

A1: Script-based Surprisal: Evidence from Event-Related Potentials

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Surprisal

Surprisal theory

Hale (2001); Levy (2008)

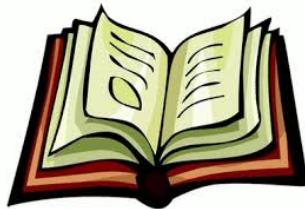
$$Effort(word) \propto Surprisal(word_i) = -\log_2 P(word_i | Context)$$

Typically, the context is **linguistic**

$$Surprisal(word_i) = -\log_2 P(word_i | word_0 \dots word_{i-1})$$

Context

John began reading the ... {BOOK, paper, invoice, menu ...}



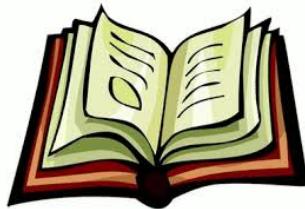
<
surprising



Context

After entering the bistro,

John began reading the ... {book, paper, invoice, MENU...}



>
surprising



Contextual probability of a word determined

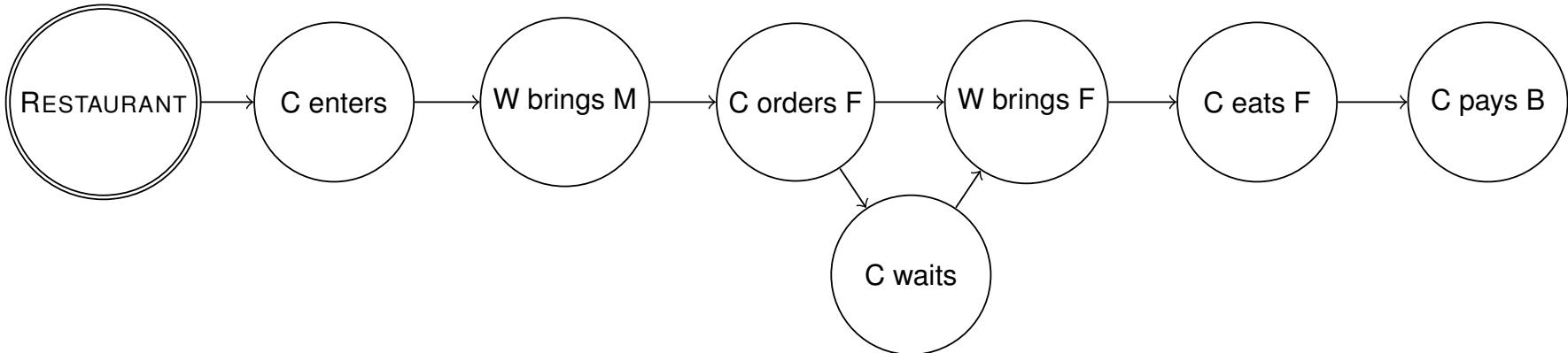
- ▶ Linguistic context
- ▶ Shared situational context
- ▶ Shared knowledge that isn't explicit in the signal
- ▶ **Script knowledge**

Scripts

"A script is a predetermined, stereotyped sequence of actions that defines a well-known situation" (Shank and Abelson 1977:41)

- ▶ **Structured knowledge** of routinised activities (e.g., going to a restaurant, making coffee)
- ▶ **Ordered sequence** of typical events/actions associated with typical participants
- ▶ **Hierarchical structure**, temporal and causal connections between events/actions

Script-based surprisal



After entering the bistro,

John began reading the {book, paper, invoice, MENU}

$$Effort(word_i) \propto Surprisal(word_i) =$$

$$= -\log_2 P(word_i | word_{0..i-1}, Script)$$

A1 Project

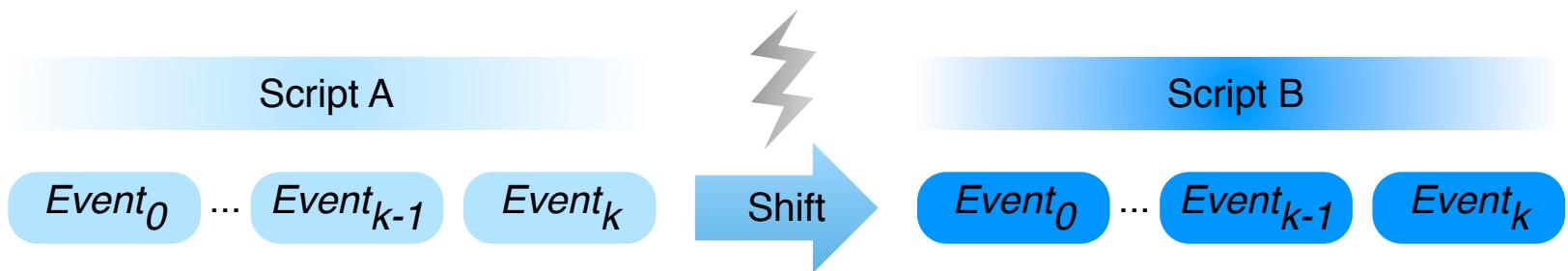
Hypothesis

Script knowledge influences predictability of words, on-line → contributes to determining surprisal and processing difficulty

