The dorsal and ventral streams differ in commutativity, not complexity

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Introduction

What we were thinking about

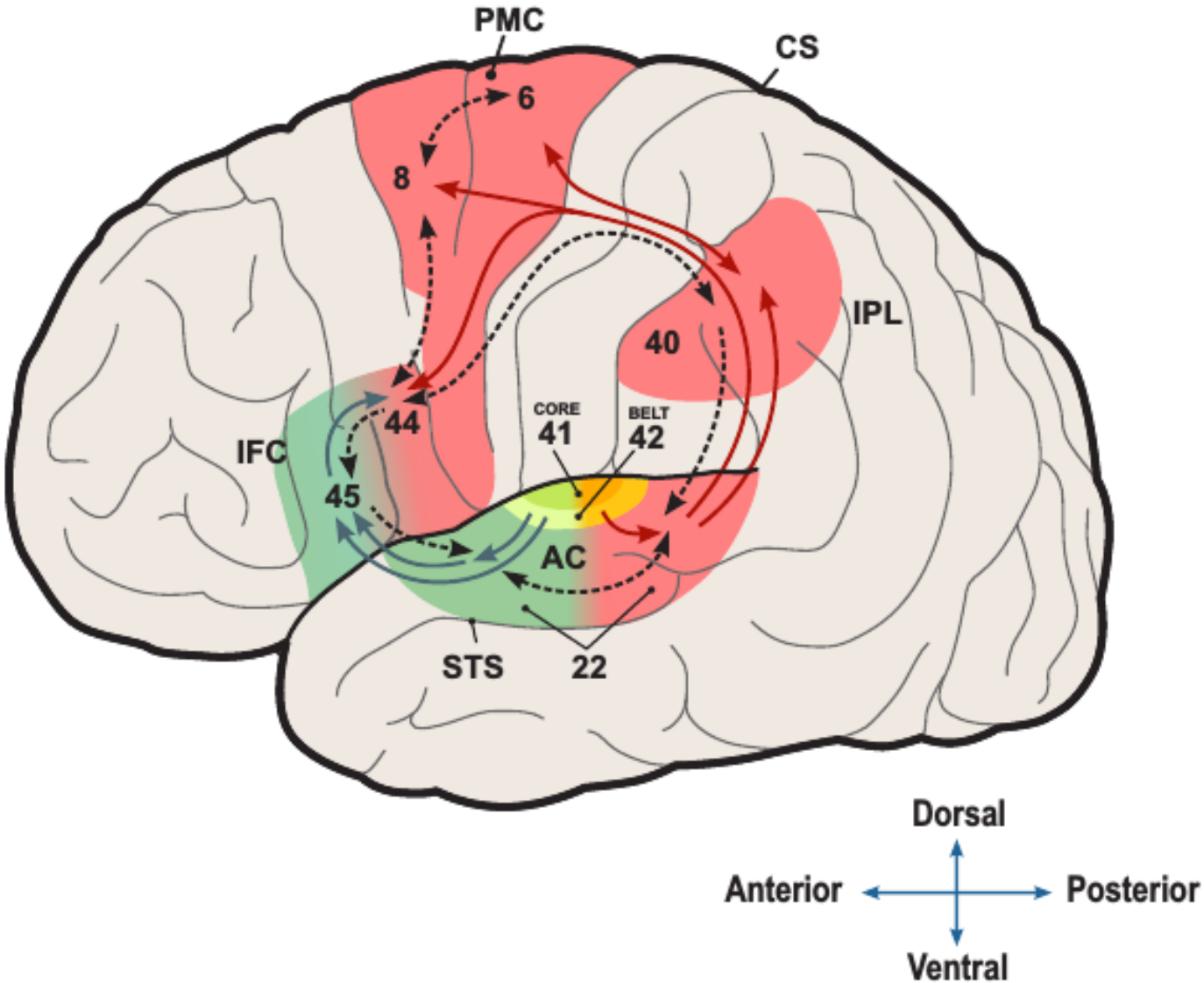
Dorsal and Ventral Streams

- based on neuroanatomical fibre tracks
- various proposals for the division of labour between streams
  - Hickok and Poeppel (2004): sound-to-meaning vs. sound-to-motor
  - Friederici (2009, 2012): complexity
  - Bornkessel-Schlesewsky & Schlesewsky (2013), Bornkessel-Schlesewsky et al. (2015): 'types' of relationships

