How does the brain respond to photographs?

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Introduction

Why are we doing this research?

• Schools often use visual supports to help students learn

• A visual scene display (VSD) is a type of visual support in which a photograph is displayed with hotspots under the targets to allow students to communicate

• Children learn language in context, therefore VSDs may be easier for the child to learn language than the more traditional grid-based design

• However: Will the physical resemblance of the photograph to its referent cause the child to rely on the perceptual similarity, thus interfering with understanding or use of it as "symbolic"?

• Our goal was therefore to find out if the brain responds to pictures in the same way as other symbols.

Hypotheses

• We expected the brain to respond to photographs in the same manner it responds to other forms of language (N400 wave)

- See: Kutas & Hillyard, 1980, 1983; Besson & Macar, 1987; Kutas & Van Petten, 1988, 1994

• If our hypothesis is supported, it would suggest VSDs are processed by the brain in the same way as demonstrably "symbolic" stimuli such as written or spoken words.

Methods

What is EEG?

• EEG – electroencephalography
  • A recording of electrical activity in the brain

Photo courtesy of EGI

• How is it measured?
  • A net of electrodes is placed on a subject's head
  • The net is soaked in a solution mixed with baby shampoo to allow for a good connection to the scalp
  • Electrical activity is recorded and amplified and appears as a continuous waveform

• What is the N400 wave?
  • The N400 wave is a negative deflecting wave that occurs around 400ms following a semantically mismatched stimulus

Methods

Semantic Mismatch

• Occurs when a semantically appropriate item is replaced with a semantically inappropriate item

• In other words, you are expecting something to "make sense" and then are "surprised" when it doesn't make sense at all.
  • Eg. I drink coffee out of a mug vs. I drink coffee out of a shoe

• This is the basis for which our study was designed

Procedure

Subjects: 20 paid volunteers (16 males, 4 females) between the ages of 18-26
  • 4 subjects were removed from the final analysis as a result of too much noise in the data or not enough useable trials
  • 1 subject was removed because of a later effect as compared to the others

Stimuli: 56 pairs of photographs and spoken phrases
  • Pairs verified by 30 students involved in the National Student Speech Language and Hearing Association (NSSLHA) as either matches or mismatches.

Conditions:
1. **Matched Condition:** The spoken phrase accurately described the photograph displayed
2. **Mismatched Condition:** The spoken phrase did not accurately describe the photograph displayed

Matched

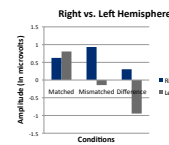The girl is riding.

Mismatched

The girl is sleeping.

We expected to see an N400 brainwave in response to the mismatched condition

Results

Visual Inspection

Match
MisMatch
Difference Wave

• Grand average for subjects 1-15 between 400-500ms
• Visible N400 across parietal sites for mismatched condition

• Waveform for Pz (Central-Parietal location)
• Visible N400 for mismatched conditions
• Difference wave also shows a negative deflection around 400ms

Results (Cont'd)

Statistical Analysis

• **Hemispheres**
  • The left hemisphere exhibited a significantly greater difference between conditions than the right hemisphere
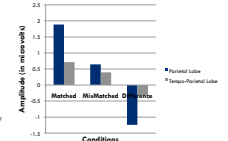 • $p = .008$, Effect size: .634

Right vs. Left Hemisphere

• The graph to the left displays the differences between the right and left hemispheres for both conditions and the difference wave
• Difference Values by Hemisphere
  • Matched: 0.178118 µV
  • Mismatched: -1.0736647 µV
  • Difference Wave: -1.2517827µV

• **Lobes**
  • The parietal lobes exhibited a significantly greater difference between conditions than the tempo-parietal lobe
  • $p = .036$, Effect size: .526

• The graph to the right displays the differences between the parietal and tempo-parietal lobe for both conditions and the difference wave
• Difference Values by Lobe
  • Matched: 1.169143 µV
  • Mismatched: 0.25041033 µV
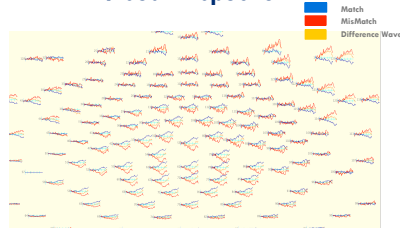 • Difference Wave: -.9187327 µV

Parietal vs. Tempo-Parietal Lobes

Discussion/Future Directions

Discussion

• N400 was present in the mismatched condition between 400-500ms

• There were significantly larger differences between each condition for the left hemisphere which is consistent with where language processing occurs

• There were significantly larger differences between each condition for the parietal lobes, which is consistent for where the N400 wave is often seen in semantic mismatch studies

• The brain responded to photographic/auditory stimuli in a semantic mismatch much the same way it does to other forms of language (eg. written and spoken words)

Future Directions

• Complete a similar study using children with developmental disabilities to see if the task elicits a similar response

• Continue to support the use of visual scene displays as educational aids and communicative devices for young children