Main goals:

- ▶ Differentiate script versus linguistic mechanisms
 - ▶ Establish the time course and priority of script influence
 - ▶ Examine use of script structure and accessibility of script participants
 - ▶ Processing at script boundaries
-
- ▶ We started from the end!

Script boundaries

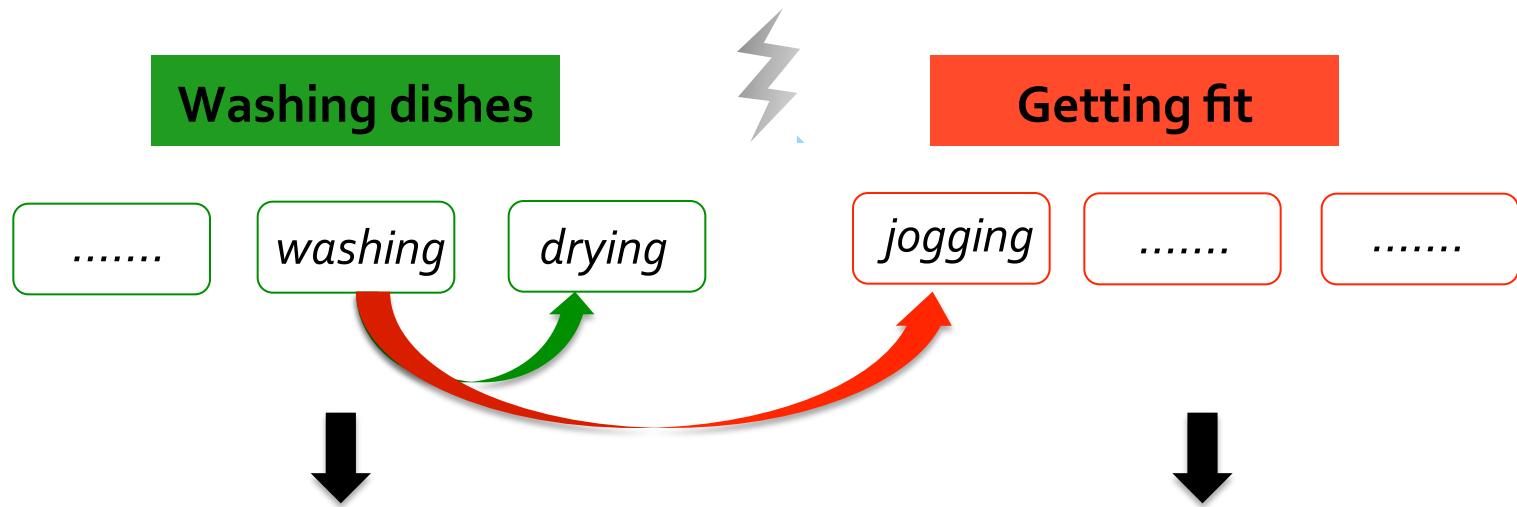


Processing at script boundaries to assess:

- ① To what extent script knowledge is used to predict upcoming events? (surprisal at the onset of a new script) → Experiment 1
- ② To what extent previous script knowledge continues to influence processing (priming vs. script knowledge use) → Experiment 2
(Poster session)

