Hemispheric Asymmetry & Joke Comprehension

Hemispheric Asymmetry

"You're a right-brained sort of person, Mr. Somersby -- very creative, artistic, etc... Unfortunately, I think I also see why you're having trouble figuring out your gas mileage."

Structural Asymmetries

LEFT HEMISPHERE

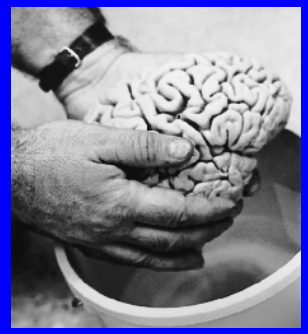
- Extends further posteriorly
- More gray matter, more neurons
- Planum temporale larger in 60-90% of people
- Larger insula, frontal operculum
- Less dendritic branching
- Greater concentration of dopamine

RIGHT HEMISPHERE

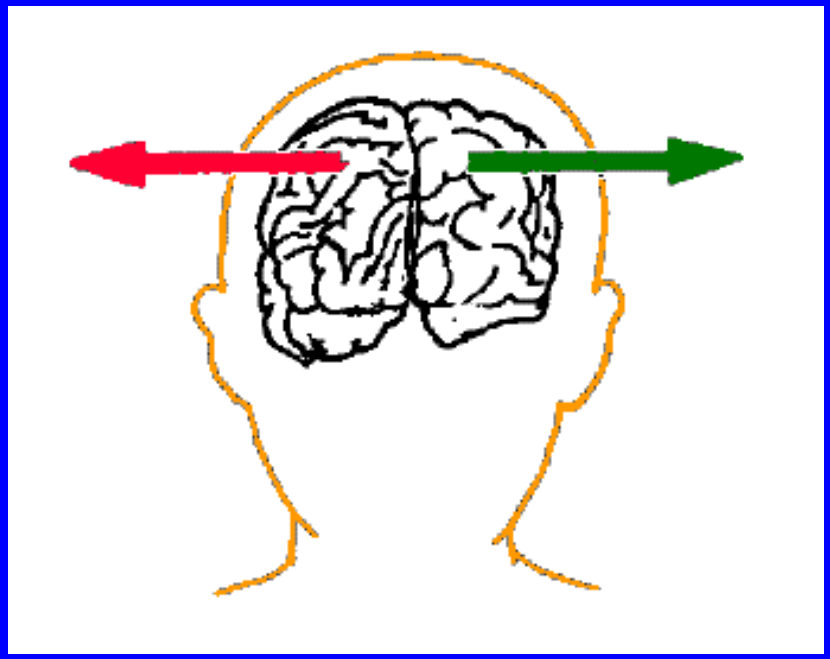
- Extends further anteriorly
- Neuron density lower in frontal “language regions”
- Heschl’s gyrus larger (sometimes twice as big)
- Smaller insula, frontal operculum
- More dendritic branching
- Greater concentration of norepinephrine

Functional Asymmetry

Left brain/Right brain



Speech
Word-finding
Grammar



Discourse
Metaphors
Jokes

When I asked the bartender for something cold and full of rum, he recommended his ...

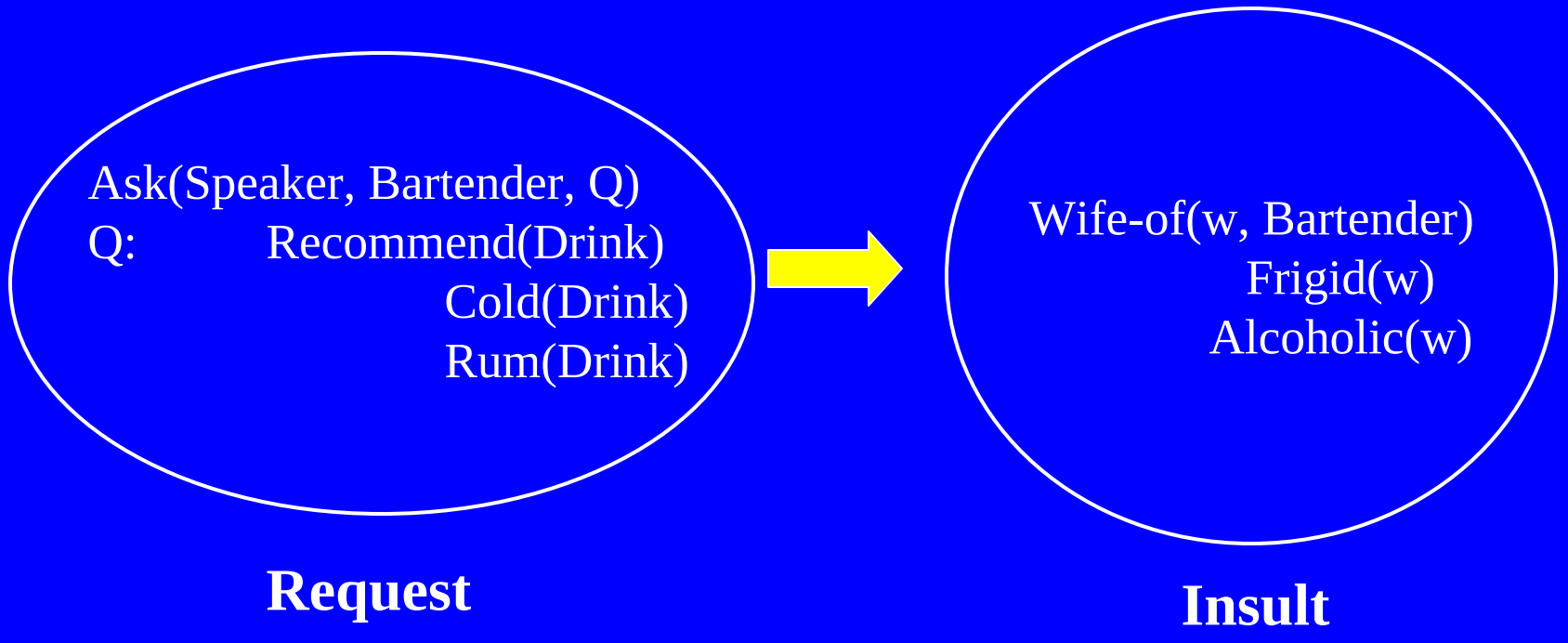
Ask(Speaker, Bartender, Q)
Q
Recommend(Drink)
Cold(Drink)
Rum(Drink)

Request

When I asked the bartender for something cold and full of rum, he recommended his **wife.**

Frame-shifting

- Semantic/Pragmatic reanalysis that reorganizes existing elements in the message-level representation into a new frame



Implications

- Highlights importance of background knowledge for comprehension & development of expectations
- Reveals flexibility in interpretation
  - ability to integrate information from initial erroneous interpretation with new information
- “Surprise” aspect of jokes is not just that a word doesn’t mean what we thought (e.g. “cold”), but that the scenario differs from what we had assumed

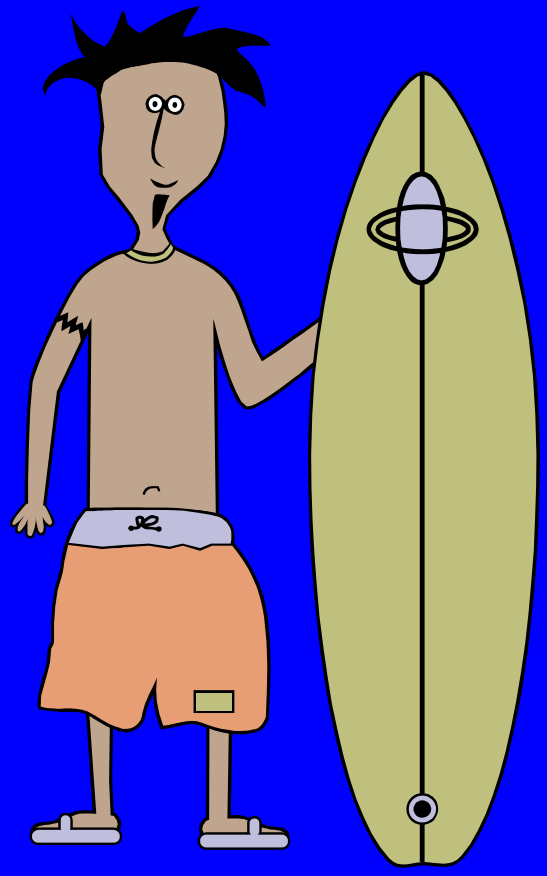
Joke Comprehension Test

A teenager is being interviewed for a summer job. "You'll get $50 a week to start off," says his boss. "Then after a month you'll get a raise to $75 a week."

(a) "I'd like to take the job. When can I start?"

(b) "That's great! I'll come back in a month."

(c) "Hey boss, your nose is too big for your face!"



RHD & Frame-Shifting

- RHD also impairs frame-shifting in non-joke materials (Brownell, et al. 1986)

Barbara became too bored to finish the history book. She had already spent five years writing it.

Johnny missed the wild pitch. The windshield was shattered.

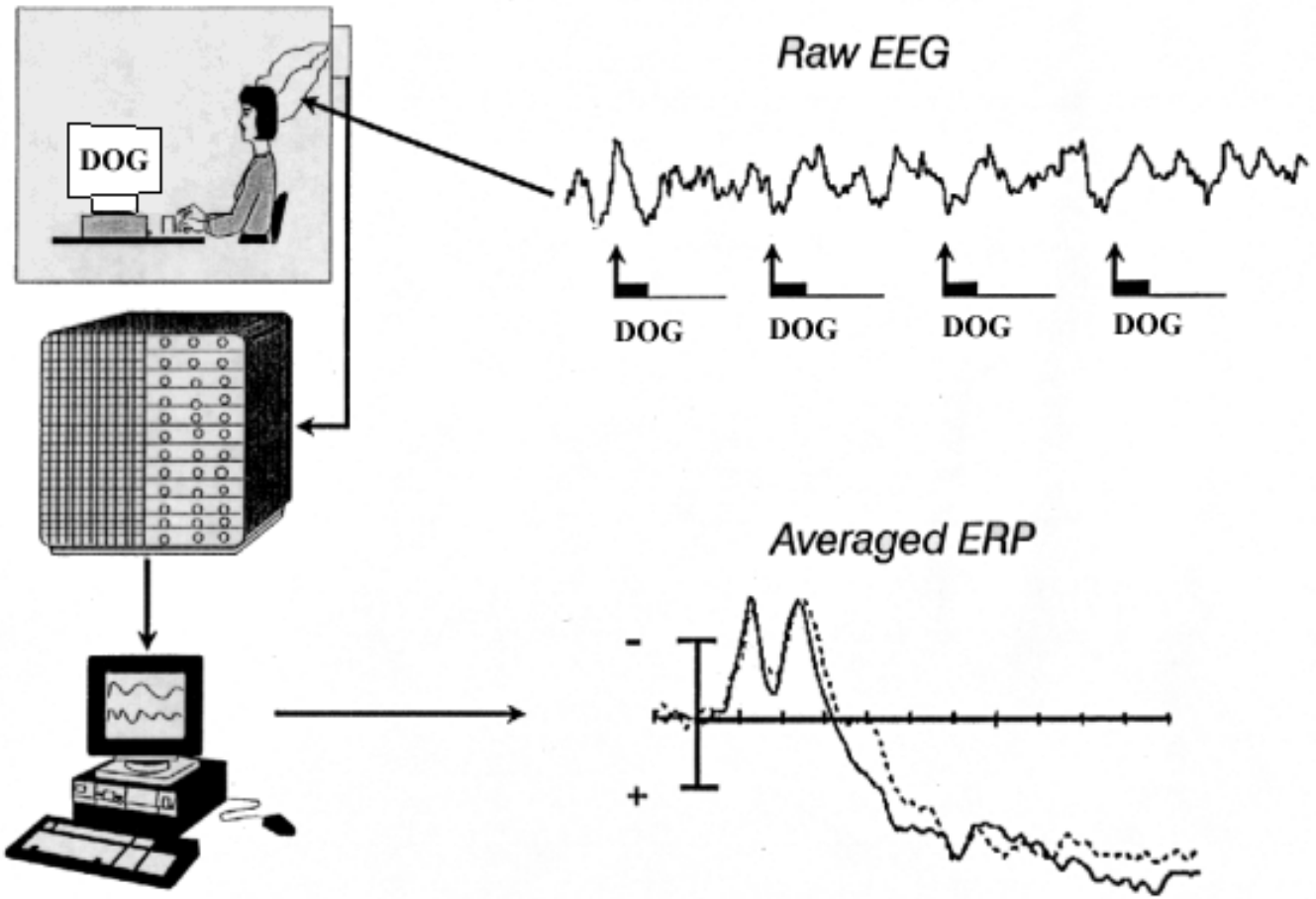
Issues

- Is there evidence for hemispheric asymmetry in joke comprehension in healthy adults?
- If so, what hemispheric differences contribute to this asymmetry?
  - Coarse Coding Hypothesis: Nature of semantic activation differs in the two hemispheres
  - Time Course Hypothesis: Timing of semantic activation differs in the two hemispheres

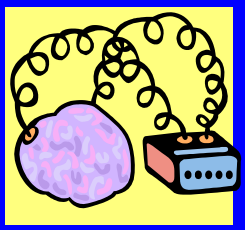
Event-Related Brain Potentials

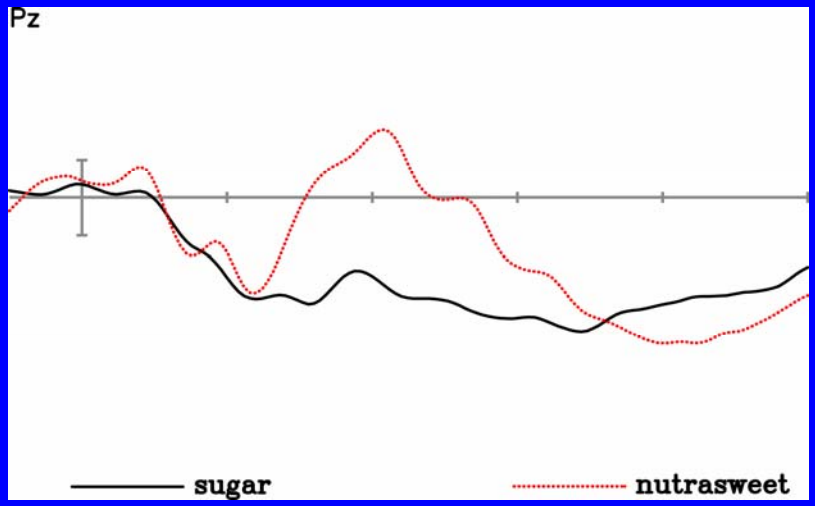
- Sensitive to language comprehension processes
- Sensitive to lateralized brain activity

Event-Related Potential Technique



Language ERP Effects





- N400
  - Negative-going wave
  - 200-700 ms post-word
  - Peak approx. 400 ms
- Modulated by
  - Word Class
  - Contextual Congruity
  - Cloze Probability
- Index of difficulty of lexical integration

Goals of Study 1

- Identify ERP indices of frame-shifting needed for joke comprehension
- Look for lateralized ERP effects

Design

High Constraint: 40%-100%

I asked the woman at the party if she remembered me from last year and she said she never forgets a (face 81%)

Straight: name. *Joke:* dress.

