IDENTIFYING EEG MEASURES OF MEMORY AND ATTENTIONAL LOAD IN LANGUAGE PROCESSING

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This is not a neural net talk!
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‘Neural’ in this talk refers to actual neurons
WHAT IS ‘THE CHANNEL’?
Can we measure distinct aspects of ‘The Channel’?
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Where should we measure?
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Can we measure distinct aspects of ‘The Channel’?

Where should we measure?

Neural communication occurs over subchannels
What is ‘The Channel’?

Can we measure distinct aspects of ‘The Channel’?

Where should we measure?

Neural communication occurs over subchannels

Underpins linguistic communication
Can we measure distinct aspects of ‘The Channel’?

Where should we measure?

Neural communication occurs over subchannels

Underpins linguistic communication

Diff neural channels ?= Diff aspects of ‘The Channel’
Use EEG

Separately measure attention and memory influences on ‘The Channel’ via different neural channels
BACKGROUND: WHAT IS EEG?
Neural firing is not continuous.
FIRING OCCURS IN PARTICULAR FREQUENCY BANDS
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(Tort et al., 2010)
FIRING OCCURS IN PARTICULAR FREQUENCY BANDS

Comparison of EEG Bands

- **Gamma**: 30-100+ Hz
- **Beta**: 12-30 Hz
- **Alpha**: 8-12 Hz
- **Theta**: 4-7 Hz
- **Delta**: 0-4 Hz
FIRING FREQUENCIES INTERACT TO ENCODE INFORMATION

Example interactions:
- Bottom-up perceptions
- Top-down predictions
- Attentional salience ranking
- Working memory encoding

Do these translate to language?

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Phase-amplitude coupling

![Graph showing phase-amplitude coupling](image)
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Do these translate to language?
High alpha (‘low attention’)
Jensen et al., (2012)
EEG $d_2 - d_1$ (6 subjects)
\(d_0\) The cart broke.
\(d_1\) that the horse pulled
\(d_2\) that the man bought
Dual task paradigm:
Combine linguistic memory task with non-linguistic, non-memory task
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A4: Use the driving simulator!
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A4: Use the driving simulator!
   With EEG?
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How to dual task with EEG?
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Combine linguistic memory task with non-linguistic, non-memory task

How to dual task with EEG?
   Only affect the ‘attentional’ channel
Little & Woollacott (2015)
Experimental Design

Conditions:
Ling: 0 vs 2 embedding
Task: Solo (no beep) vs Dual (beep)
Focus: Ling vs Alt

Ling-solo vs \{ Ling-dual, Alt-dual \}
Stimuli
2 embeddings:
Either both A will V1 and B will V2 or S2.
Either both G will V1 and B will V2 or S2.

0 embeddings:
Now today, A will V1 and B will V2 or S2.
Now today, A will V3 and B will V2 or S2.
2 embeddings:
Entweder werden zuerst die Pflanzlinge umgesetzt und dann gedeiht der Garten oder der Baum trägt keine Früchte.
Entweder werden zuerst die Pflanzlinge umgetopft und dann gedeiht der Garten oder der Baum trägt keine Früchte.

0 embeddings:
Meistens werden sorgfältig die Pflanzlinge umgesetzt und dann gedeiht der Garten oder der Baum trägt keine Früchte.
Meistens werden sorgfältig die Pflanzlinge umgetopft und dann gedeiht der Garten oder der Baum trägt keine Früchte.
8 topic domains
~12 coordinator pairs / domain = 96 stimuli
2 versions of each stimulus (0,2)
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96 fillers
>50% shorter than test stimuli
50% begin with N coord
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96 fillers
  >50% shorter than test stimuli
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Comprehension variants for each item/filler
  66% change content word
  33% change coordinator
EXPERIMENTAL TIMING

450 ms / word
~ 10 words / sentence
(96 stimuli + 96 fillers)
6 seconds for comprehension+feedback (50%)
1 second for alt feedback (66%)
~30 second break after each domain
~30 minutes + setup + cleanup
Hypotheses and Conclusion
• $\alpha, \gamma$ (Attentional salience ranking)
  ling-solo-0 < ling-dual-0 = alt-dual-0
HYPOTHESES

- $\alpha, \gamma$ (Attentional salience ranking)
  
  ling-solo-0 < ling-dual-0 = alt-dual-0

- $\theta, \gamma$ (Working memory encoding)
  
  ling-solo-0 < ling-solo-2
HYPOTHESES

• $\alpha, \gamma$ (Attentional salience ranking)
  ling-solo-0 $<$ ling-dual-0 $=$ alt-dual-0

• $\theta, \gamma$ (Working memory encoding)
  ling-solo-0 $<$ ling-solo-2

• Can we see the effects independently?
  ling-solo-0 $<_{a<m}$ ling-dual-2
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  ling-solo-0 < ling-dual-0 = alt-dual-0

• $\theta, \gamma$ (Working memory encoding)
  ling-solo-0 < ling-solo-2

• Can we see the effects independently?
  ling-solo-0 $<_a<_m$ ling-dual-2

• $\alpha$ power (Inhibition)
  alternate task regions $> \text{focused task region}$
• Younger vs Older Subjects
• English vs German
Open questions:

- Focus change? Just in pilot?
- 1-2-3 beeps?
- Easy vs Hard beeps?
Any questions or suggestions?

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