Processing at script boundaries

John was washing the plates. Then he began ... {DRYING, jogging}



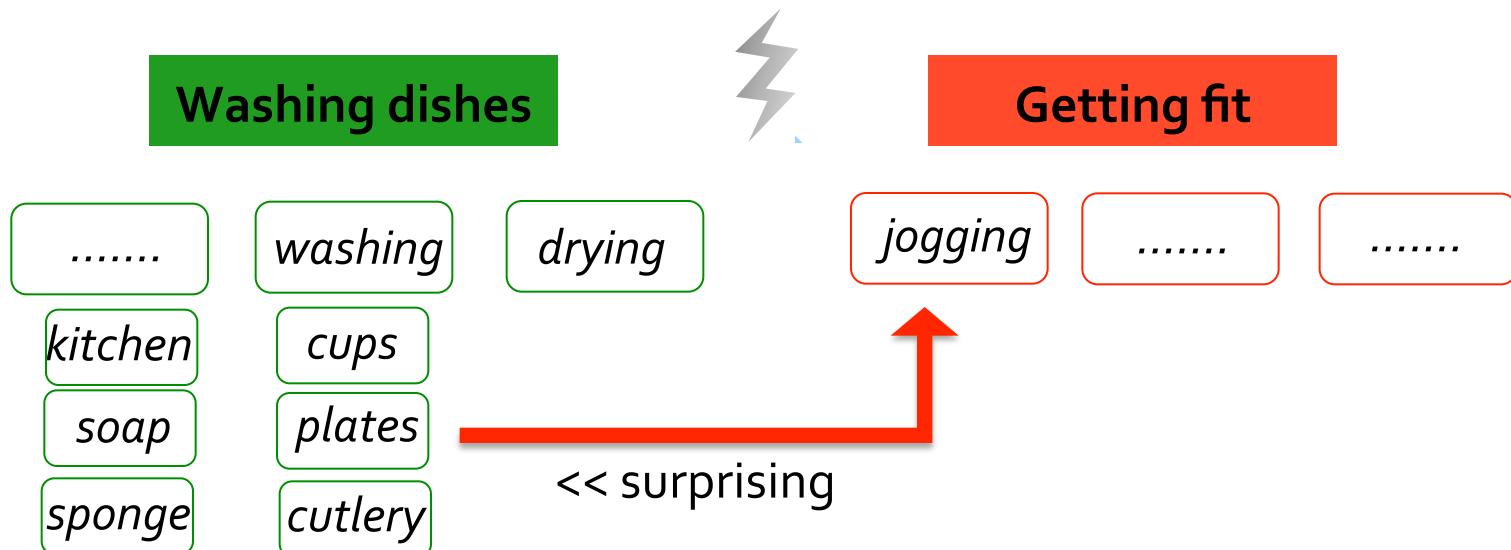
Script-congruent event
confirms expectations

<
surprising

Script-incongruent event:
current event model updated

Processing at script boundaries

...was washing the plates, the cups and the cutlery... {DRYING, jogging}



*The more fine-grained / detailed the representation of the script,
the harder the processing of the incongruent event*

Experiment 1 – 2x2 design

Intro

Jan ist mit dem Frühstück fertig.

(*Jan has finished breakfast.*)

Coarse-grained context

Er geht in die Küche, wo er den Teller abwäscht.

(*He goes to the kitchen, where he washes the plate.*)

Fine-grained context

Er geht in die Küche, wo er erst die Tasse, dann das Besteck und dann den Teller abwäscht. (*He goes to the kitchen, where he first washes the cup, then the cutlery and then the plate.*)

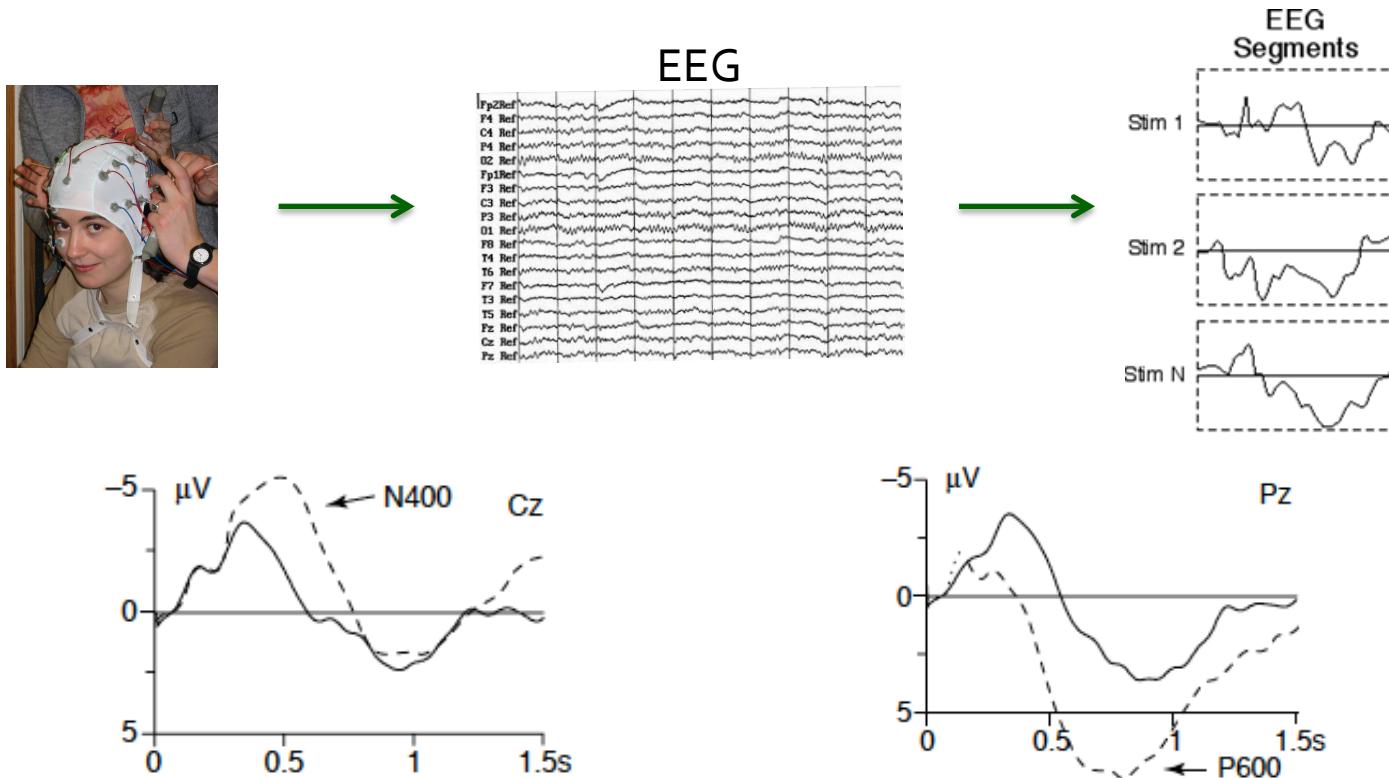
Target (script-congruent / incongruent)

