Donders Institute
for Brain, Cognition and Behaviour

**Lea Hald, Ian Hocking[1], Julie-Ann Marshall[1],
David Vernon[1] & Alan Garnham[2]**

**Modality switching and negation:
ERP evidence for modality-specific simulations during
negation processing**

**[1]Canterbury Christ Church University, UK
[2]University of Sussex, UK**

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Background

- Pecher, Zeelenberg & Barsalou (2003)

- Property-verification task: decide whether last word (typically) describes a property of the first word.

- Carnation can be black.

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Modality Switch Effect

Television can be loud. auditory
Old books can be musty. olfactory

Soap can be perfumed. olfactory
Old books can be musty. olfactory

- Faster/more accurate to respond when previous sentence matched in modality.

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Modality Switch Effect & ERPs

- Property verification task: visual & auditory modalities
- Auditory example

Candles flicker.	Visual
Leaves <u>rustle</u>.	Auditory
High heels click.	Auditory
Leaves <u>rustle</u>.	Auditory

- Visual property modality switching: increased amplitude N400
- Auditory property modality switching: larger late positive complex

Collins, Pecher, Zeelenberg & Coulson, 2011, *Front. Psychology*

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Modality Switch Effect & ERPs

- Sentence verification task: visual & tactile modalities
- Looked at true and false sentences

- Tactile sentence example

Mismatch-true/false:	*A leopard is spotted.*	visual
	A peach is <u>soft/hard</u>.	tactile
Match-true/false:	*An iron is hot.*	tactile
	A peach is <u>soft/hard</u>.	tactile

Hald, Marshall, Janssen & Garnham, 2011, *Front. Psychology*

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Summary of previous results

- ## Modality Switch Effect
  - For True sentences (*leopard spotted/ iron hot >> A peach is <u>soft</u>.*) switching elicited a greater negativity across anterior electrodes from 160-215 ms, 270-370 ms and again from 500-700 ms.
  - For False sentences (*leopard spotted/iron hot >> A peach is <u>hard</u>.*) no significant effect of switching was seen.

- ## Effect of Veracity
  - For Mismatched sentences, False sentences (*iron hot >>A peach is <u>hard</u>.*) elicited a typical N400 from 350-550 compared to True sentences (*iron hot >>A peach is <u>soft</u>.*).
  - For Matched sentences, no significant effect of veracity was seen.

<div align="right">Hald, Marshall, Janssen & Garnham, 2011, Front. Psychology</div>

Donders Institute for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Motivations for current study

1. Modality Switch Effect: Can we find a modality switch effect with sentences containing negation?

2. Veracity: Can modality information change the processing of negation?

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

1. Modality Switch Effect: Can we find a modality switch effect with sentences containing negation?

- Sentence verification task: visual & tactile modalities
- Sentences presented visually – one word at a time.

- Visual sentence example

Mismatch-true/false: *A light bulb is very hot.*   tactile

Rice isn't <u>black/white</u>.   visual

Match-true/false: *A giraffe is spotted.*
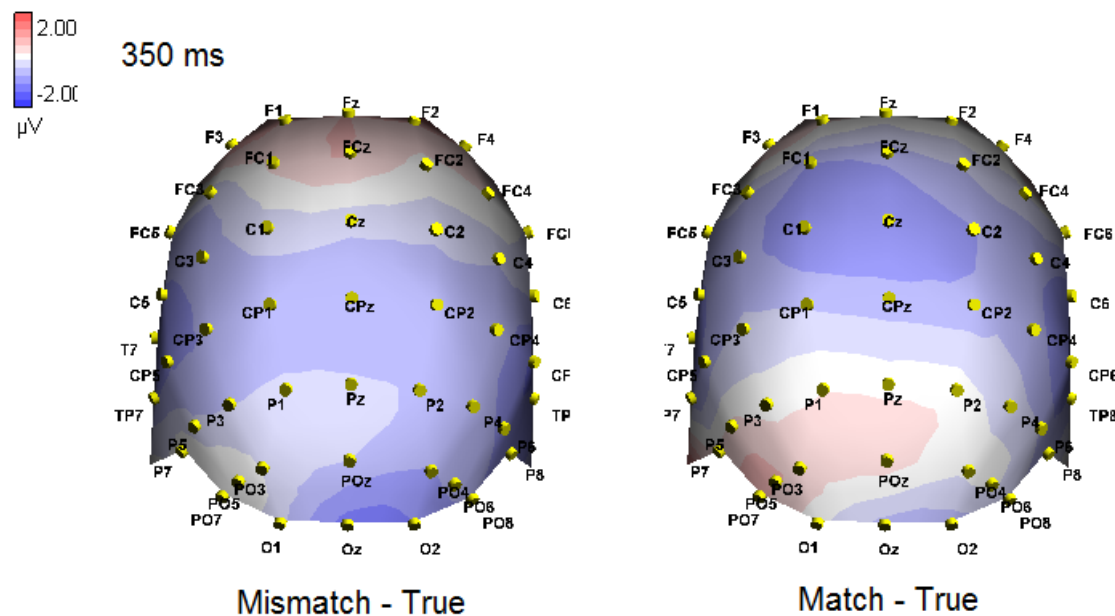visual   *Rice isn't <u>black/white</u>.*
visual

Modality Results for True Sentences

Modality Mismatch-True   *A light bulb is very*
   hot.   *Rice isn't* black.