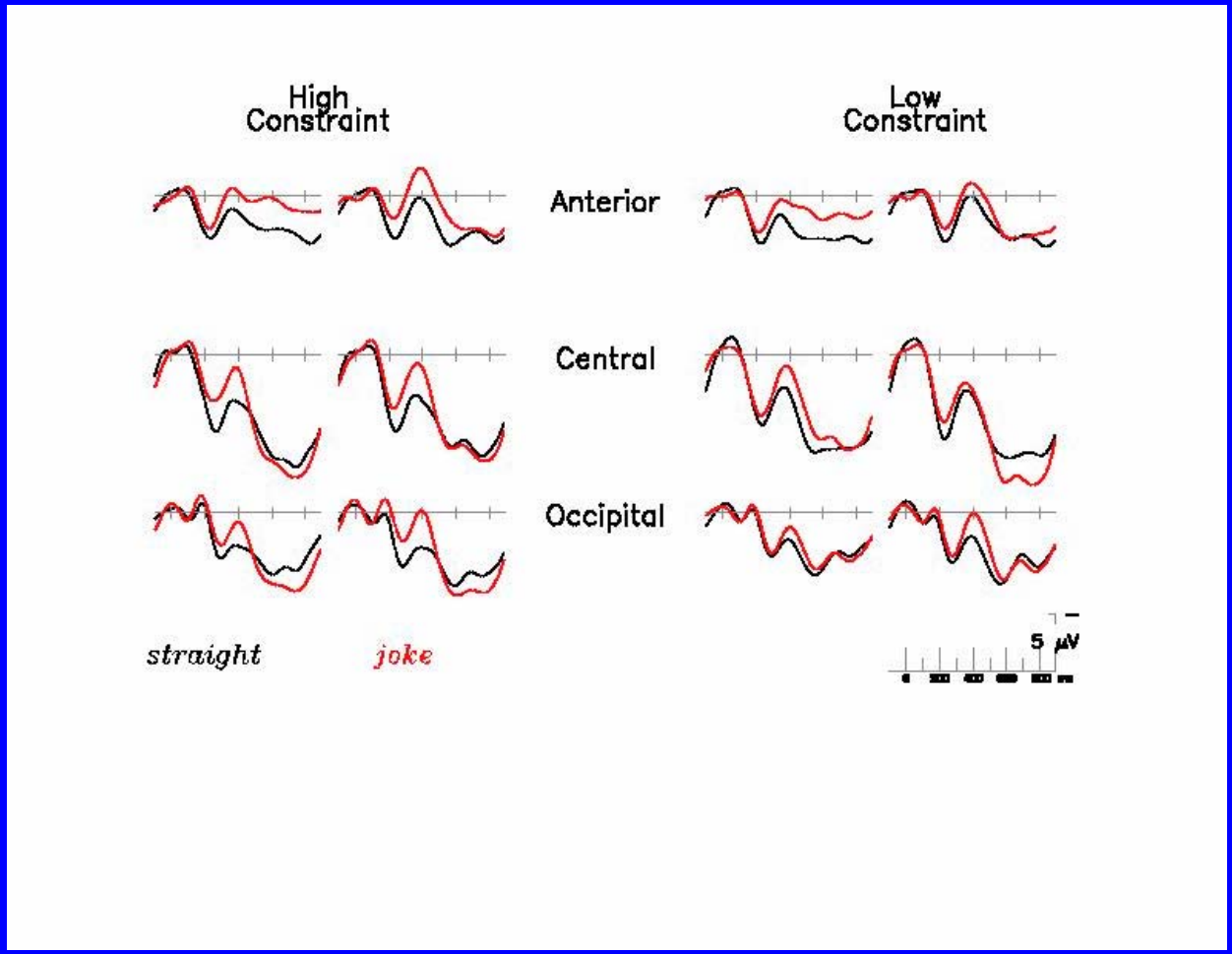
Low Constraint: 10%-40%

My husband took the money we were saving to buy a new car and blew it all at the (casino 18%)

Straight: tables. *Joke:* movies.

(Coulson & Kutas, 2002)

ERPs to Jokes



(Coulson & Kutas, 2002)

Findings

- ERP indices of joke processing
  - High Constraint: Enhanced N400 & LPC
  - Low Constraint: Late fronto-central positivity
- ERP index of frame-shifting
  - Sustained negativity
- Lateralized ERP effects
  - N400: R>L
  - LPC: R>L
  - Sustained negativity: evident only over a few left anterior sites

Good vs. Poor Joke Comprehenders

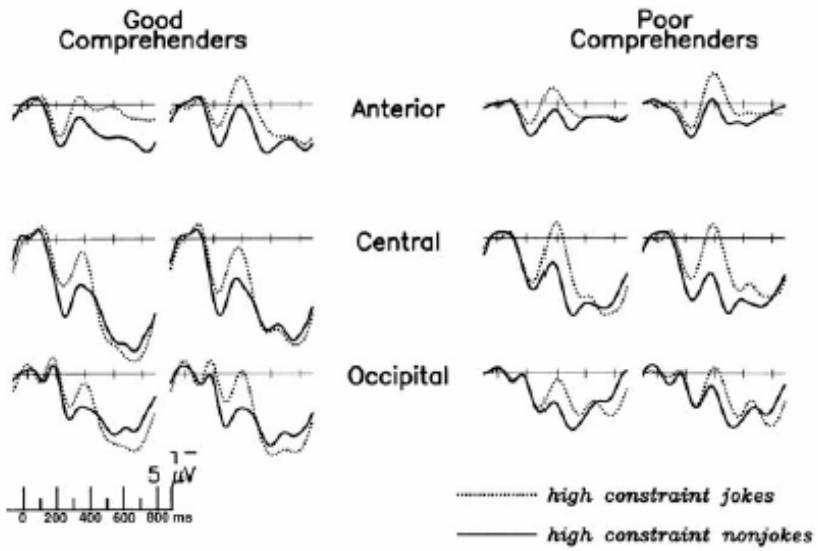


Fig. 3. Grand average ERPs to joke (dotted) and non-joke (solid) endings to high constraint sentences in good joke comprehenders ($n = 14$) and poor joke comprehenders ($n = 14$).

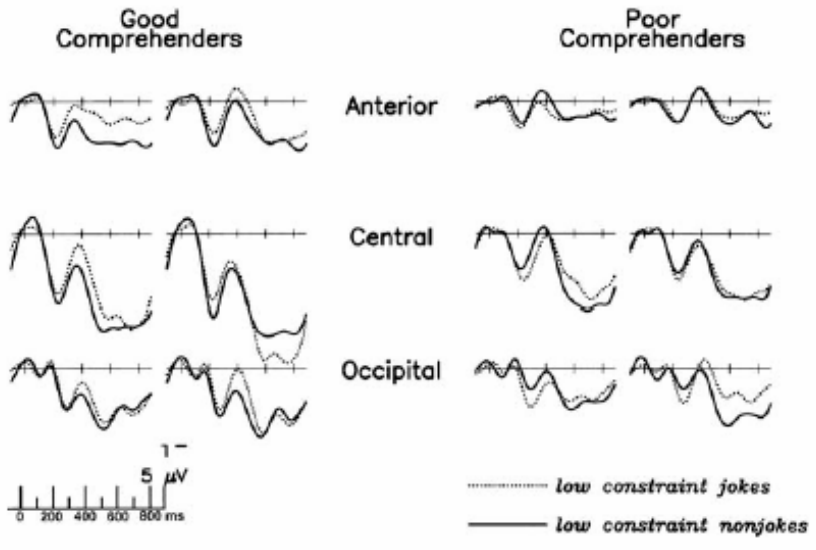
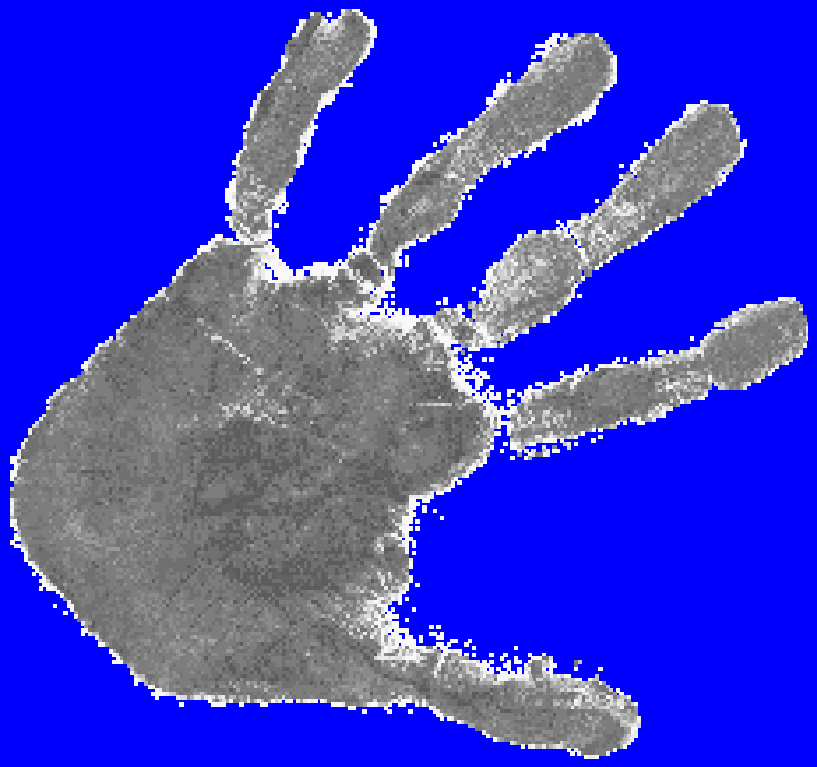


Fig. 4. Grand average ERPs to joke (dotted) and non-joke (solid) endings to low constraint sentences in good (left) and poor (right) joke comprehenders.

Handedness



- 90% of people are right-handed
- 95-98% of right-handers are LH dominant for speech
- 70% of left-handers are LH dominant for speech
- 30% evidence of bilateral speech representation
- Better aphasia recovery rates in left-handers

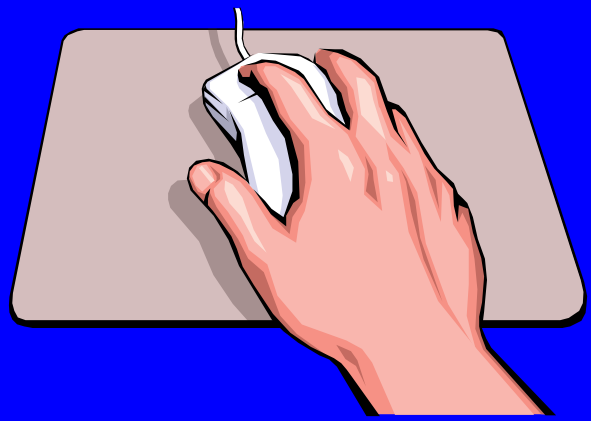
Handedness & Asymmetry

Left-Handers

- Larger Corpora Callosa
- Symmetric Plana Temporale
- Less Hemispheric Specialization

Right-Handers

- Smaller Corpora Callosa
- Asymmetric Plana Temporale
- More Hemispheric Specialization



Handedness & Joke Comprehension

- If left-handed folks have more bilateral language representation, what are the consequences for the processing of figurative language phenomena for which the RH is assumed to play a critical role?

Issues in Coulson & Lovett (2004)

- Do ERPs elicited by jokes differ in the two groups?
- Evidence of less lateral asymmetry in lefties' brainwaves?

Materials

Sentences ending either as jokes or with equally unexpected straight endings consistent with the contextually evoked frame

Straight ending: A replacement player hit a homerun with my BALL.

Joke ending: A replacement player hit a homerun with my GIRL.