Dann beginnt er mit dem Abtrocknen/ Joggen, ...

(*Then he starts drying/jogging...*)

Method: Event-Related Potentials (ERPs)

- ERPs measures brain electrical activity time-locked to a word

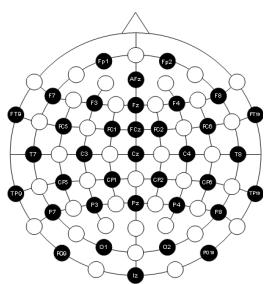
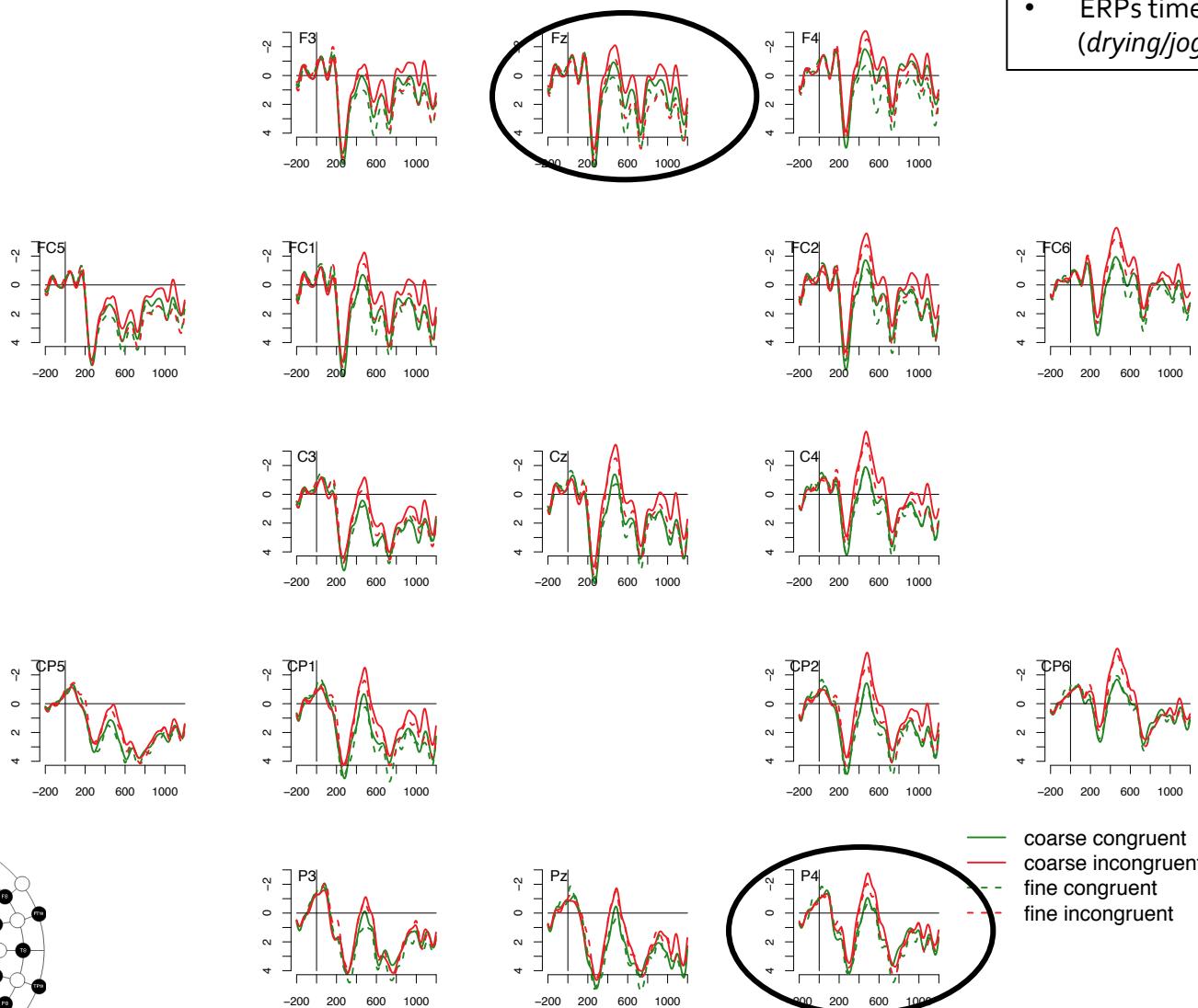