Modality Match-True   *A giraffe is*
   spotted.   *Rice isn't*
<u>*black*</u>.

295 ms

Mismatch - True   **Match -True**
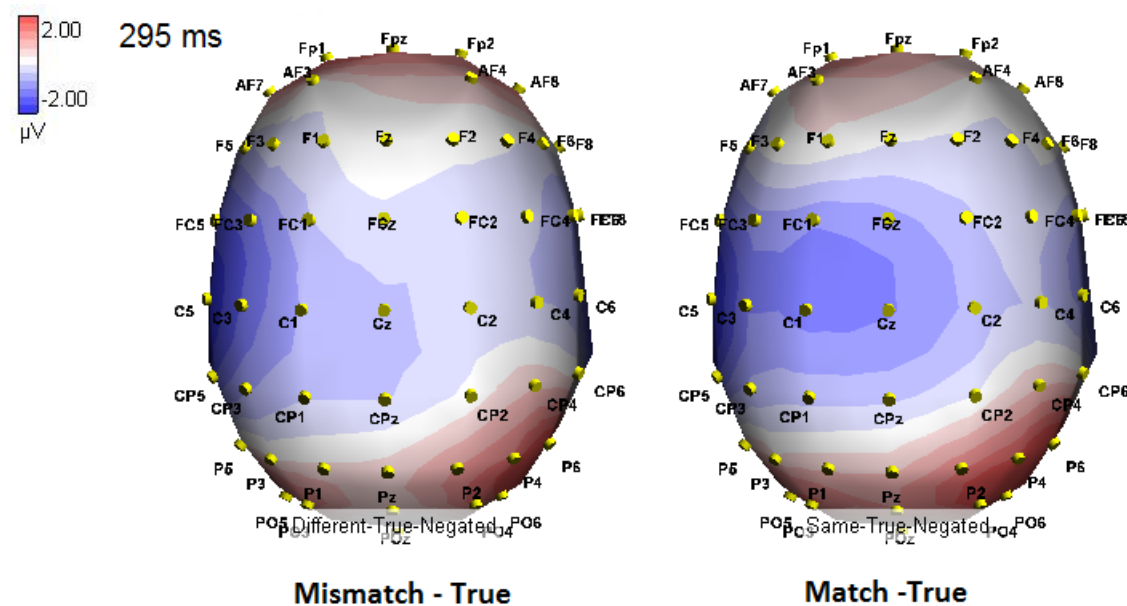
1. 190-500ms Match shows greater negativity than Mismatch across frontral-central electrodes. Maximal over the left hemisphere.
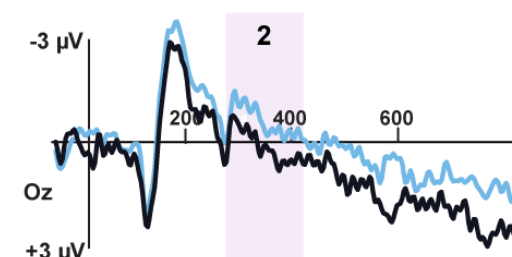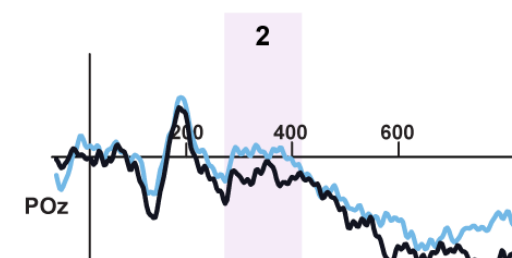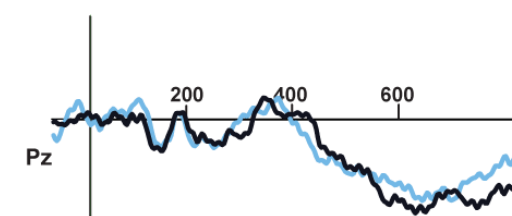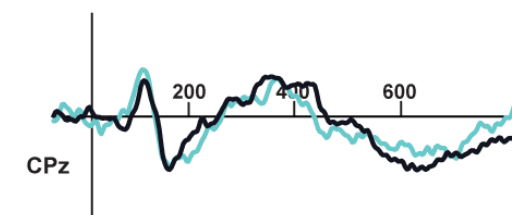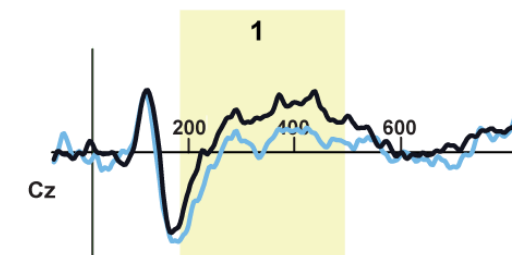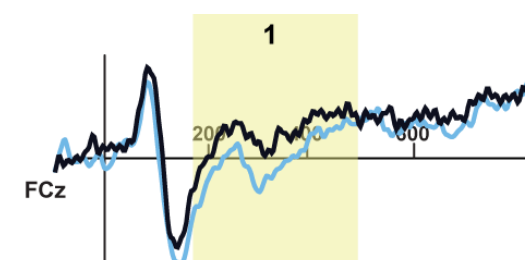
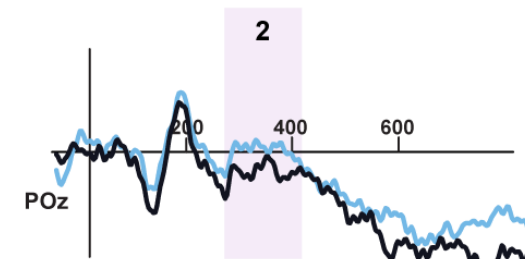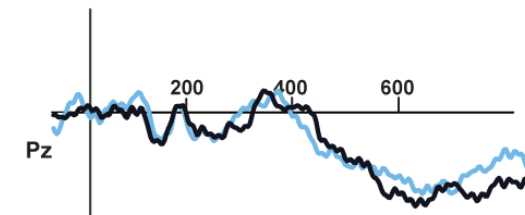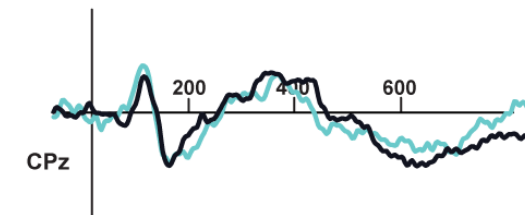# Modality Results for True Sentences