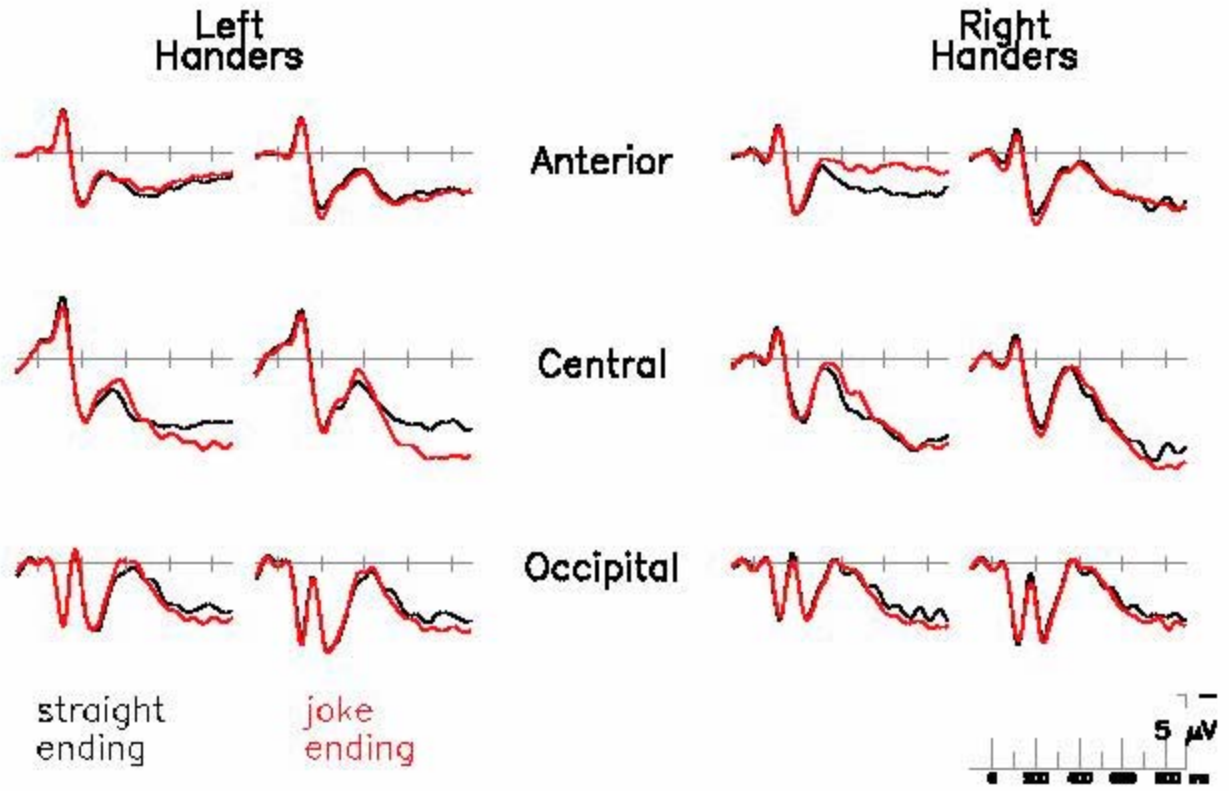
Participants

Left Handers

- Laterality Quotient: -51
- Token Test: 37.4/40
- Semantic Relations: 16.1/18
- Peabody Picture Vocabulary Test: 164.3/175 (raw score)
- 8 men and 8 women

Right Handers

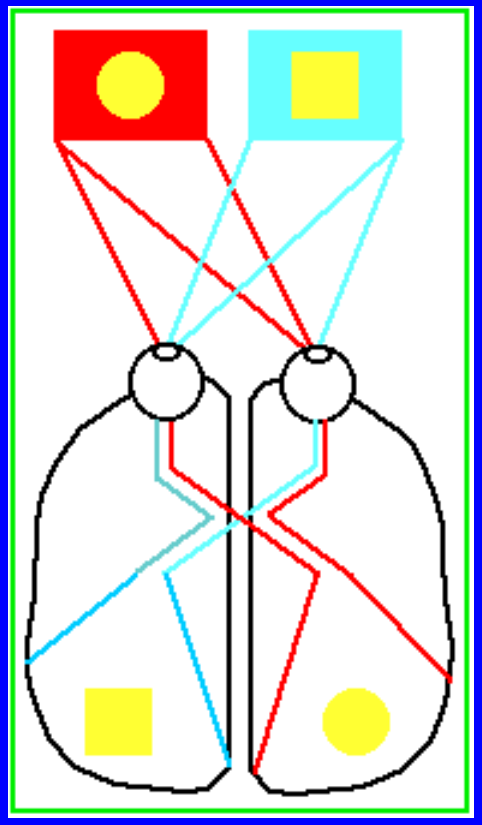
- Laterality Quotient: +71
- Token Test: 37.2/40
- Semantic Relations: 15.8/18
- Peabody Picture Vocabulary Test: 162.0/175 (raw score)
- 8 men and 8 women


Left Handers
Right Handers
Anterior
Central
Occipital
straight ending
joke ending
5 μV

Findings

- Slow sustained joke effects
  - Righties: left anterior negativity
  - Lefties: fronto-central positivity
  - Highly lateralized brain response in righties not evident in lefties' ERPs

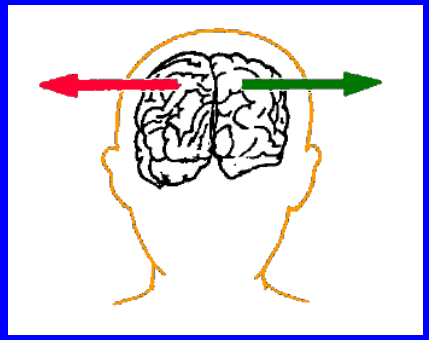
Visual System



Hemifield Priming

RVF/LH

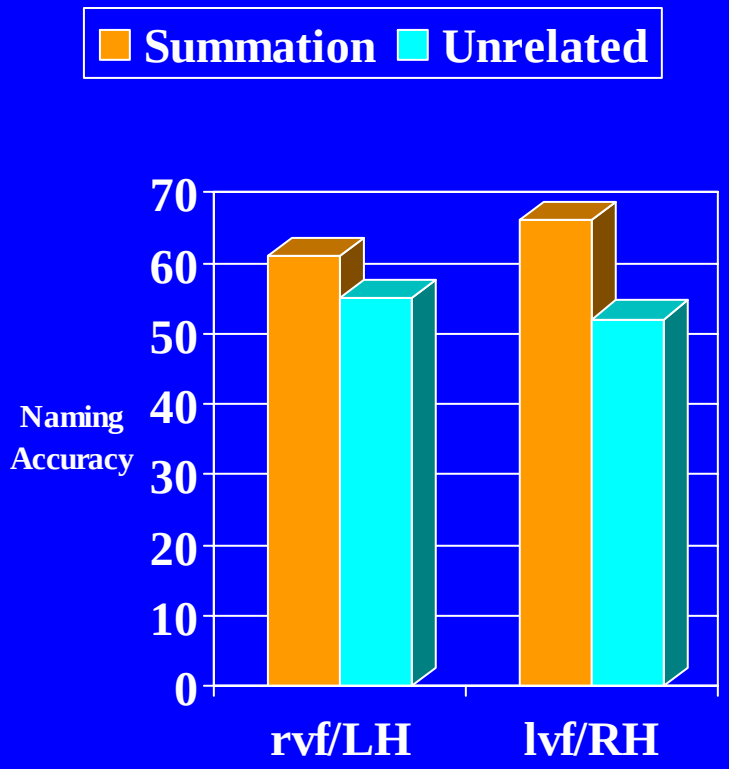
- Strongly Associated Category Members (yes)
  - Sofa – Chair
- Nonassociated Category Members (no)
  - Lamp – Table
- Typicality Effects (yes)
  - Robin – Crow >
  - Duck – Crow



LVF/RH

- Strongly Associated Category Members (yes)
  - Sofa – Chair
- Nonassociated Category Members (yes)
  - Lamp – Table
- Typicality Effects (no)
  - Robin – Crow =
  - Duck – Crow

Summation Priming



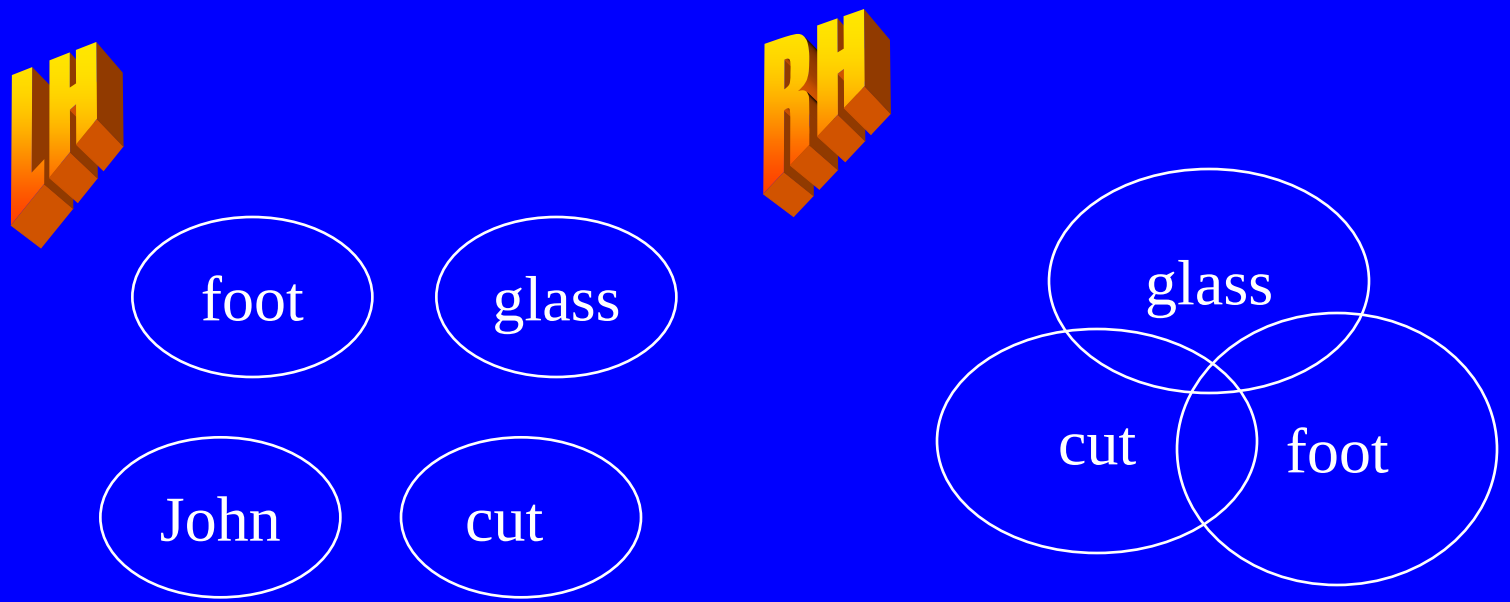
Beeman et al. (1994)

foot, cry, glass

- CUT (summation)
- SNOW (unrelated)

Coarse Coding Hypothesis

Difference in effects of LHD and RHD reflect broader semantic activations in the RH that are crucial for the interpretation of figurative language.



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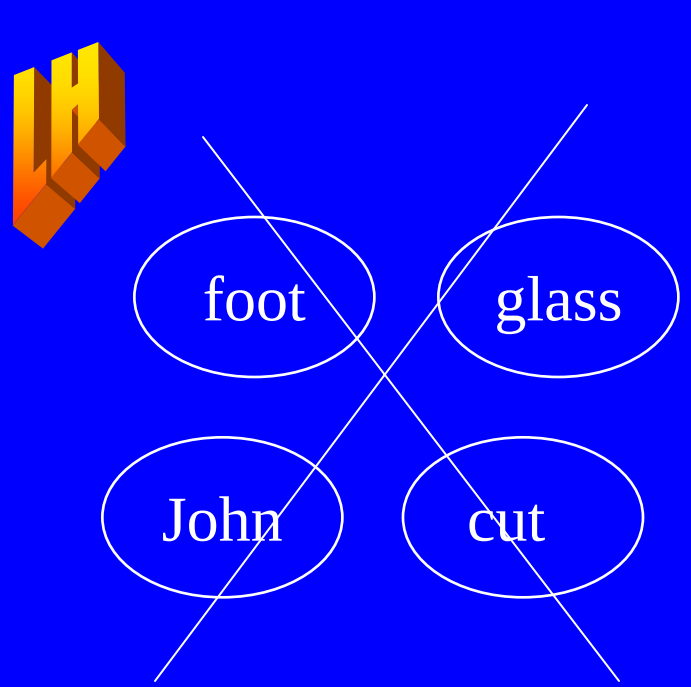
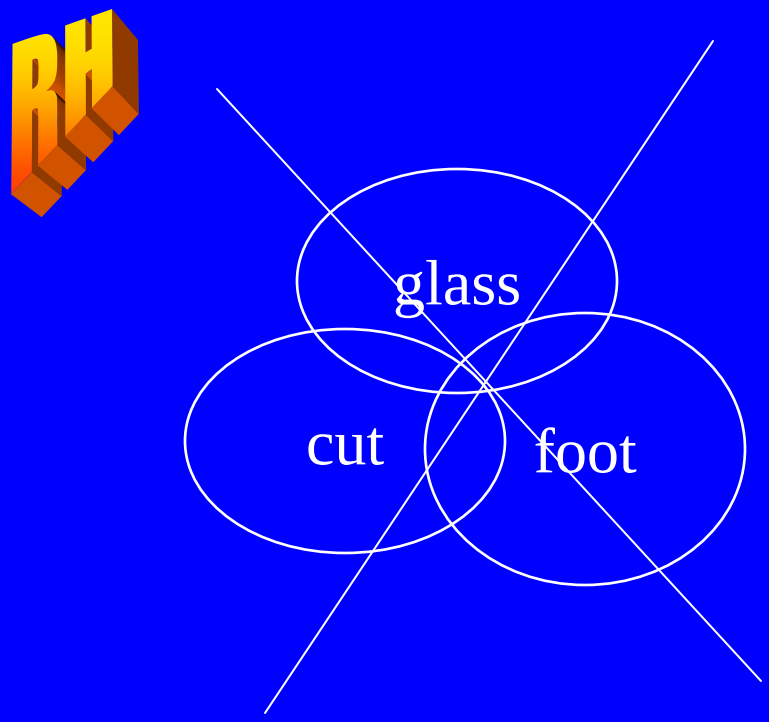