- Word predictability (cloze)

- Discourse model updating

Results – 20 participants

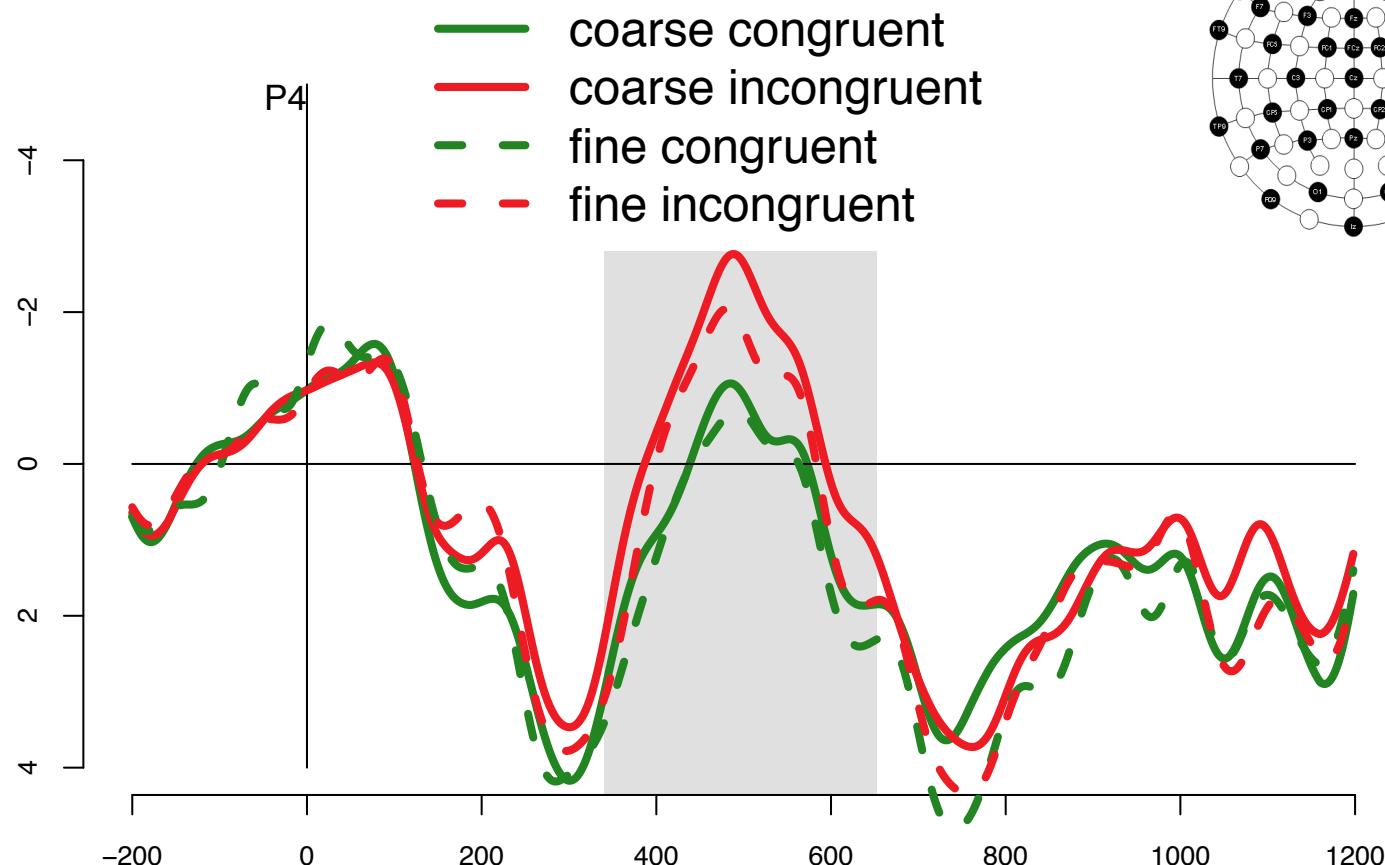
- 120 items + fillers
- Word-by-word presentations (350ms word + 100ms blank)
- ERPs time-locked to target (*drying/jogging*)