Modality Mismatch-True   *A light bulb is very*
  hot.   *Rice isn't black.*

Modality Match-True   *A giraffe is*
  spotted.   *Rice isn't*
black.

2.00

-2.00

μV

350 ms

Mismatch - True

Match - True

2. 270-420ms Mismatch shows greater negativity than Match across posterior electrodes. Maximal over the left hemisphere.
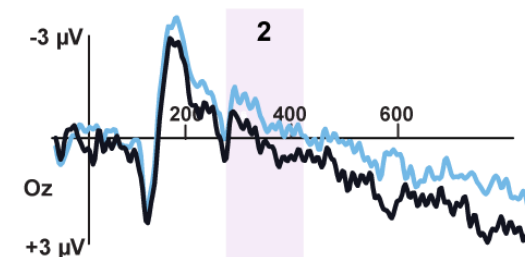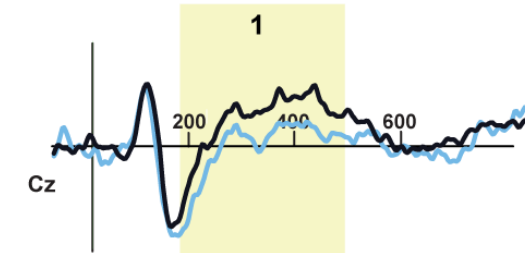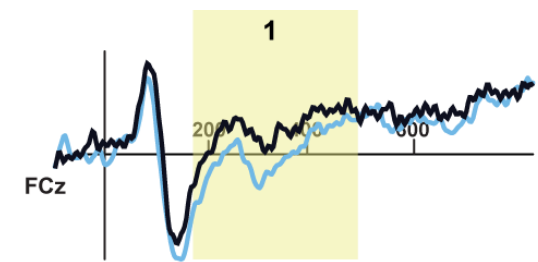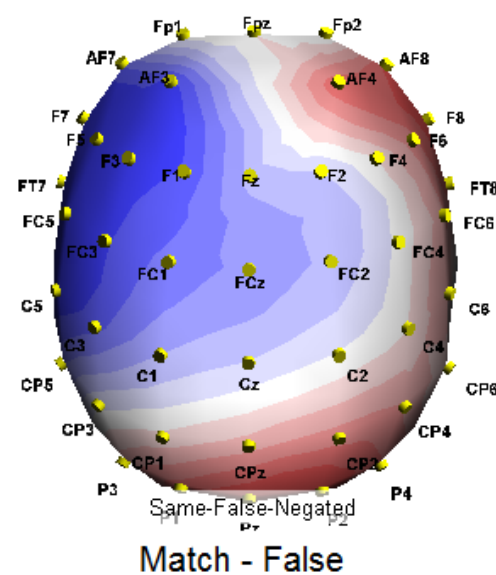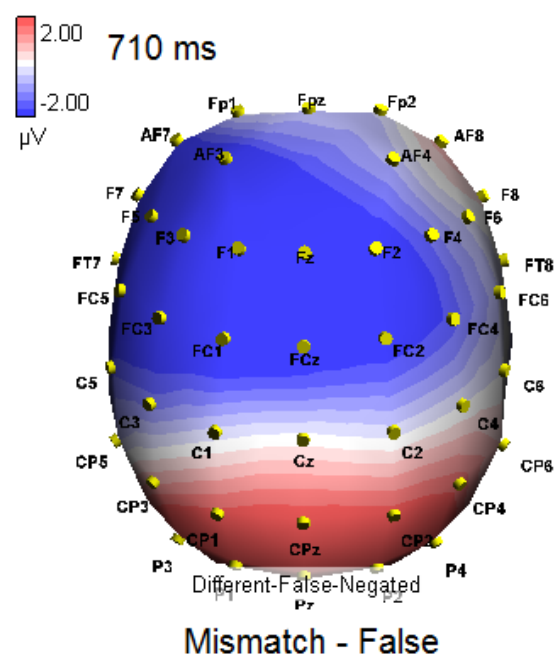
FCz

Cz

CPz

Pz

POz

-3 μV

Oz

+3 μV

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Modality Results for False Sentences

Modality Mismatch-False *A light bulb is very hot.*
  Rice isn't *white*.