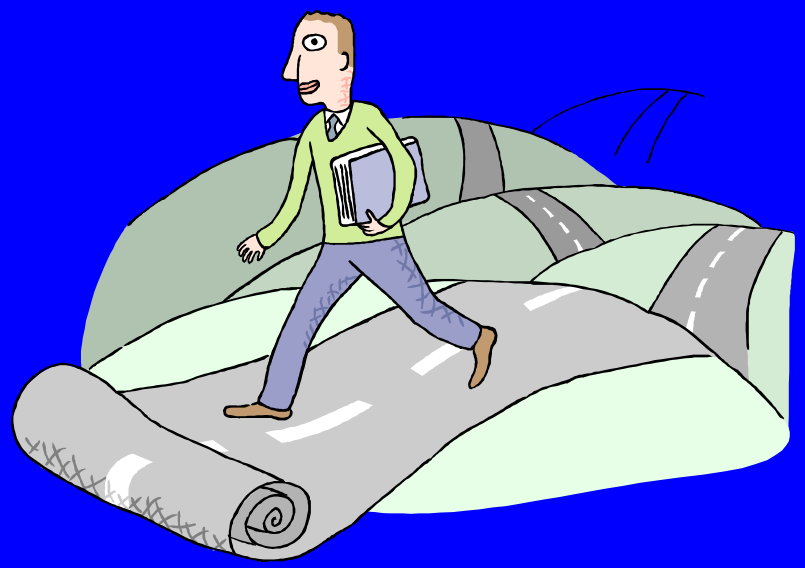


Alternative Formulation

- Beyond “broad” activation metaphor
- Semantic activation in the RH might involve alternative frames (schemas, scripts, ICMs) that represent causal and relational information important for joke comprehension

Testable Implications

- If RH involvement in joke comprehension involves semantic activation, the RH should show advantage for lexical integration of “punch-word” for jokes.
  - Smaller joke effects on the N400 with LVF/RH presentation than RVF/LH presentation



Materials

High Cloze (Expected)

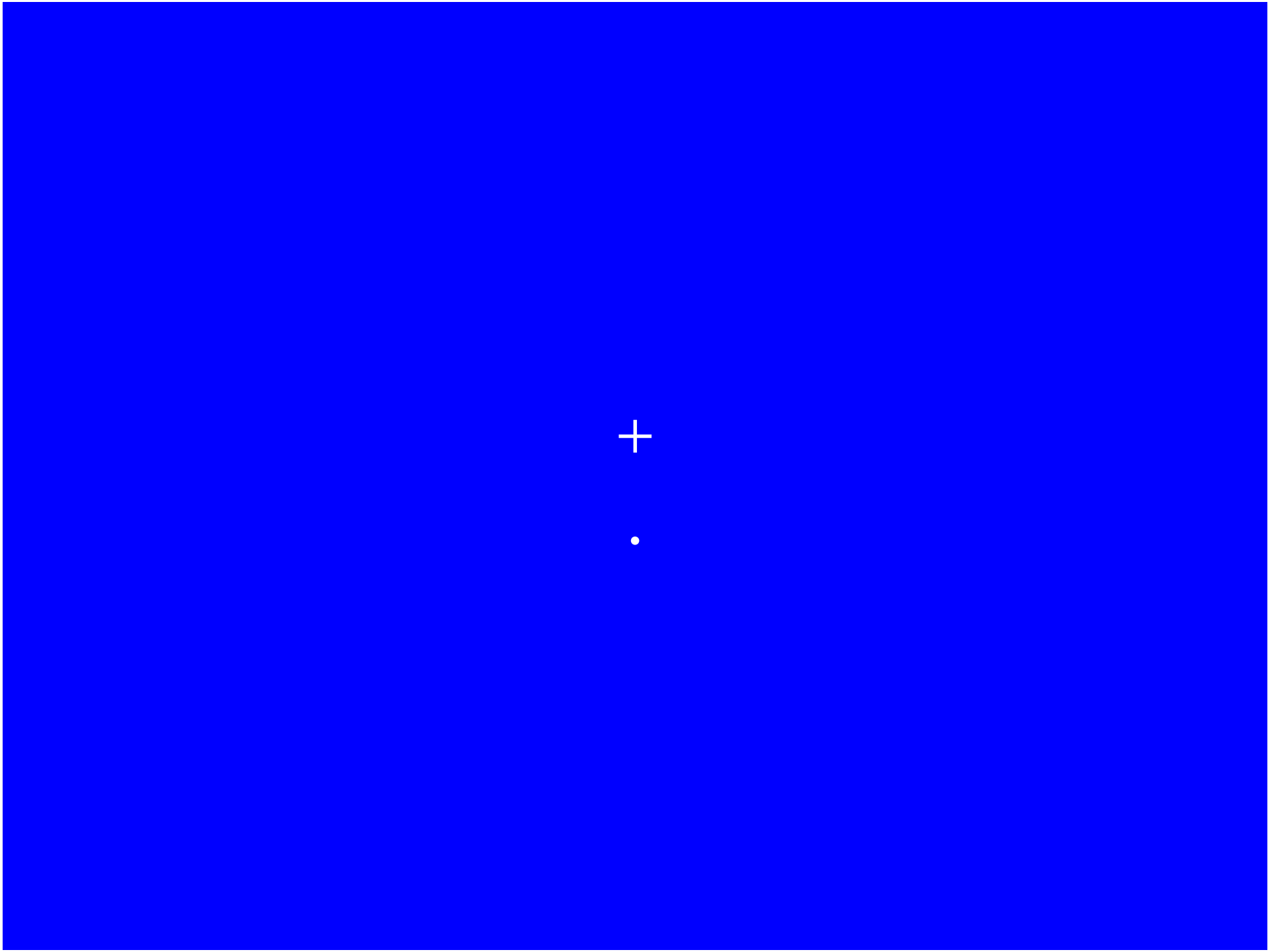
Our new green car blocked the narrow DRIVEWAY.

Low Cloze (Unexpected)

Straight ending: A replacement player hit a homerun with my BALL.

Joke ending: A replacement player hit a homerun with my GIRL.

(Coulson & Williams, 2005)



A
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replacement

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player
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hit

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a
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home

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run
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with

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my
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+ girl.

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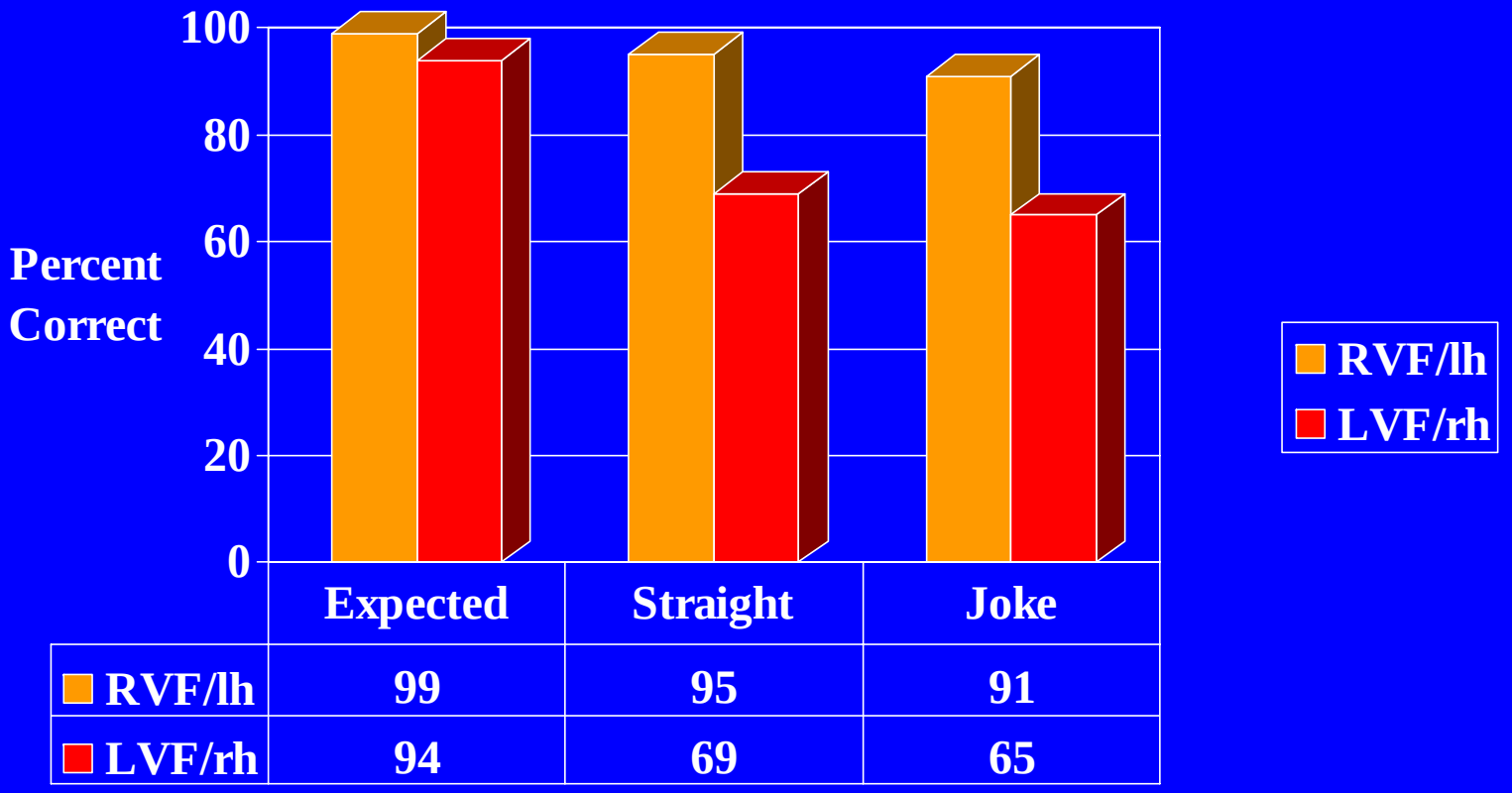
?