Results

N400 effect

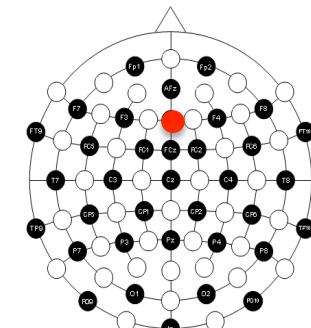
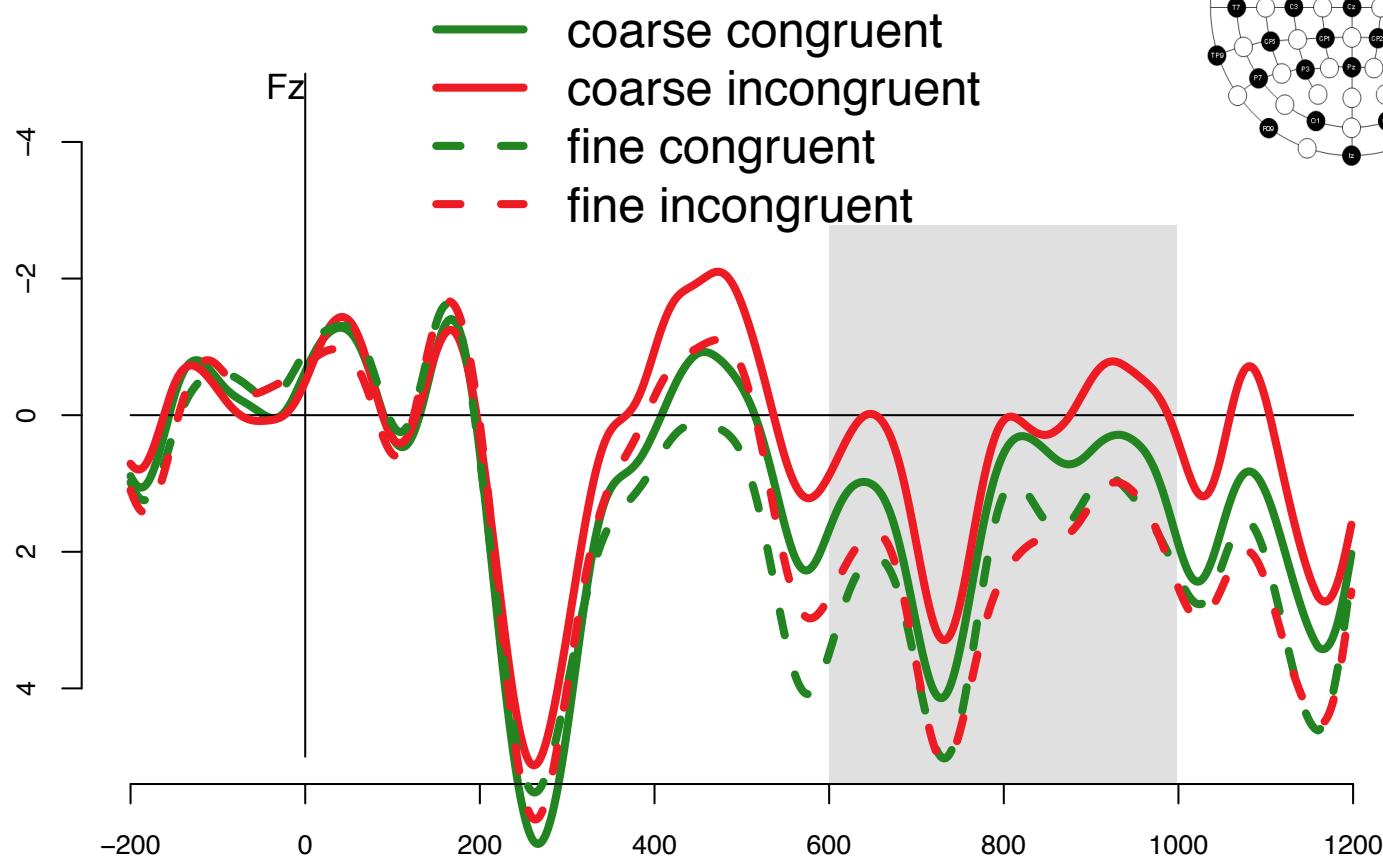
Main effect of congruity: Incongruent > Congruent



