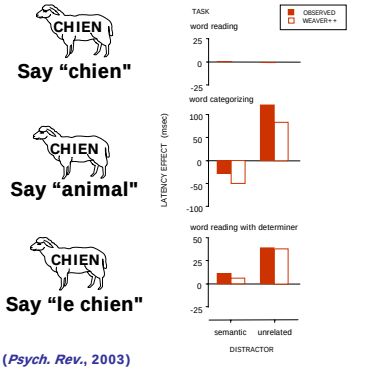






(Glaser & Düngelhoff, *JEP:HPP*, 1984)

Picture distractor



Roelofs (*Psych. Rev.*, 2003)

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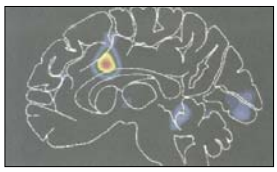
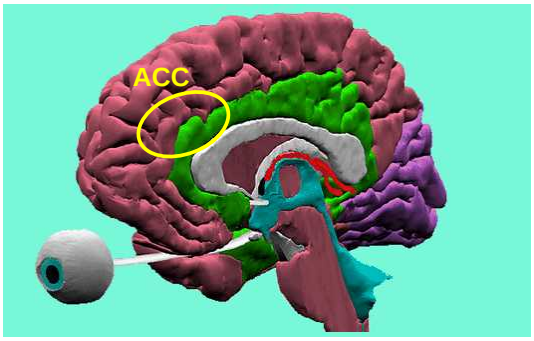
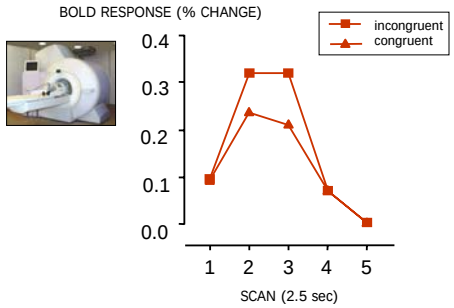
Prefrontal-parietal control network

anterior cingulate cortex



Posner & Raichle (*Images of Mind*, 1994)





MacDonald et al. (*Science*, 2000)

Two accounts of ACC function

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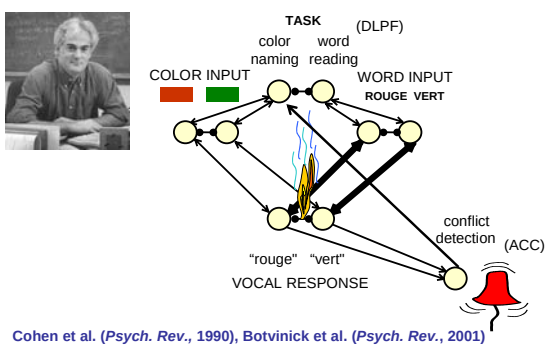
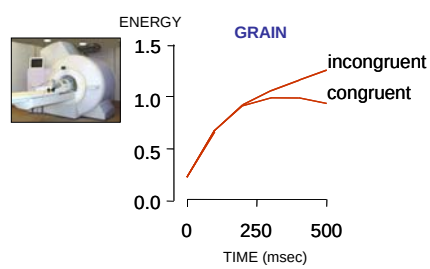
GRAIN

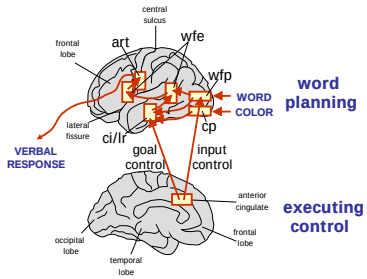


Cohen et al. (*Psych. Rev.*, 1990), Botvinick et al. (*Psych. Rev.*, 2001)



Botvinick et al. (*Psych. Rev.*, 2001)

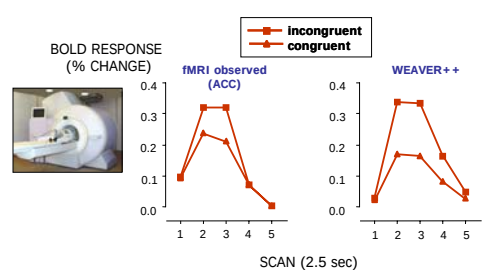
WEAVER++



Roelofs (*Psych. Rev.*, 2003)

IF task is color naming THEN select concept for color and enhance its activation

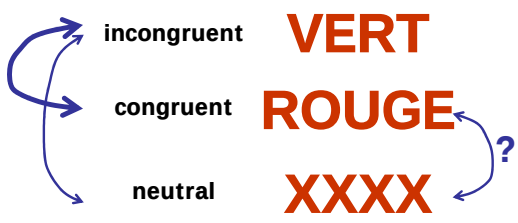
$$\text{BOLD response}(t) = wt^{du/\Delta t}\, e^{-t/\text{crindiff}}$$