His girlfriend cheated on him.
Yes/No

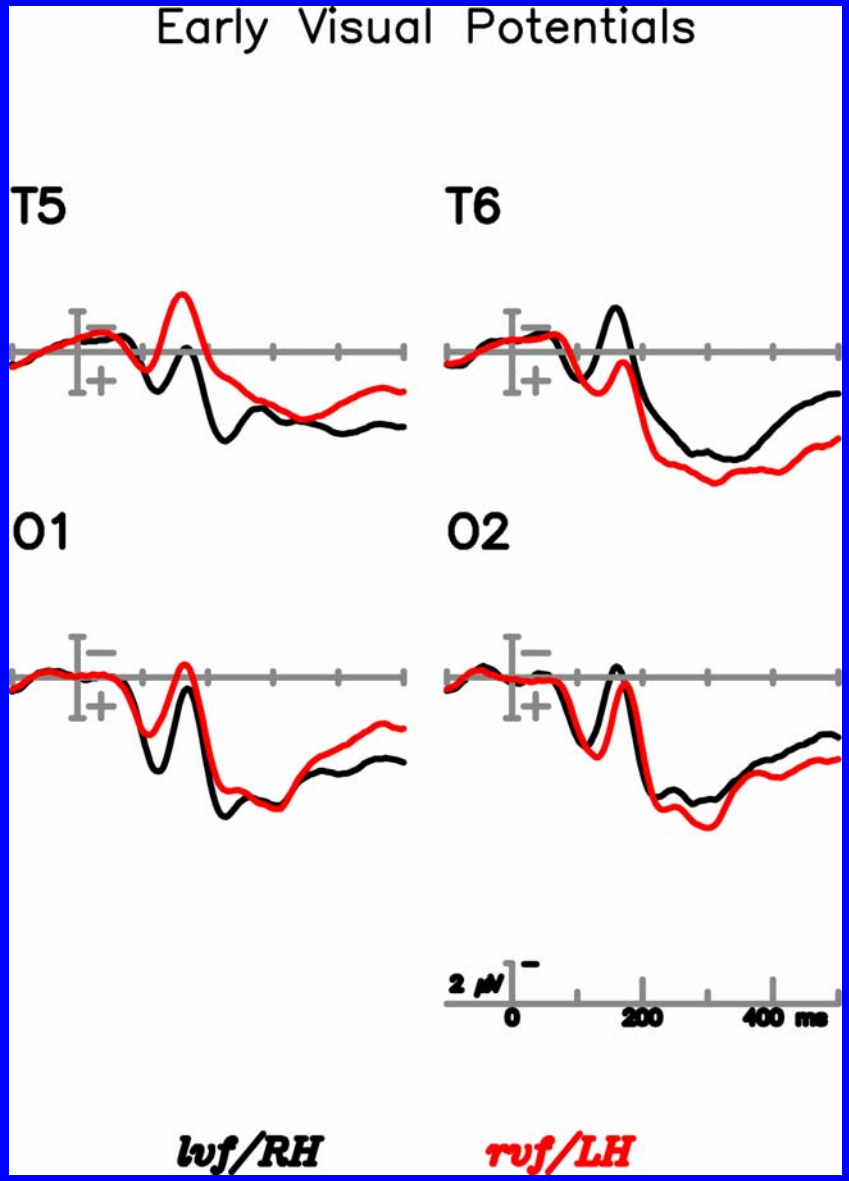
Naming Accuracy

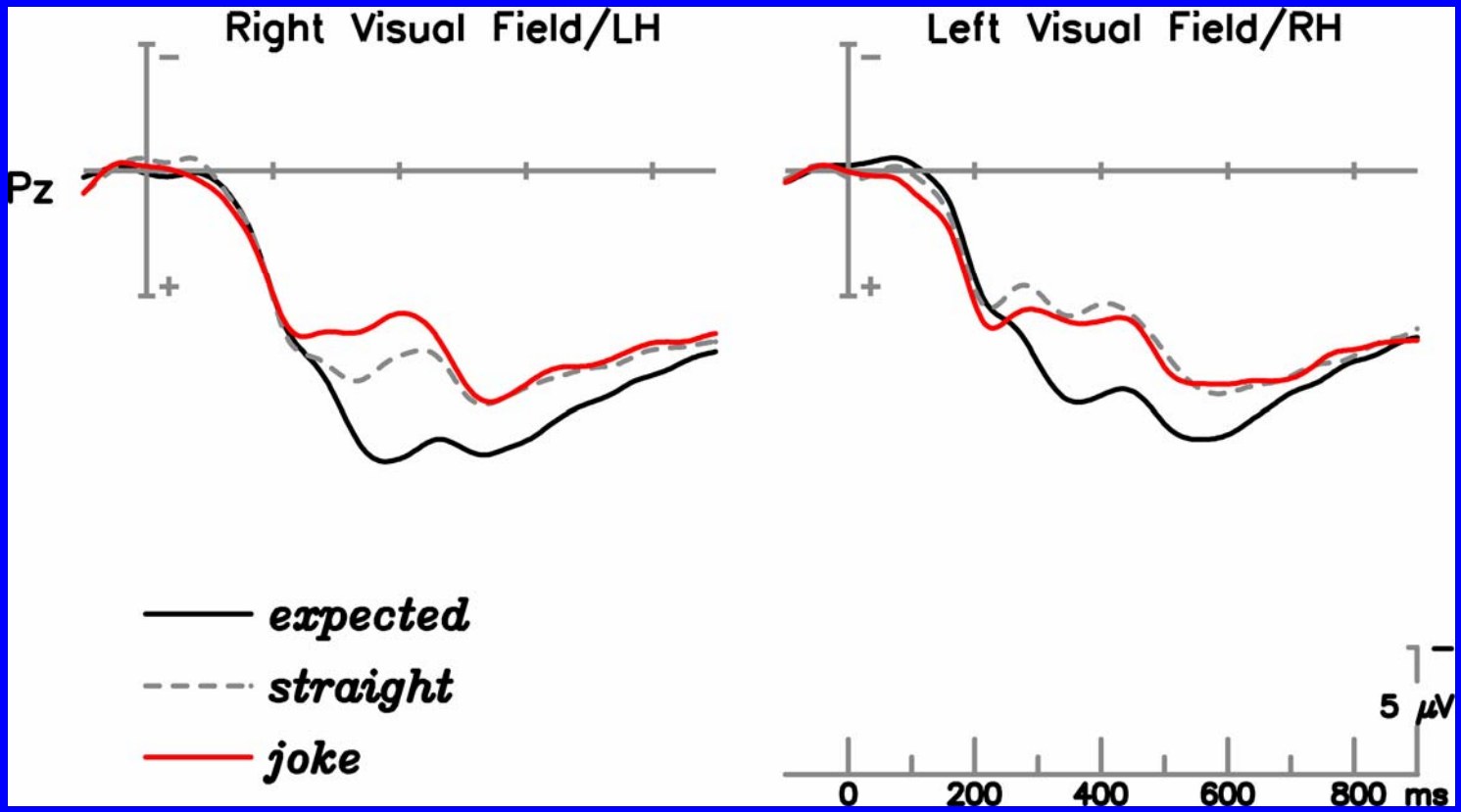


	Expected	Straight	Joke
RVF/lh	99	95	91
LVF/rh	94	69	65

Comprehension

	Expected	Straight	Joke
RVF/lh	95	95	92
LVF/rh	94	93	91

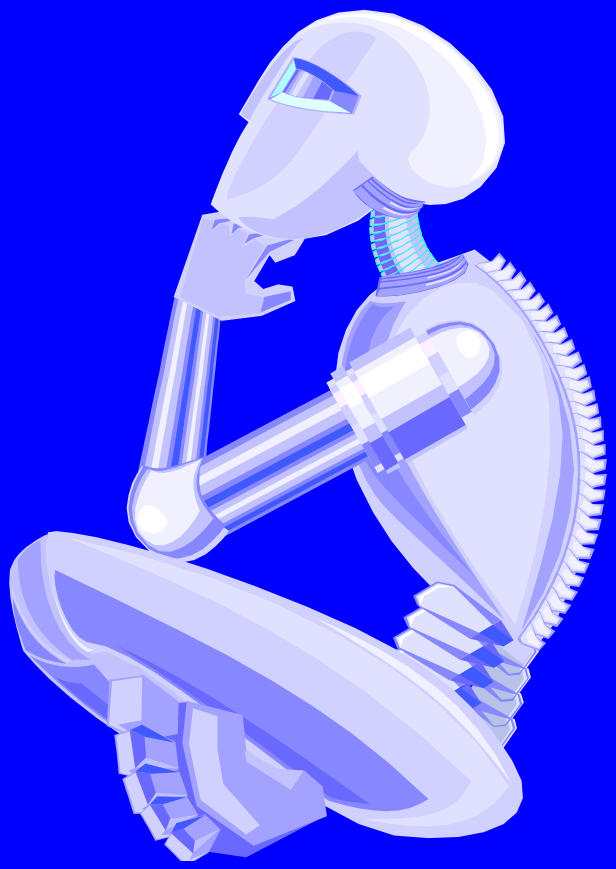

Early Visual Potentials
T5
T6
O1
O2
2 μV
0
200
400 ms
lvf/RH
rvf/LH



(Coulson & Williams, 2005)

Right Visual Field/LH
Left Visual Field/RH
Pz
straight – expected
joke – expected
5 μV
0
200
400
600
800 ms

Findings



- Consistent w/Coarse Coding Hypothesis
- LVF/rh presentation: Straight N400=Joke N400
- RVF/lh presentation: Joke N400 >Straight N400
- Semantic Activation in RH facilitates lexical integration of critical word in jokes

Next Question:

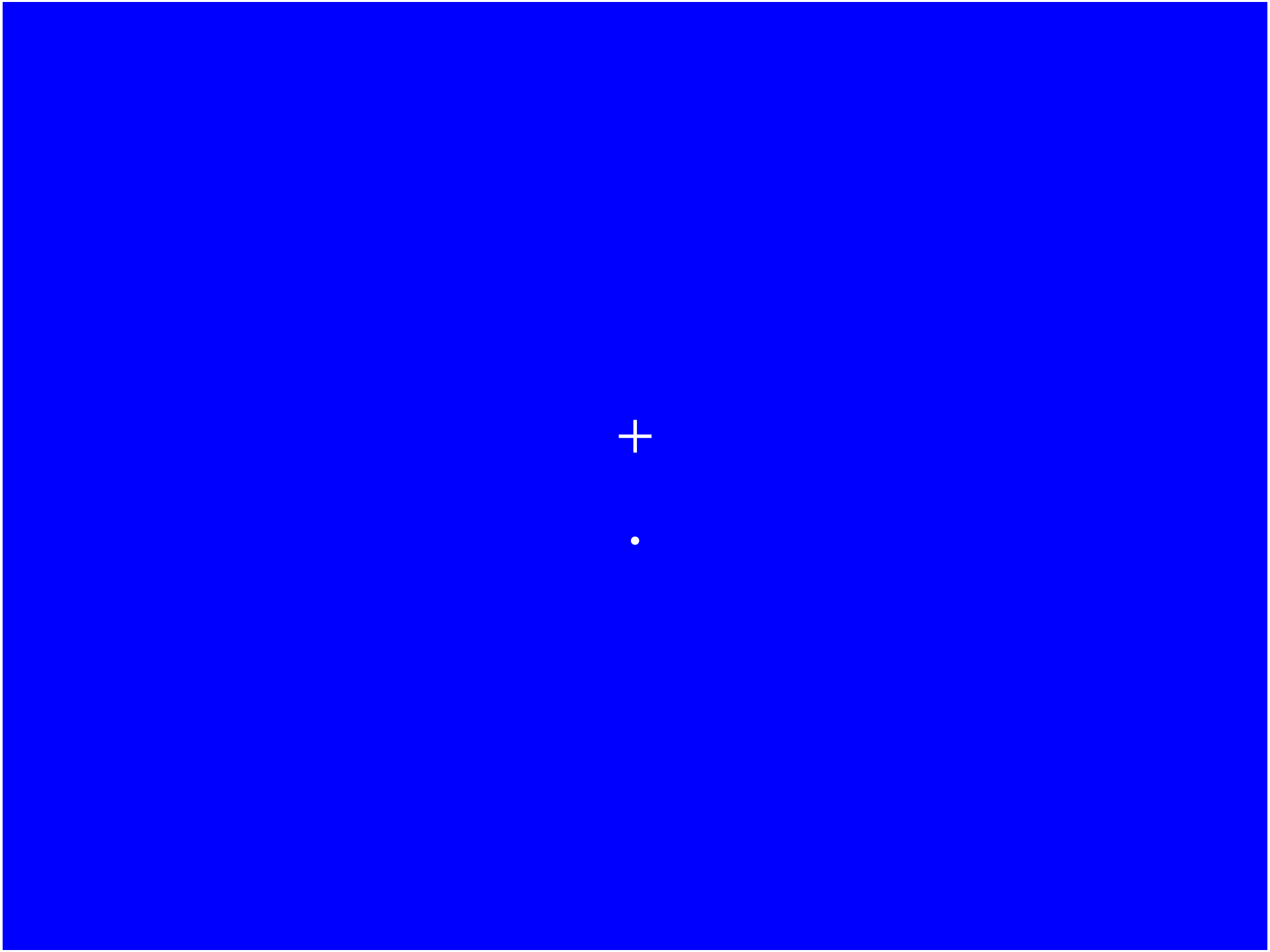
- Do semantic representations in the two hemispheres differ in a way relevant to joke comprehension?
  - Is the RH activating joke-relevant information?
  - Is the RH just equally confused by joke and straight endings?

DVF Priming Study

My church welcomes all denominations, but prefers…

Joke:	twenties	funds (related)
		grass (unrelated)
Straight:	Mormons	tolerance (related)
		grass (unrelated)

(Wu & Coulson, 2003)



My
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church

welcomes

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all

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denominations,

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but

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prefers

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twenties.

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+ funds

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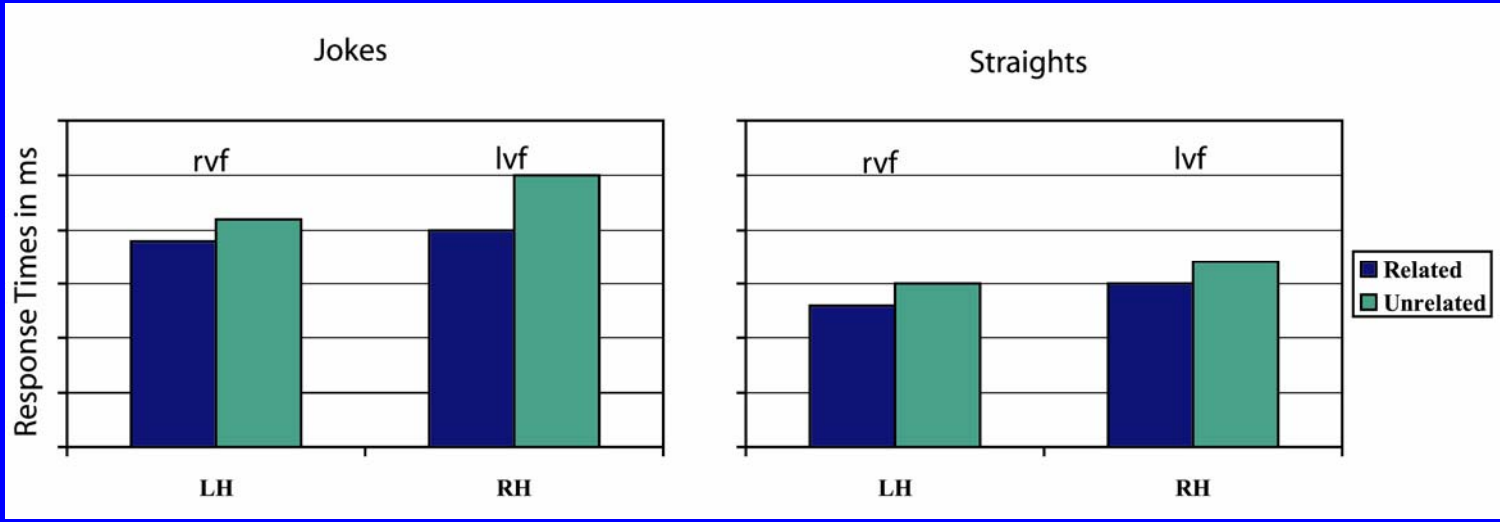
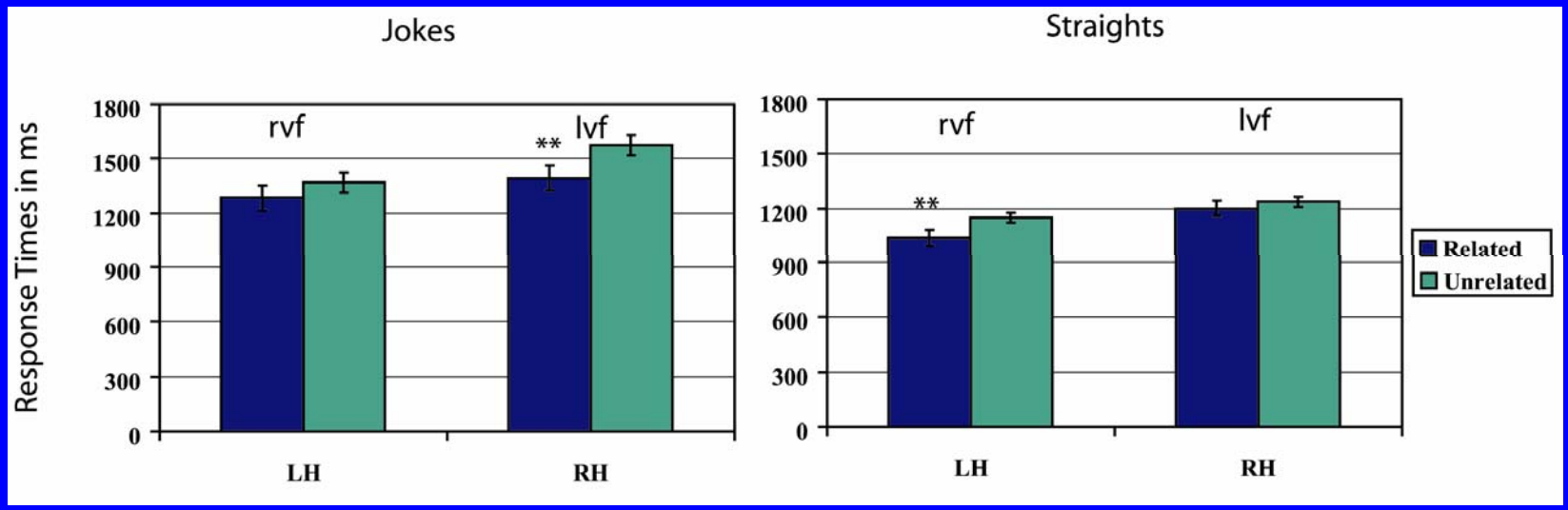
Predictions