Results

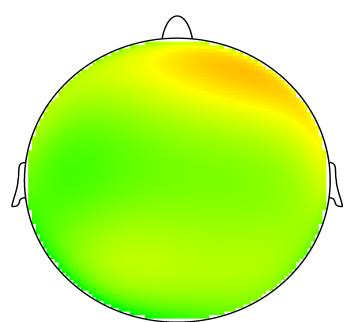
Frontal positivity

Main effect of Granularity: Fine > Coarse
Interaction Granularity X Congruency

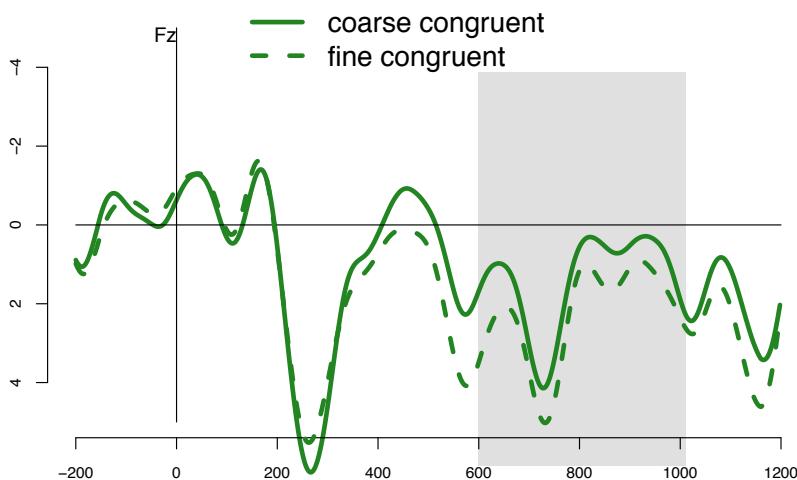


Frontal positivity- interaction

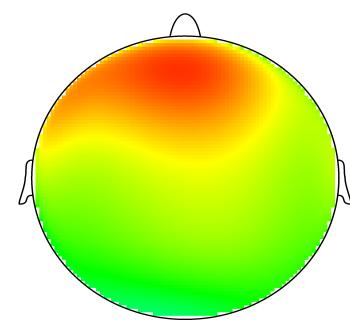
Congruent targets



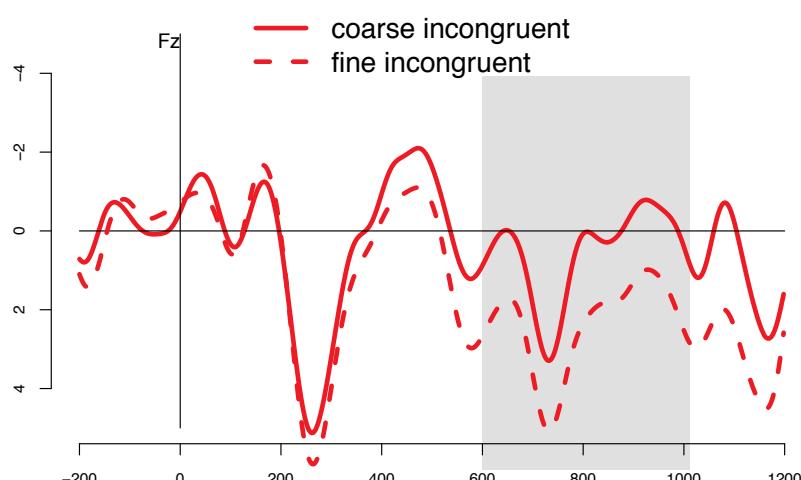
Fine-grained – coarse-grained



Incongruent targets



Fine-grained – coarse-grained



Discussion

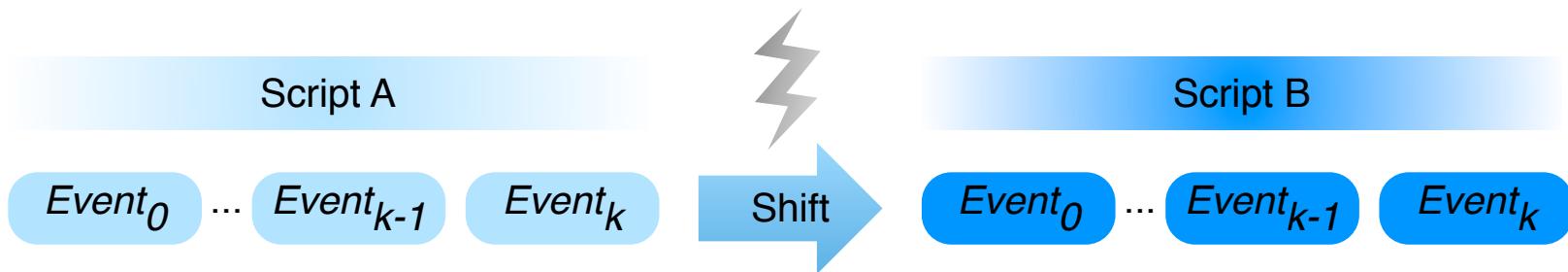
N400

- ▶ Sensitive to congruency → incongruent events less expected than congruent events
- ▶ Insensitive to contextual manipulation → minimal linguistic material sufficient to activate script-knowledge

Frontal positivity

- ▶ Sensitive to contextual manipulation → model updating
- ▶ Frontal positivity indexes cost for integrating events in more detailed contexts (main effect)
- ▶ When the events are surprising (= mark a script boundary) → stronger effect (interaction)

Script boundaries



Processing at script boundaries to assess:

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(Poster session)

Experiment 2 - design

Yesterday Diana went to the train station.

Short temporal shift

One moment later she booked a {TICKET, taxi}

Long temporal shift

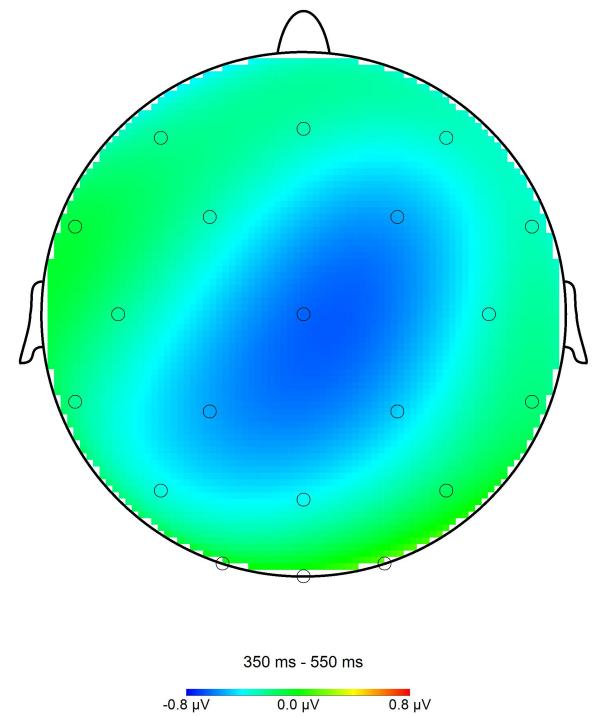
The day after she booked a {ticket, taxi}