Modality Match-False *A giraffe is spotted.*
  Rice isn't *white*.

710 ms

Mismatch - False Match - False

1. 420-1000ms Mismatch shows greater negativity than Match across frontal-central electrodes. Slightly left maximal.
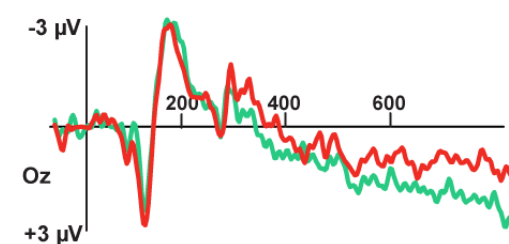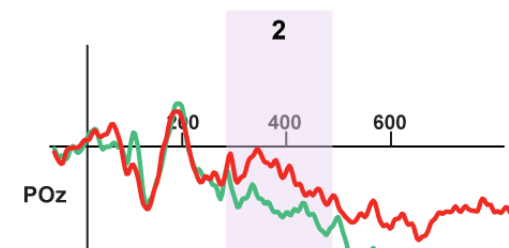
Donders Institute for Brain, Cognition and Behaviour

Radboud University Nijmegen

Modality Results for False Sentences

Modality Mismatch-False *A light bulb is very
hot.* *Rice isn't* *white**.*

Modality Match-False *A giraffe is
spotted.* *Rice isn't*
*white**.*

Mismatch - False   Match - False

2. 300-500ms Match shows greater negativity than Mismatch across central-posterior electrodes.
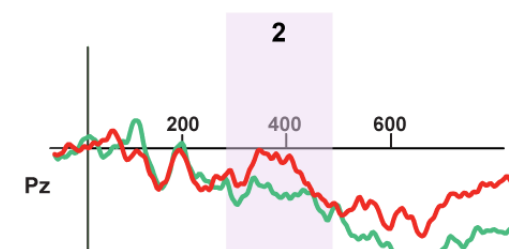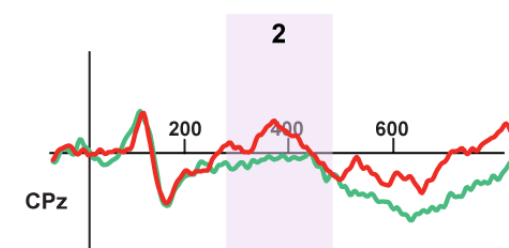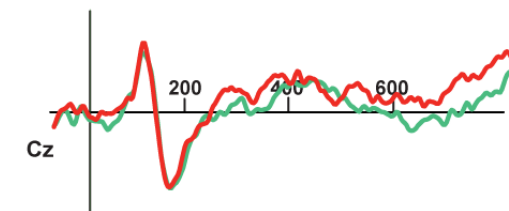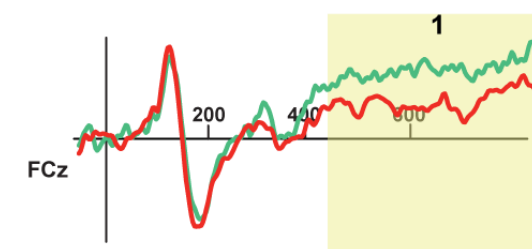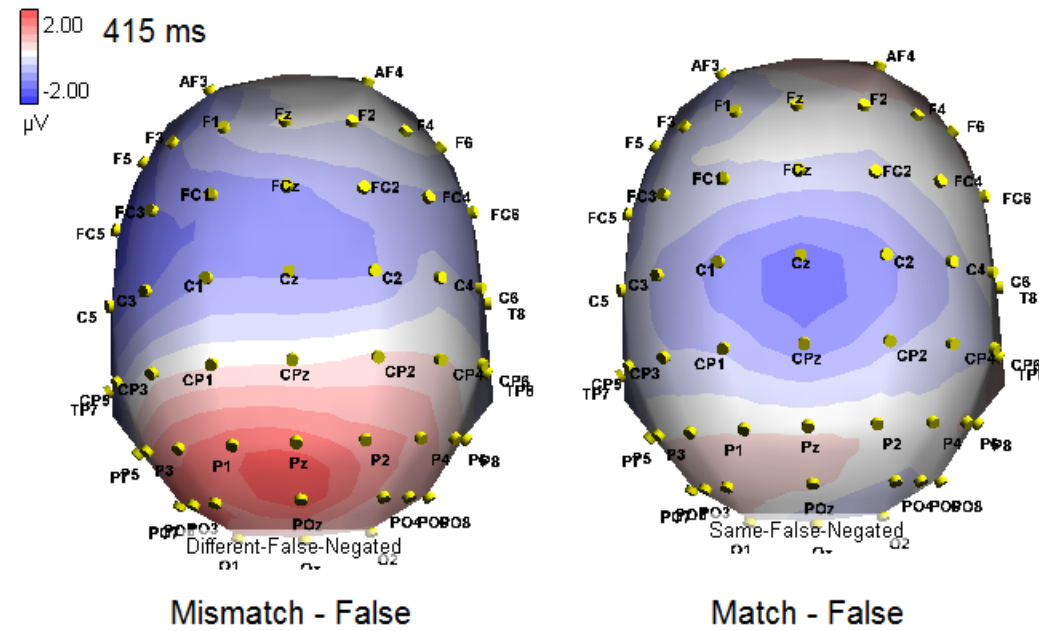
Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011
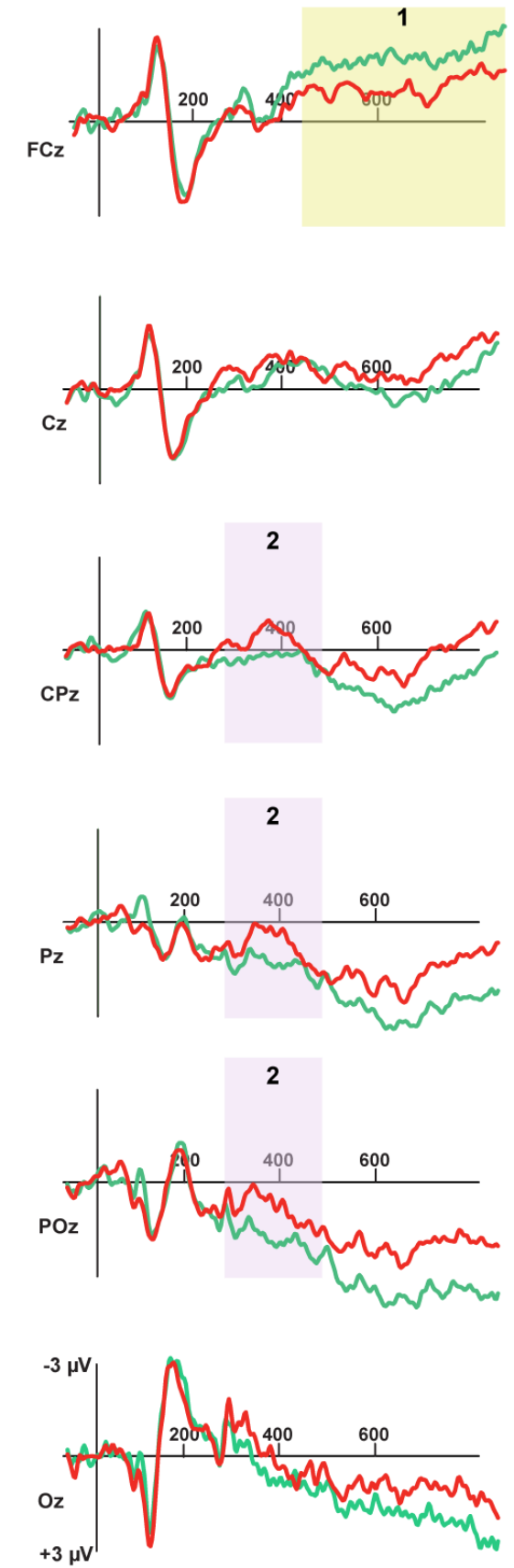
1. Modality Switch Effect: Can we find a modality switch effect with sentences containing negation?

- Yes!

- True sentences (*light bulb hot/giraffe spotted>> Rice isn't <u>black</u>*.) switching elicited a greater negativity across posterior electrodes from 270-420 ms.

- False sentences (*light bulb hot/giraffe spotted>> Rice isn't <u>white</u>*.) showed opposite pattern. Match showed greater negativity than Mismatch across central-posterior electrodes from 300-500 ms.