Results



(Wu & Coulson, 2003)

Conclusions of Reaction Time Study

- RH advantage for joke-related information
  - Consistent with the coarse coding hypothesis
- LH advantage for straight-related information
  - RH not advantaged for all kinds of contextually related information

(Wu & Coulson, 2003)

DVF ERP Priming Study

Joke: My church welcomes all denominations,

but prefers **twenties.** funds

Straight: My church welcomes all denominations,

but prefers **Mormons.** funds

(Coulson & Wu, 2005)

DVF ERP Priming Study

Joke: My church welcomes all denominations,

but prefers **twenties.** funds

Straight: My church welcomes all denominations,

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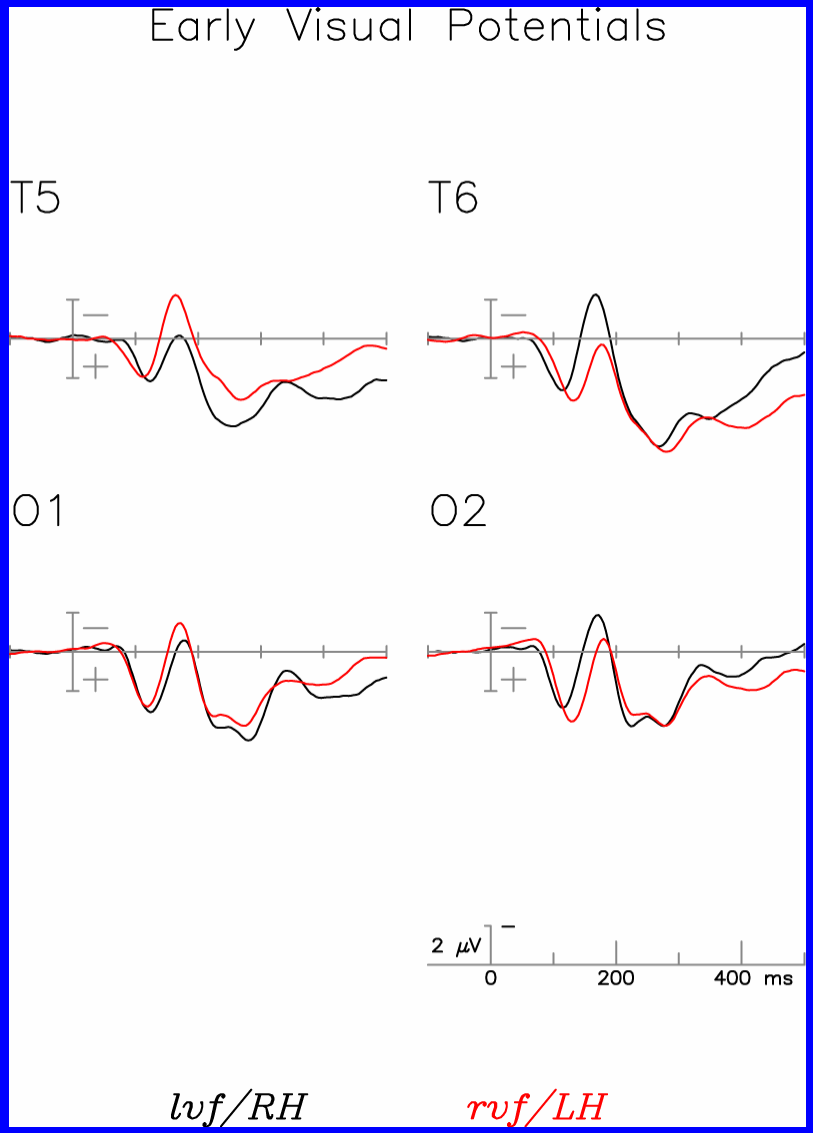
(Coulson & Wu, 2005)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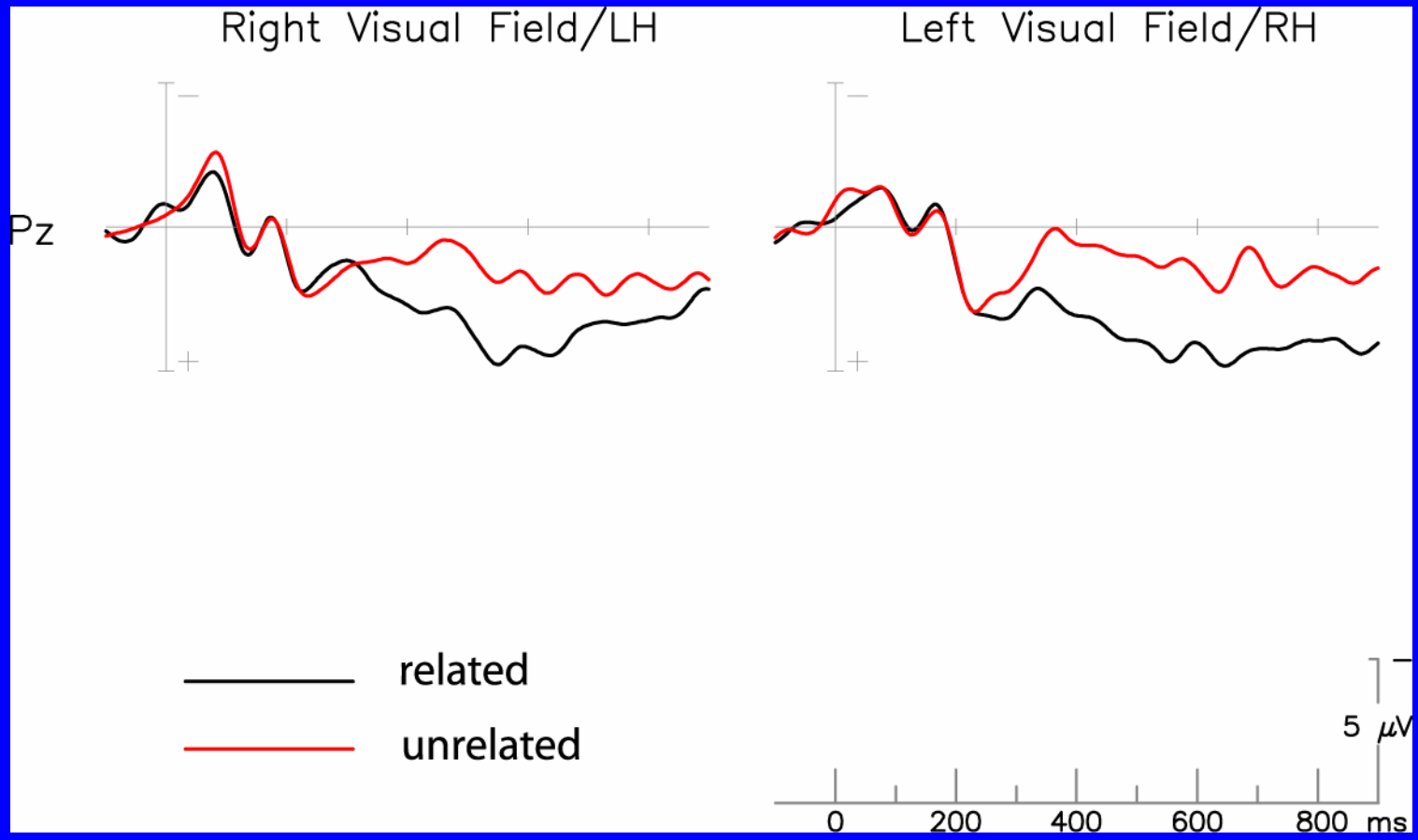
Right Visual Field/LH
Left Visual Field/RH
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related
unrelated
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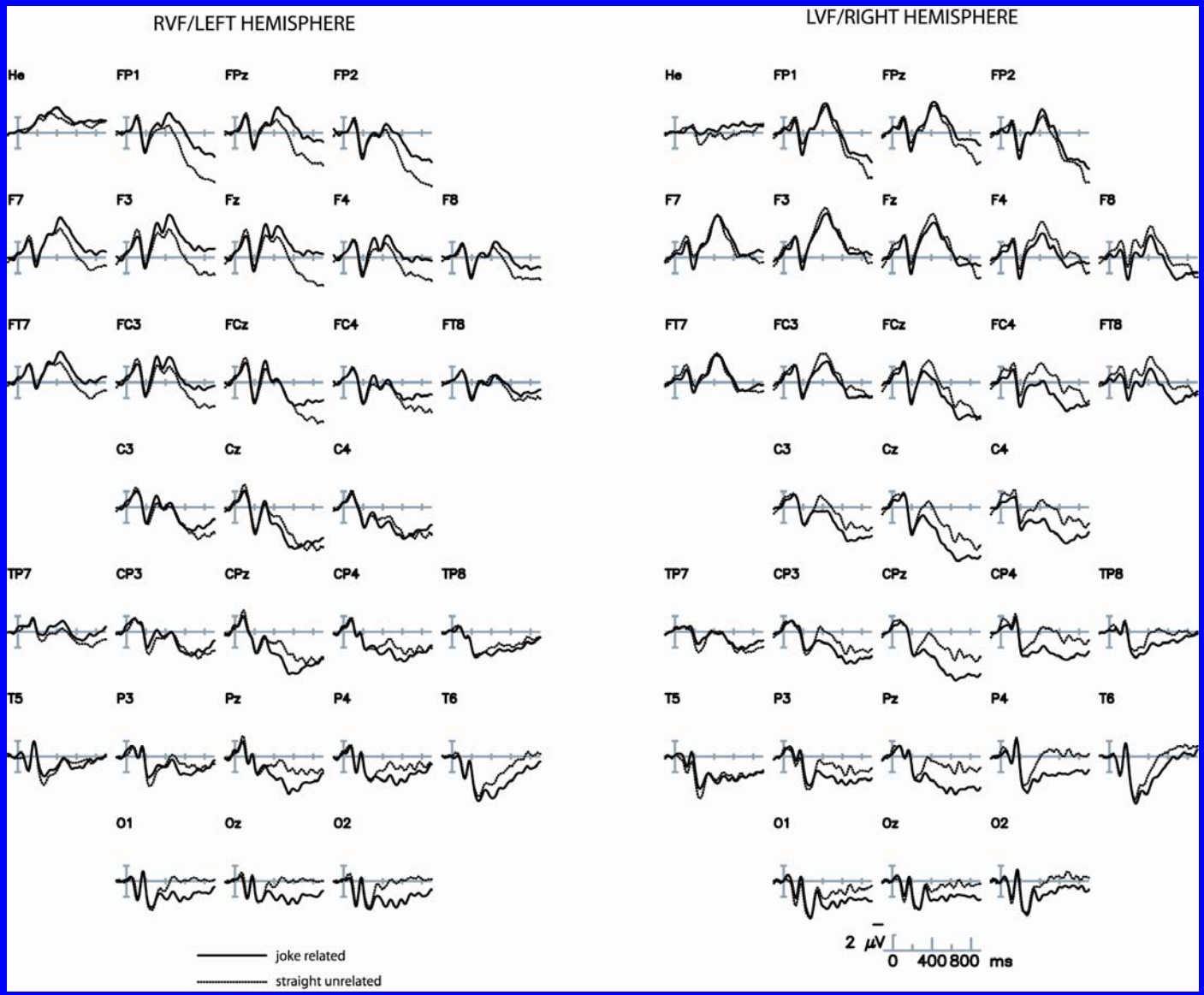
200
400
600
800 ms


RVF/LEFT HEMISPHERE
LVF/RIGHT HEMISPHERE
He
FP1
FPz
FP2
F7
F3
Fz
F4
F8
FT7
FC3
FCz
FC4
FT8
C3
Cz
C4
TP7
CP3
CPz
CP4
TP8
T5
P3
Pz
P4
T6
O1
Oz
O2
joke related
straight unrelated
2 μV
0 400 800 ms

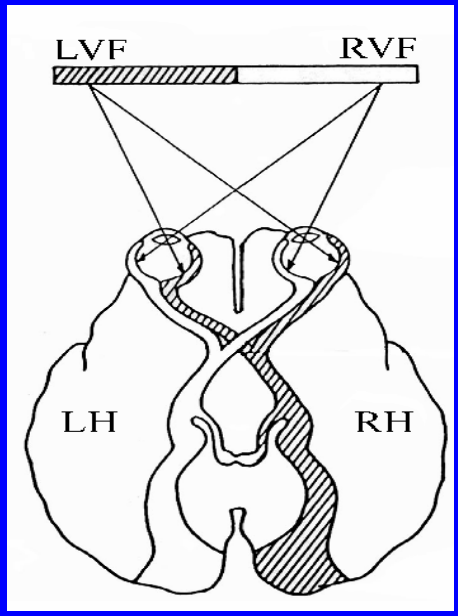
Coulson & Wu, 2005

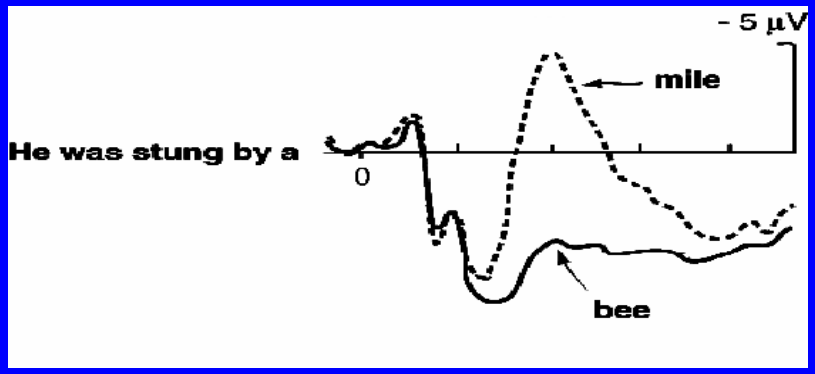
- N400 reflects joke-related priming
  - Larger LVF N400 effect suggests joke-related information more active in the RH
  - Consistent with coarse coding hypothesis
- RVF Frontal positivity
  - Selection of information for further processing?
  - Suppression of irrelevant information?
  - (Vain) search through semantic memory for link to context?
- Exclusive RVF effect suggests LH may be more important for incorporating joke-relevant information

Puns

- "Six women have come forward that say Arnold Schwarzenegger groped them without their consent. This proves he would be a hands-on governor." —Jay Leno
- Rare case in which both meanings of an ambiguous word or phrase are contextually relevant
- Is the RH important for pun comprehension?
  - Activate subordinate meanings of ambiguous words?