- ▶ Script knowledge → ticket harder with long temporal shifts
- ▶ Priming → no difference

Preliminary results – 16 subjects

N400 effect

Main effect of congruency:
Incongruent > Congruent



Frontal positivity Interaction?

Come to the poster session!!

Take on message

$$\begin{aligned} \text{Effort}(\text{word}_i) &\propto \text{Surprisal}(\text{word}_i) = \\ &= -\log_2 P(\text{word}_i \mid \text{word}_{0..i-1}, \text{Script}) \end{aligned}$$

Script-based surprisal should capture:

- ▶ Lexical retrieval facilitated by script knowledge activation (N400)
- ▶ Integration processes (P600) sensitive to more fine-grained modulations of script knowledge activation (Brouwer & Hoeks, 2013)

Thank you ...
... and to the members of SFB 1102!

References

- Brouwer, H. and Hoeks, J. C.J., (2013). A time and place for language comprehension: mapping the N400 and P600 to a minimal cortical network. *Frontiers in Human Neuroscience*, 7, 758
- Hale, J. (2001). A probabilistic earley parser as a psycholinguistic model. In *Proceedings of the second meeting of NAACL '01*, pages 1–8, Stroudsburg, PA, USA
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- Schank, R. and Abelson., R. P. (1977). *Scripts, plans, goals and understanding: An inquiry into human knowledge structures*. Lawrence Erlbaum, Hillsdale, NJ