What we propose

- complex relations processed in both streams
- commutativity (sequence-ordering) relevant difference
  - dorsal stream: non commutative
  - ventral stream: commutative
- (incrementality still relevant for both streams)
- 'hierarchical' relations possible in both streams

What we propose



Bornkessel-Schlesewsky & Schlesewsky (2015)

What we predict in electrophysiology

- component latency determined by temporal receptive window (Hasson et al. 2008, 2015 inter alia), independent of stream
- topography determined by temporal receptive window and stream
- different topographies for sequence vs. non-sequence violations at timescales previously observed – e.g. LAN vs. N400

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Is this visible even for syntactically and semantically possible but unlikely/marked constructions?

Experiment

What we tested

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- small, simple violations of ordering and cooccurence
- small timescales, violation apparent at (near) word level

What we used as stimuli

- noun phrases with two adjectives
- first constinuent (i.e. subject, no context) in a transitive sentence
- auditory presentation
- Three conditions
  - control: *the big red ballon*
  - sequence: *the red big balloon*
  - cooccurence: *the heavy red balloon*
- non critical stimuli included other constructions (including double violations) and noun phrases with three adjectives

Who we tested

- 18 healthy native speakers of Australian English
- 11 females
- mean age 24$\pm$2.5 years

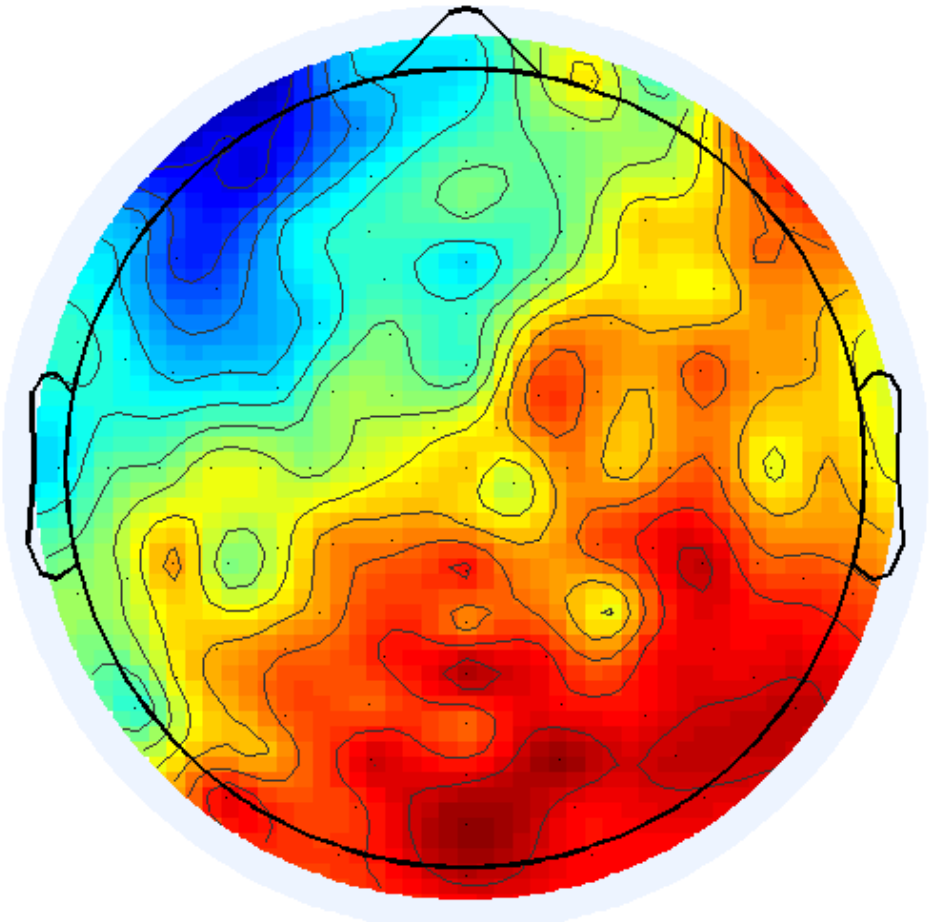
How we analysed

- ERP:
  - 0.3–30 Hz FIR bandpass filter
  - automatic absolute-threshold rejection of 40μV
- linear mixed-effects models
  - design-based random-effect terms for subjects and items (cf. Bates et al. 2015)
  - fixed-effect terms for sagittality, laterality, condition with sum-encoding
- subsequent pairwise comparisons using least-square means

What we found

At the second-adjective

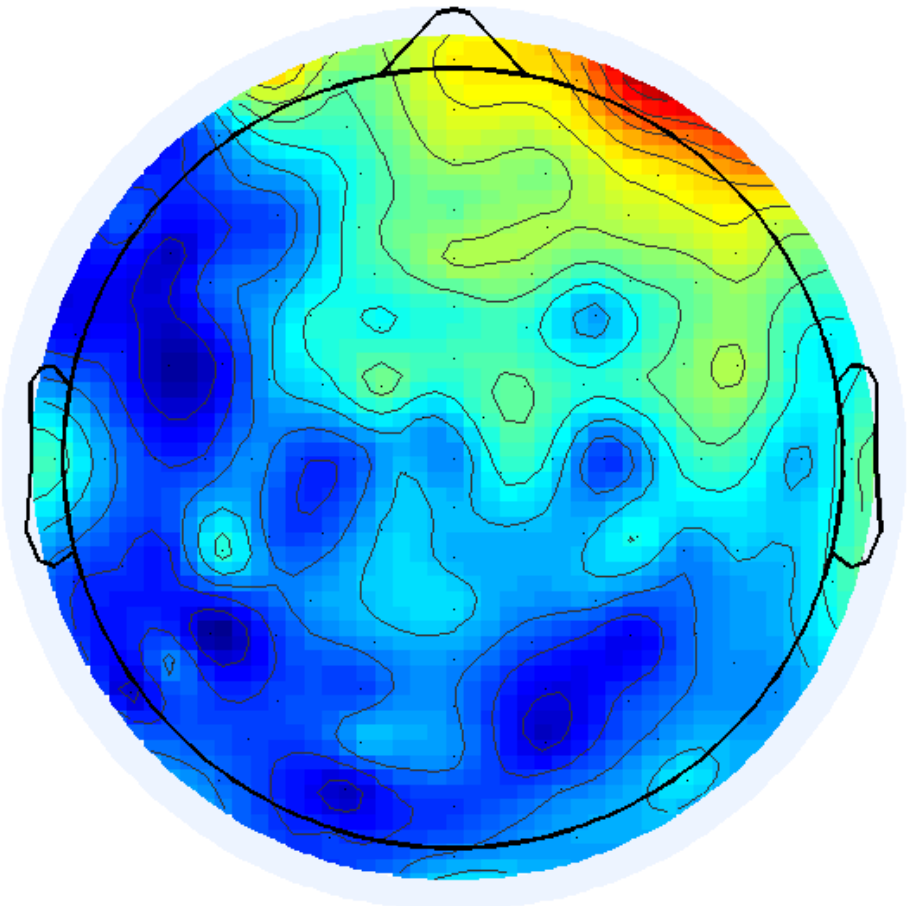
Sequence violations elicit a left-anterior negativity



What we found

At the head noun

Cooccurence violations elict centro-parietal negativity



Conclusions

What we conclude

- Local, word-level combinatorics more important than complexity
- Centro-parietal negativity projected from ventral stream for unusual combinations (unordered pairings)
- (Left)-Anterior negativity projected from dorsal stream for unusual permutations (ordered pairings)

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Commutativity is not complexity.

And commutativity is the relevant distinction between the streams.

What we're still planning

- TMS: virtual legions of single streams to test causality
- ICA + potentially source localisation
- Double violation as examination of stream cross-talk

Thanks to

- my co-authors
- Eloise Denaro

Cognitive Neuroscience Laboratory

Questions?