DVF ERP Priming Paradigm





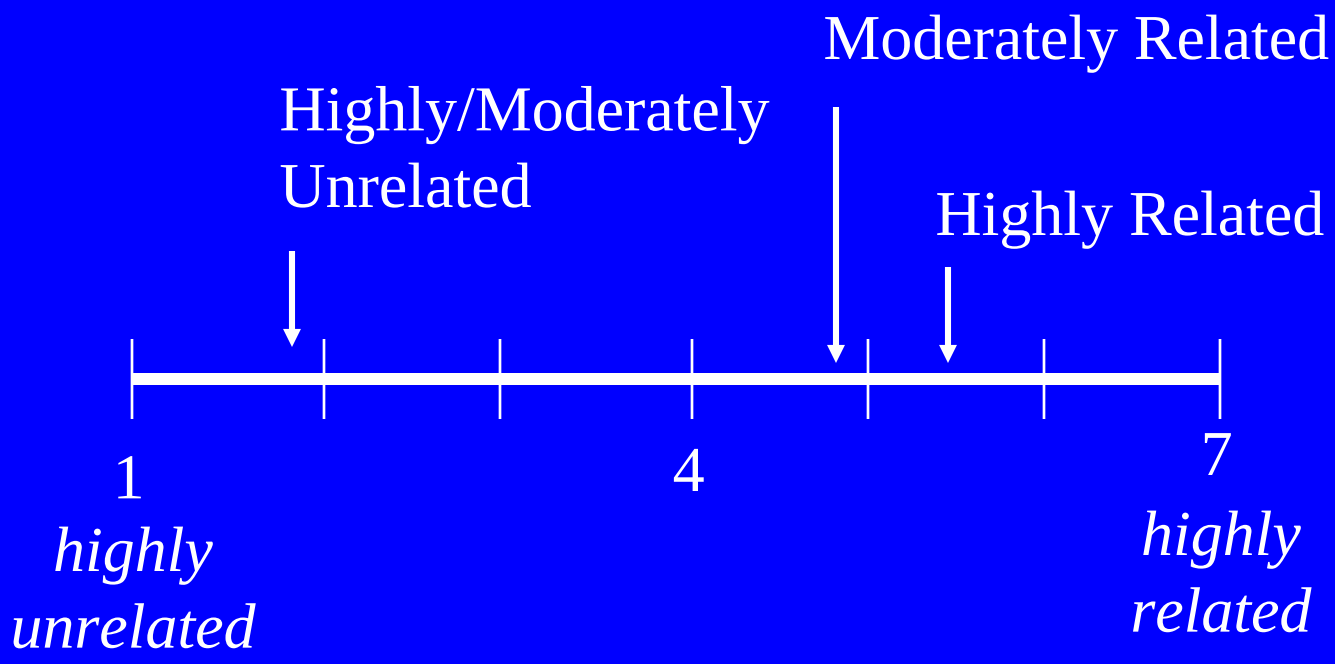
Materials

Pun	Probe Word
During branding cowboys have sore calves.	Cow (Primary Related)
During branding cowboys have sore calves.	Leg (Secondary Related)
I could have been a swimmer if I had a stroke.	Cow (Primary Unrelated)
Seven days without a pun makes one weak.	Leg (Secondary Unrelated)

Sample Pun Stimuli

- The calendar maker's days were numbered. *date/death*
- On a long trek, nomads used camels to get them over the hump. *animal/terrain*
- The clam's relationship was on the rocks. *problem/stones*
- Lightning storms can be very striking. *electrocute/amaze*
- I could have been a balloonist but the idea didn't get off the ground. *lift/reality*

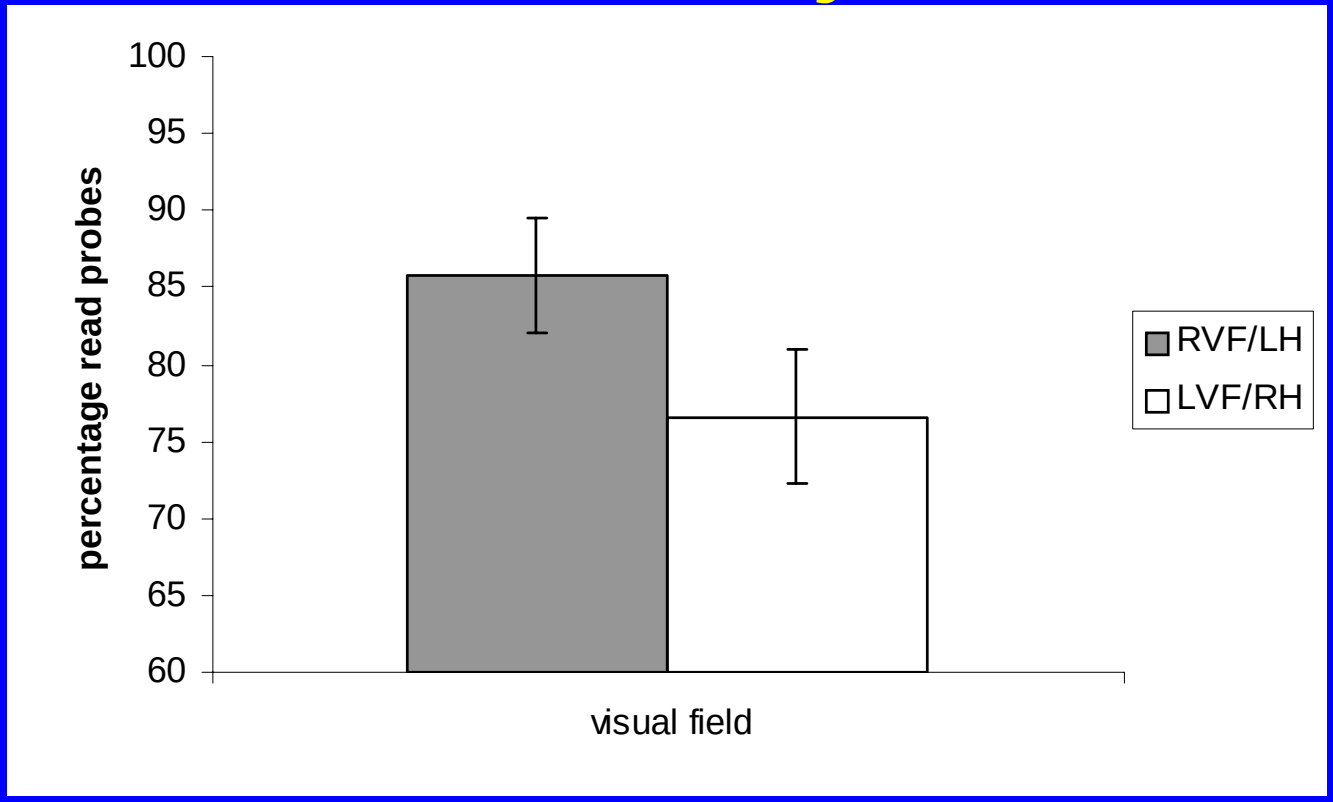
Relatedness Norming

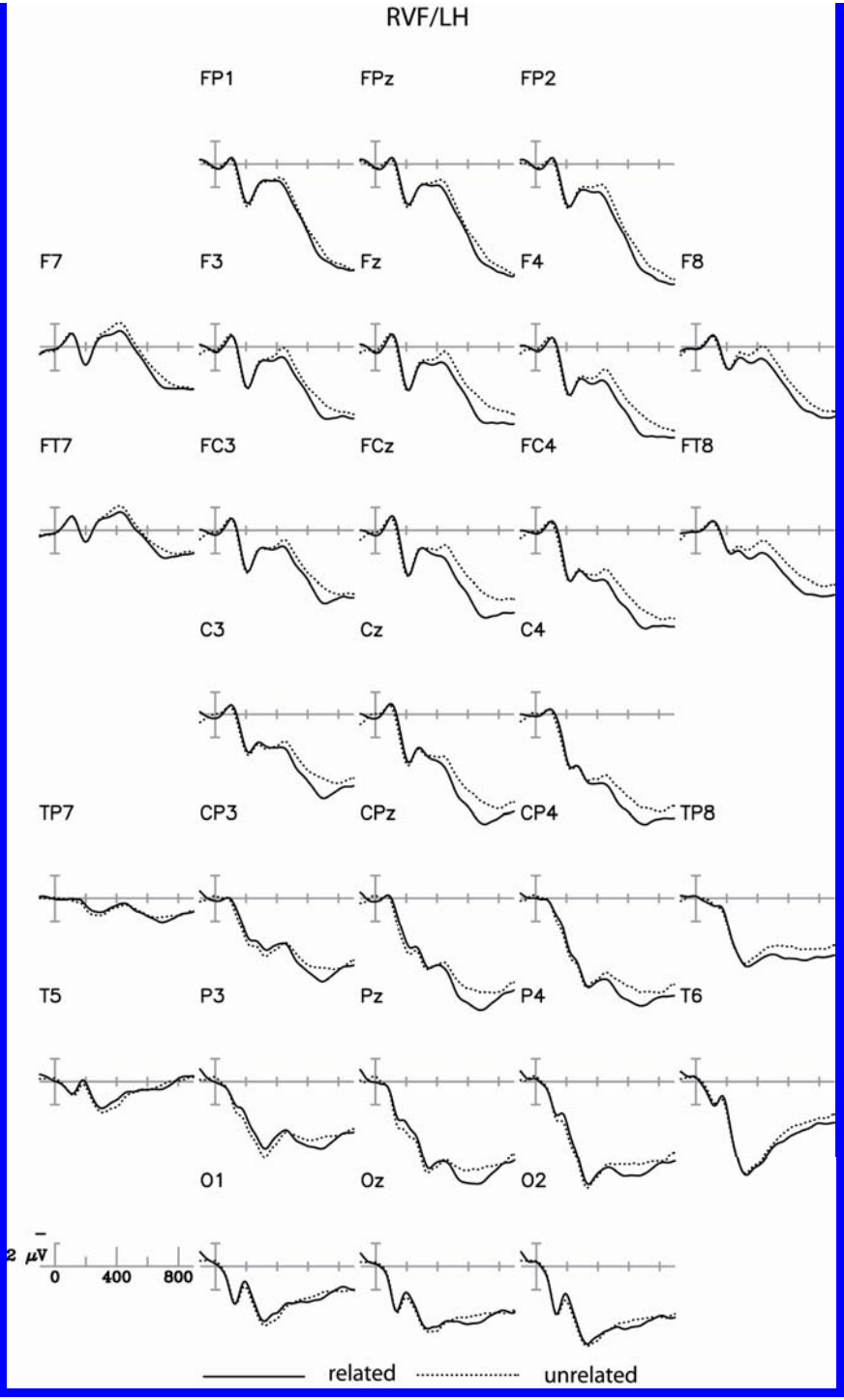


Procedure

- Cross-modal “priming”
  - Listen to puns
  - Read laterally presented probe words
    - 0 ms ISI
- Tasks
  - Indicate with a button-press if unable to read laterally presented probe
  - Answer true/false comprehension probe, visually presented after each pun/probe