- Similarly, both conditions showed a late frontal negativity, but again, in the opposite direction (Match-True more negative compared to Mismatch-True and Mismatch-False more negative compared to Match-False)

Donders Institute for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

2. Veracity: Can modality information change the processing of negation?

Typical ERP studies have shown an interaction between the truth value & affimative/negative sentences.

Affirmative, True	*A robin is a <u>bird</u>.*	
Affirmative, False	*A robin is a <u>tree</u>.*	larger N400
Negative, True	*A robin is not a <u>tree</u>.*	larger N400
Negative, False	*A robin is not a <u>bird</u>.*	

Fischler, Bloom, Childers, Roucos & Perry, 1983, *Psychophysiol.*; see also Hald et al., 2005; Lüdtke, et al., 2008; but see Nieuwland & Kuperberg, 2008; Hald et al., 2011 for exceptions

Donders Institute for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

2. Veracity: Can modality information change the processing of negation?

- Visual sentence example

Mismatch-true/false: *A light bulb is very hot.*   tactile

                                   Rice isn't <u>black/white</u>.   visual

Match-true/false: *A giraffe is spotted.*
        visual   *Rice isn't <u>black/white</u>.*
                        visual

Mismatched modality: True vs. False

Modality Mismatch-True   A light bulb is very
    hot.   Rice isn't **black**.