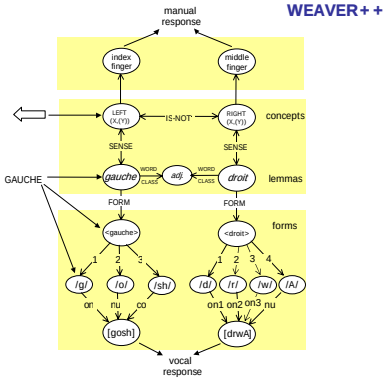


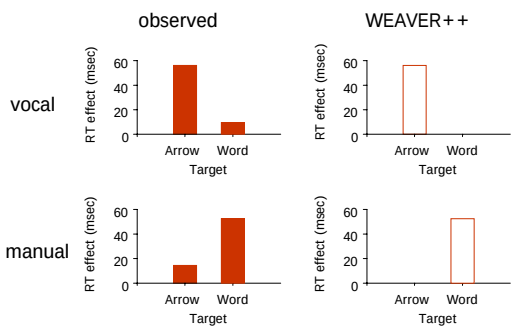
MacDonald et al. (*Science*, 2000)

Roelofs & Hagoort (*Cogn. Brain Res.*, 2002)

Stroop subtractions in neuroimaging





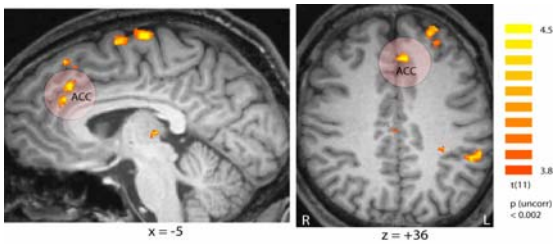


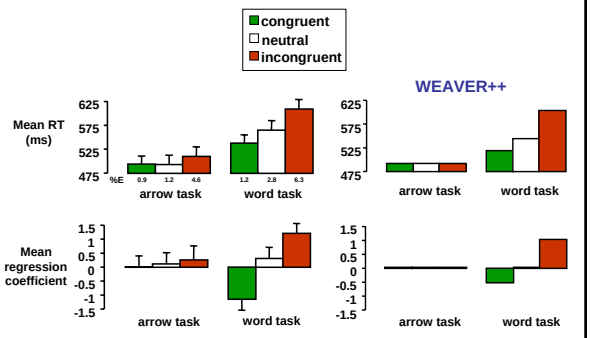
Turken & Swick (*Nat. Neurosc.*, 1999)

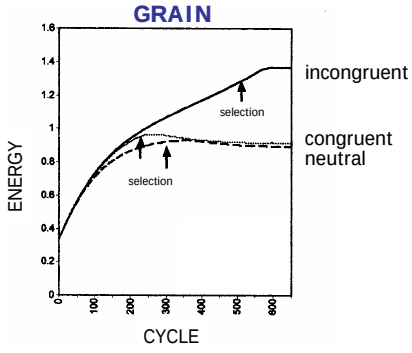
	congruent	neutral	incongruent
Respond to the arrow	DROIT	XXXX	GAUCHE
Respond to the word	DROIT	DROIT	GAUCHE

Roelofs, Van Turennout, & Coles (*submitted*)

Incongruent *vs.* congruent in word task







Botvinick et al. (*Psych. Rev.*, 2001)

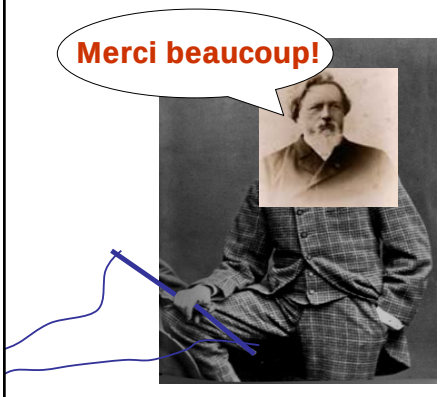
Summary

1. **Structure of lexical memory:**
   Concepts, lemmas, forms
2. **Stroop asymmetry and its time course:**
   Strength vs. architecture
3. **Control processes:**
   ACC: conflict detection vs. regulation

WEAVER++ on the Web

http://www.nici.ru.nl/~ardiroel/weaver++.htm

Stroop demo

GREEN

http://www.nici.ru.nl/~ardiroel/stroop.htm