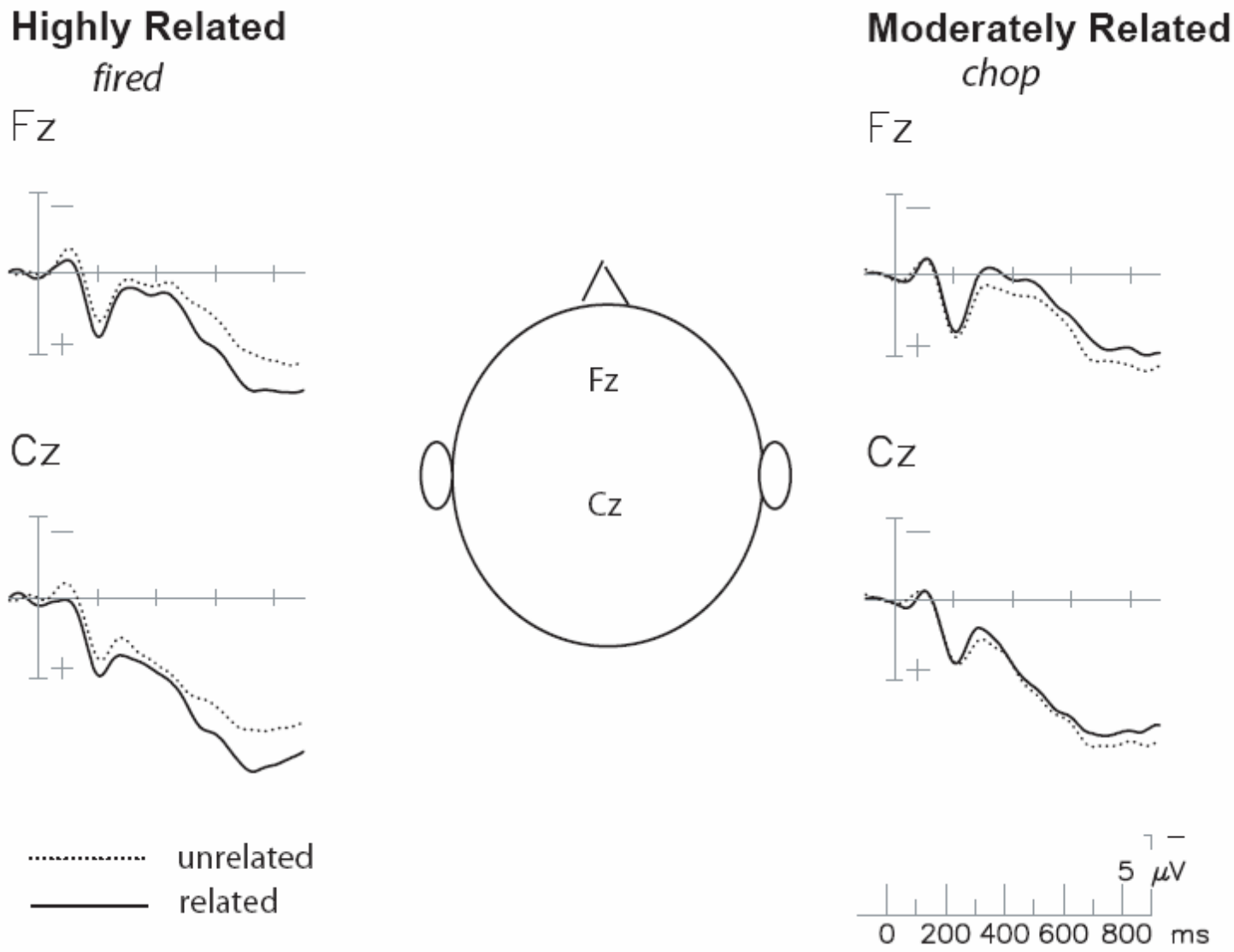
“Readability”




RVF/LH
FP1
FPz
FP2
F7
F3
Fz
F4
F8
FT7
FC3
FCz
FC4
FT8
C3
Cz
C4
TP7
CP3
CPz
CP4
TP8
T5
P3
Pz
P4
T6
O1
Oz
O2
2 μV
0
400
800
related
unrelated

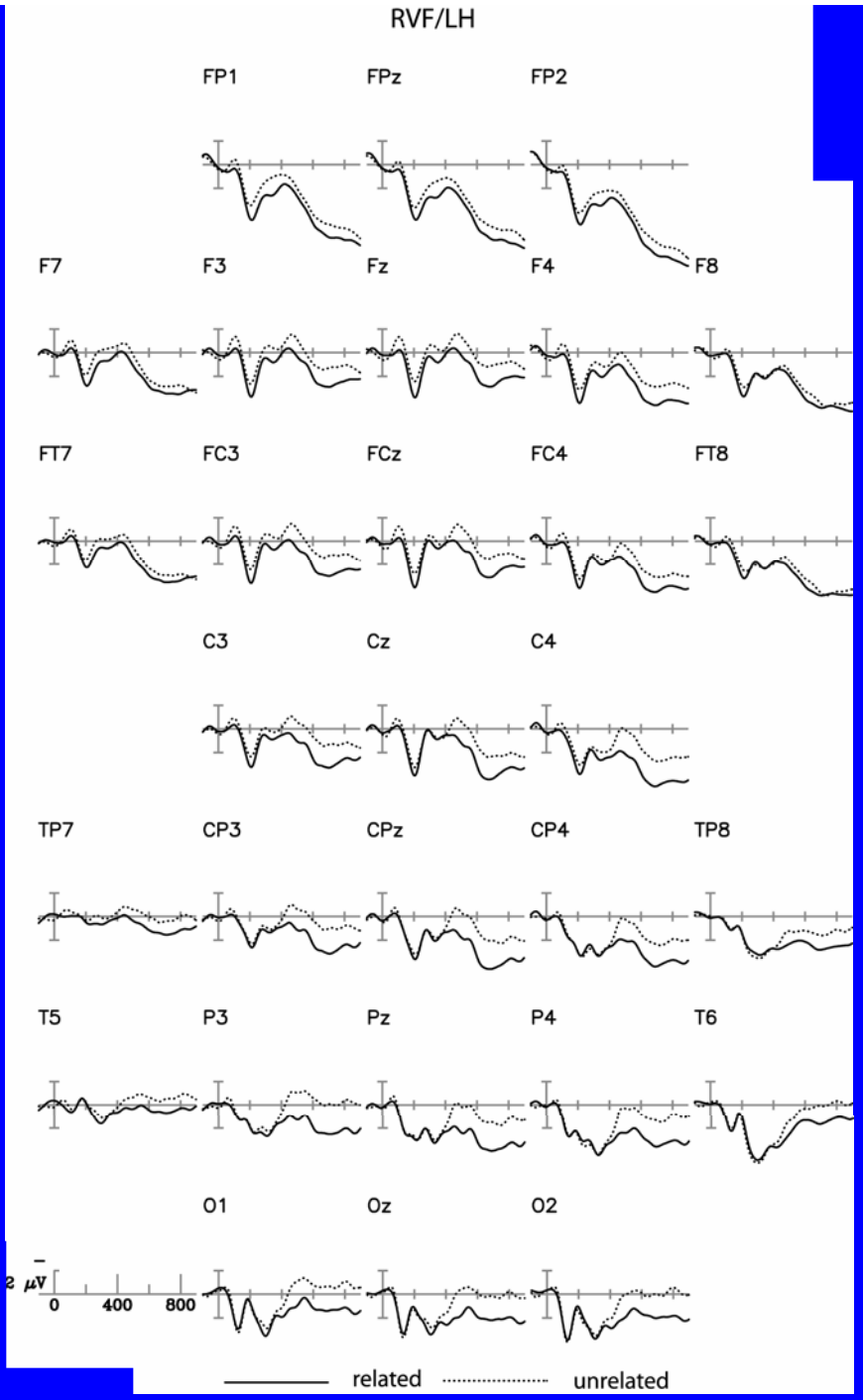
LVF/RH

"I used to be a lumberjack, but then I got the axe."



Procedure

- Cross-modal “priming”
  - Listen to puns
  - Read laterally presented probe words
    - **500 ms ISI**
- Tasks
  - Indicate with a button-press if unable to read laterally presented probe
  - Answer true/false comprehension probe, visually presented after each pun/probe


RVF/LH
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C3
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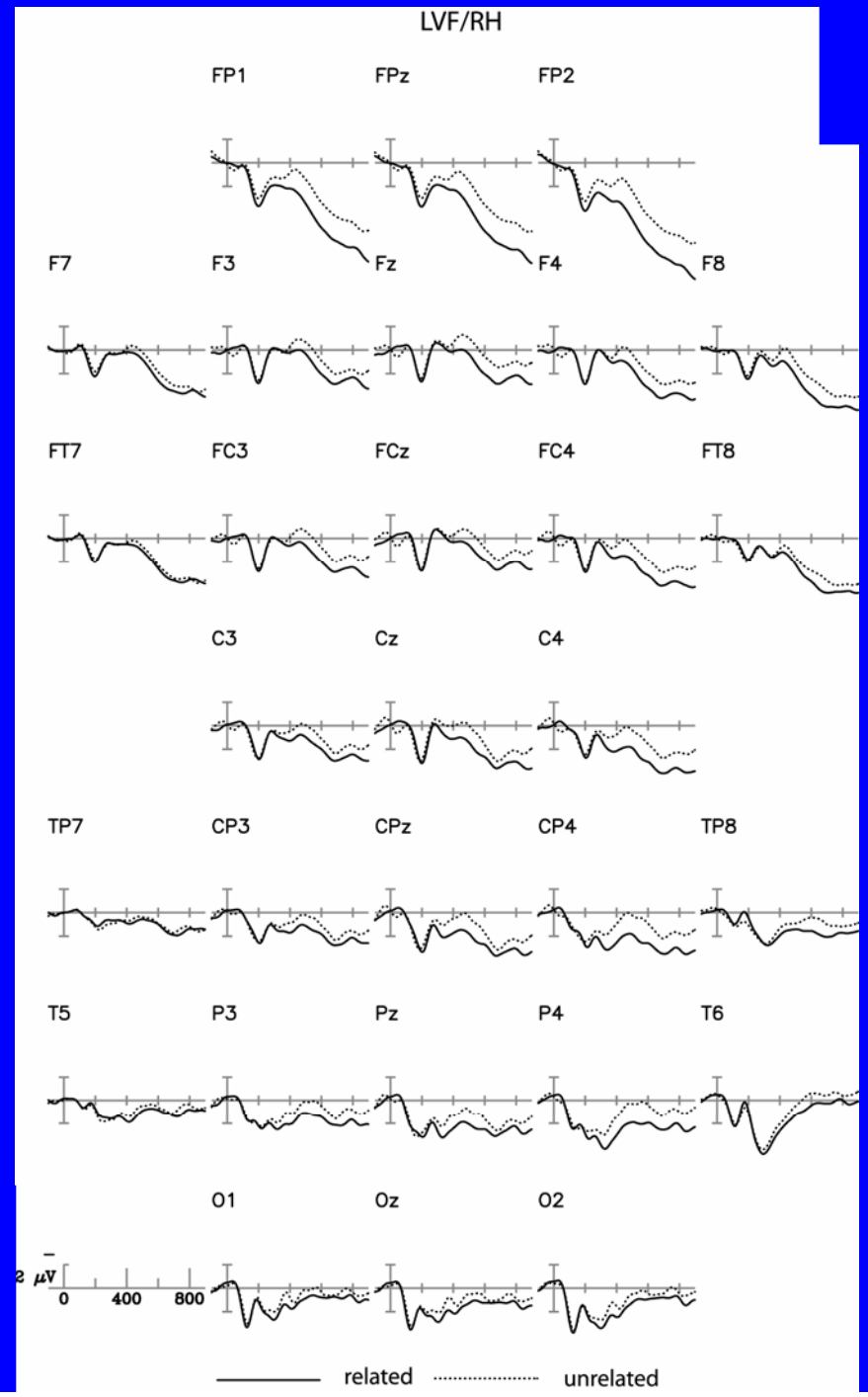
TP7
CP3
CPz
CP4
TP8
T5
P3
Pz
P4
T6
O1
Oz
O2
2 μV
0
400
800
related
unrelated


LVF/RH
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F8
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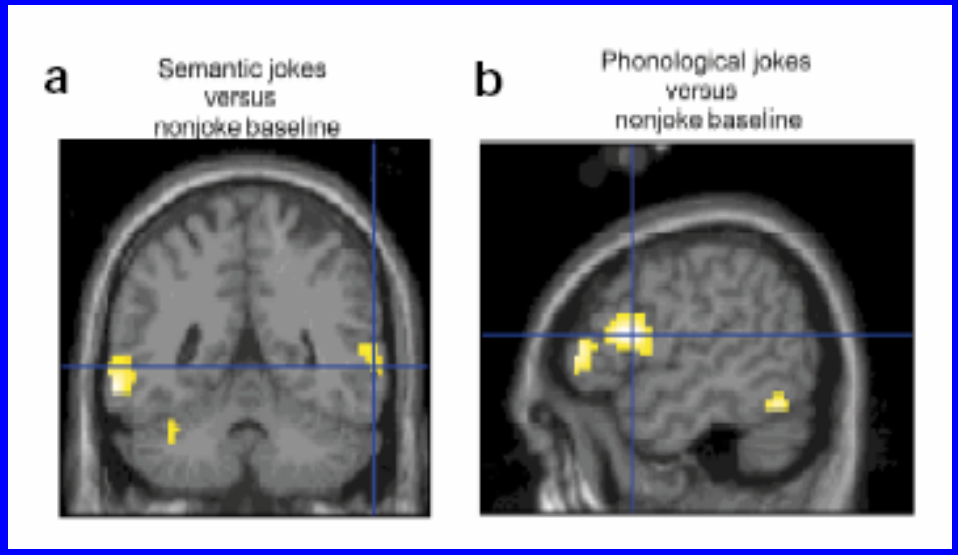
FC3
FCz
FC4
FT8
C3
Cz
C4
TP7
CP3
CPz
CP4
TP8
T5
P3
Pz
P4
T6
O1
Oz
O2
2 μV
0
400
800
related
unrelated

Coulson & Severens, 2006

- Initially
  - Both meanings of puns active in LH
  - Only highly related meaning active in RH
- Later
  - Both meanings of puns active in both hemispheres
- Puns differ from more semantic jokes in their involvement of the RH

Goel & Dolan, 2001

- Semantic Jokes
  - What do engineers use for birth control?
  - Their personalities.
  - The pill.
- Puns
  - Why did the golfer wear two sets of pants?
  - He got a hole in one.
  - It was a very cold day.



"I've got it, too, Omar. . . . a strange feeling like we've just been going in circles."