Modality Mismatch-False   A light bulb is very
    hot.   Rice isn't **white**.

Mismatch - True   Mismatch - False

1. 330-850ms False shows greater negativity than True across frontal-central electrodes. Maximal over the left hemisphere.
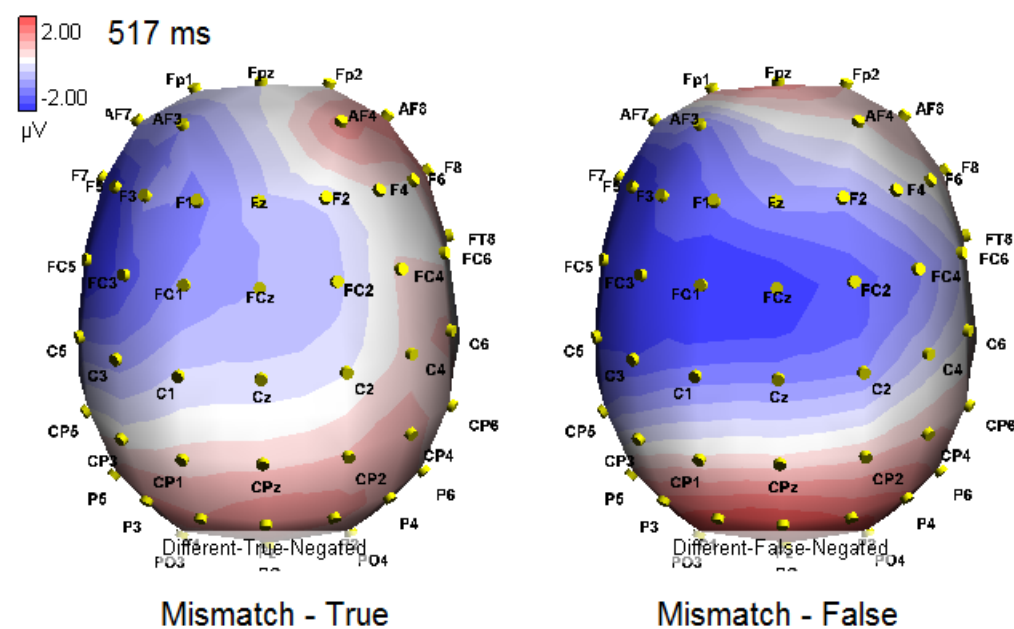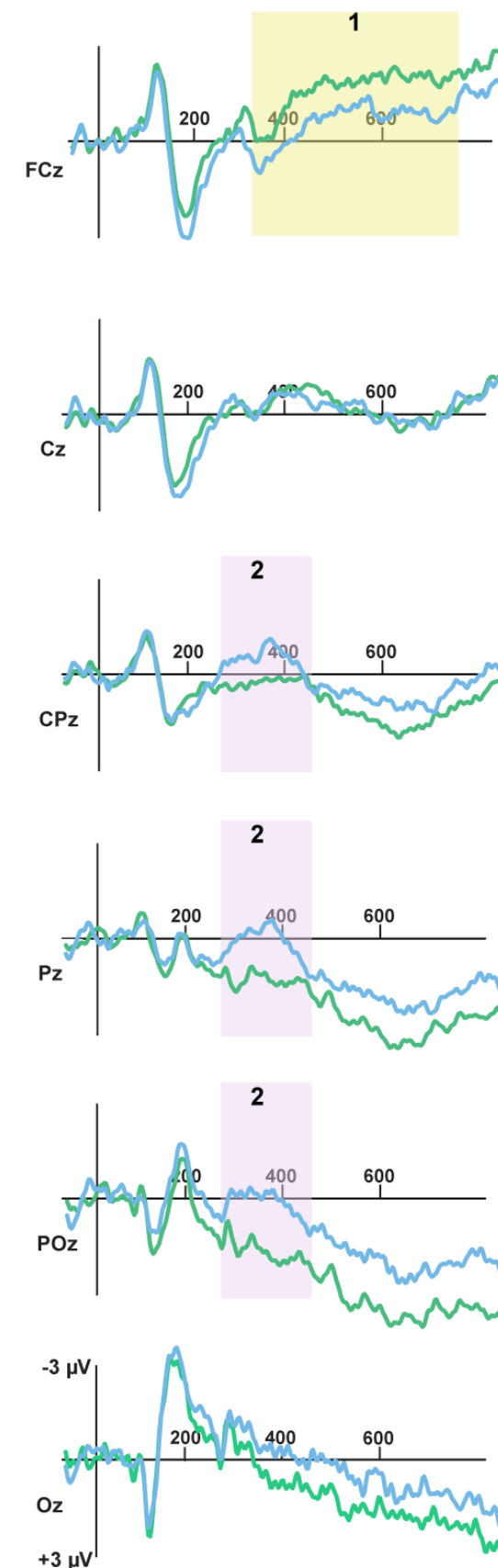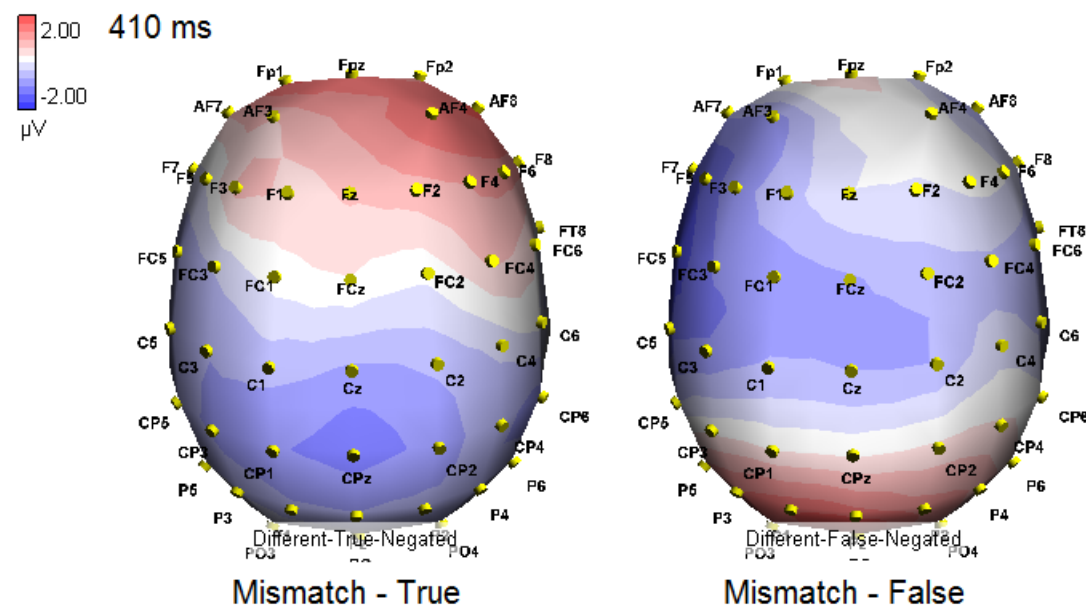
Mismatched modality: True vs. False

Modality Mismatch-True   A light bulb is very
    hot.   Rice isn't **black**.

Modality Mismatch-False   A light bulb is very
    hot.   Rice isn't **white**.

2. 290-430ms True shows greater negativity than False across central-posterior electrodes. Maximal over the left hemisphere.
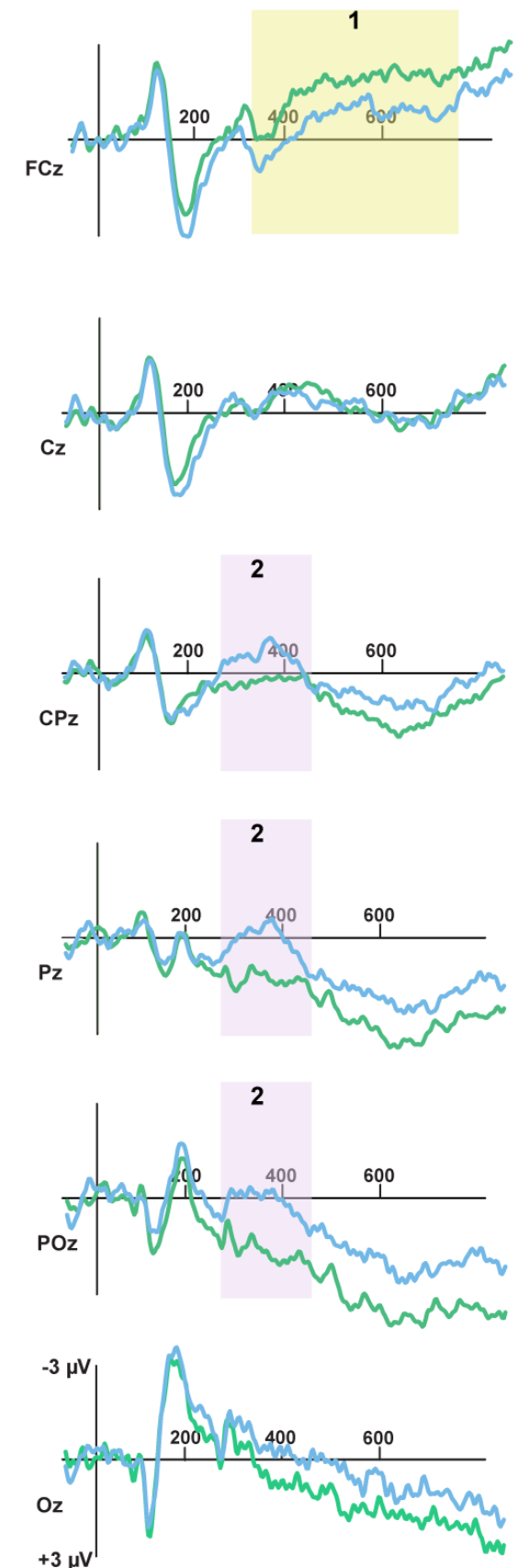
Matched modality: True vs. False

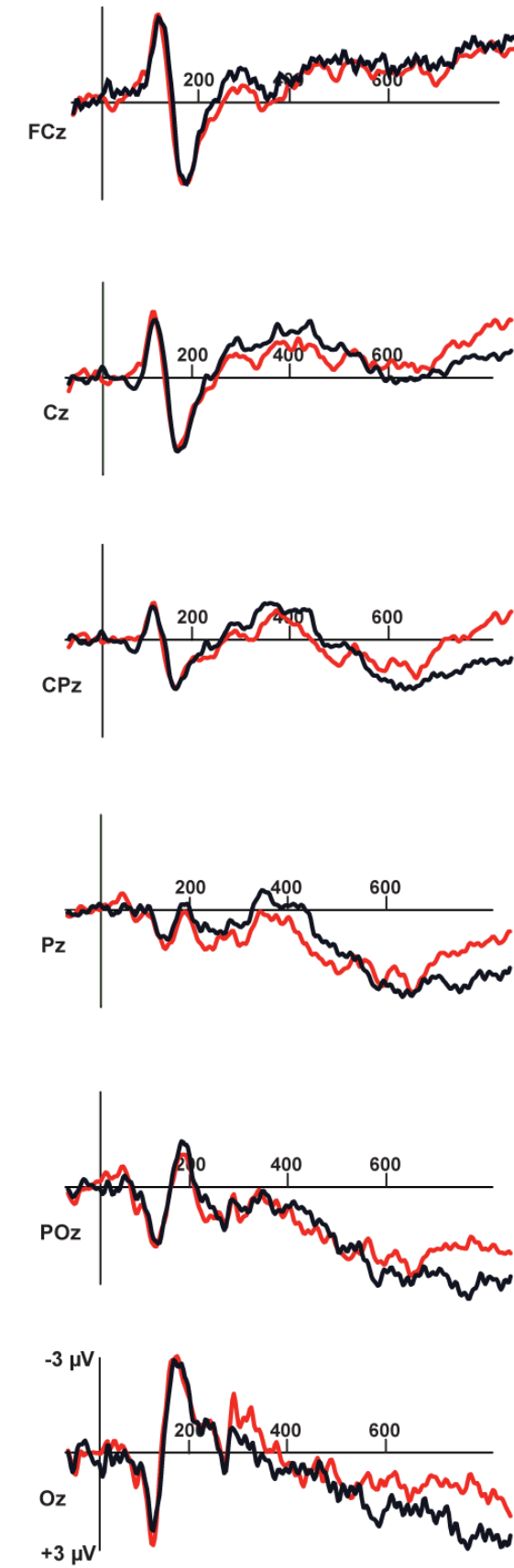Modality Match-True   A giraffe is
   spotted.   Rice isn't
   <u>black</u>.

Modality Match-False   A giraffe is
   spotted.   Rice isn't
   <u>white</u>.

No significant differences found.

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

2. Veracity: Can modality information change the processing of negation?

- Yes – sort of…

- Mismatch sentences (*light bulb hot >> Rice isn't <u>black/white</u>.*) True sentences elicited a standard N400 compared to False sentences. The typical finding with negated true vs. false sentences.

- Match sentences (*giraffe spotted>> Rice isn't <u>black/white</u>.*) No effect of veracity was seen.

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Overall Summary of Results

1. Modality Switch Effect: Switching lead to a greater negativity (N400-like effect) for True sentences but for False sentences it was the Match Modality that led to a greater negativity.

2. Veracity: Typical veracity effects were found in the Mismatch Modality condition. In the Match modality, no veracity differences were found.

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Conclusions & Theoretical Implications

- Modality switching always leads to (early) processing costs (affirmative, negative, true and false sentences).
- Why does modality switching have the opposite effect in the ERP for false sentences (Match-False greater N400 than Mismatch-False)?
  - The Match allows for quicker recognition of the falsehood, hence greater N400. The Mismatch results in processing costs which in turn leads to slower recognition of the falsehood.
  - Predicts a smeared peak N400 for the Mismatch-False condition.
- A better model of how false sentences are represented in an embodied fashion is needed.

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Conclusions & Theoretical Implications

- The effect of modality matching on veracity (whether the sentence is affirmative or negative) is robust.
  - Matching modality can facilitate processing, making information in false sentences no more difficult to comprehend than true sentences.

Thank You!

Ian Hocking
Julie-Ann Marshall
David Vernon
Alan Garnham

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Design

- 160 pairs of experimental sentences.
- 40pairs in each of the four conditions.
- First sentence in all experimental pairs was affirmative.
- Half of items in each condition were visual, the other half tactile.
- 80 false-false negation filler pairs.
- Equal number of negated & affirmative sentences overall.
- Equal number of true and false sentences overall.
- Fully within subject design.
- 64 channel WaveGuard Cap (ANT system)

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen

Hald, Hocking, Marshall, Vernon & Garnham, 25 August 2011

Modality Switch Effect

- Control study

Sheet can be spotless.
Air can be clean.

Sheet can be spotless.
Meal can be cheap.

- An associative priming effect did not occur in the RTs or errors.

Donders Institute
for Brain, Cognition and Behaviour

Radboud University Nijmegen