Embodiment (2)

SS16 - (Embodied) Language Comprehension

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Overview

Last week

Traditional cognition

Cognition for action
  Theoretical basis
  Supporting evidence
  Problems with this concept

Body-based cognition
  Symbol grounding problem
  Perceptual symbol systems

• This week:

  • Body-based cognition
    • Behavioural evidence
    • Brain imaging evidence
    • Evidence from clinical populations

  • Problems with embodiment

  • Middle ground approaches
Embodied Language Processing

Body-based Cognition

This strict embodied view suggests that sensorimotor experiences are essential to meaning.

So, we are looking for evidence of sensorimotor and language processing influencing each other.
Embodied Language Processing

**Behavioural Evidence**

**Words priming motor behaviour**

- Participants unscrambled words to make sentences
- Either lots of words linked to elderly or neutral words
- Crucially, no words linked to speed
- Experimenters timed how long it took people to walk away

*Bargh et al (1996)*
Embodied Language Processing

Behavioural Evidence

Shimuhuru word reading test vs Schumacher word reading test

- Participants read out words from one of these lists
- They were secretly timed doing so

MacRae et al. (1998)
Embodied Language Processing

Behavioural Evidence

- Schumacher was the quickest!
- Concept of “speed”, quickened language production

MacRae et al. (1998)
Embodied Language Processing

Behavioural Evidence

• Auditory lexical decision task

Myung et al. (2006)
Lexical Decision task

Typewriter

Word

Nonword
Lexical Decision task

Tarfburter

Word

Nonword
Embodied Language Processing

Behavioural Evidence

• Auditory lexical decision task

• e.g. On “Typewriter” after the prime of “Piano” or “Blanket”

• Note typewriter is orthographically, phonetically and semantically different than both

• But the motor associations are more similar to “Piano”

Myung et al. (2006)
Embodied Language Processing

Behavioural Evidence

• Auditory lexical decision task

• e.g. On “Typewriter” after the prime of “Piano” or “Blanket”

• Participants were quicker to respond after “Piano”

• Similar sensory-motor area activated, thus accessing “typewriter” easier

Myung et al. (2006)
Embodied Language Processing

Behavioural Evidence

- Action-sentence compatibility compatibility effect (ACE)

Participants asked if sentences make sense

For example:

“Open the cupboard”

or

“Close the cupboard”

Glenberg & Kaschak (1998)
Embodied Language Processing

Behavioural Evidence

- Action-sentence compatibility effect (ACE)

Glenberg & Kaschak (1998)
Embodied Language Processing

Behavioural Evidence

- Action-sentence compatibility effect (ACE)

Glenberg & Kaschak (1998)
Embodied Language Processing

Behavioural Evidence

• Action-sentence compatibility effect (ACE)

Faster with:

“Open the cupboard”

than

“Close the cupboard”

Glenberg & Kaschak (1998)
Embodied Language Processing

Behavioural Evidence

- Action-sentence compatibility effect (ACE)
  - Self-paced reading
  - More of an “online” measure

Zwann and Taylor (2006)
Self-paced Reading

..then she...
Self-paced Reading

...opened...
Self-paced Reading
Self-paced Reading

...jar...
Embodied Language Processing

Behavioural Evidence

- Action-sentence compatibility effect (ACE)
  - Self-paced reading
  - More of an “online” measure
  - Used a volume dial

Zwann and Taylor (2006)
Embodied Language Processing

“Opened”

Zwann and Taylor (2006)
Embodied Language Processing

“Opened”

Zwann and Taylor (2006)
Embodied Language Processing

“Opened”

Zwann and Taylor (2006)
Embodied Language Processing

“Opened”

Zwann and Taylor (2006)
Embodied Language Processing

“Opened”

Zwann and Taylor (2006)
Embodied Language Processing

“Closed”

Zwann and Taylor (2006)
Embodied Language Processing

Behavioural Evidence

Method

Subjects. Sixty students (42 female) enrolled in introductory psychology courses participated for course credit. The subjects' mean age was 18.8 (range 18–20) years.

Stimuli and design. The same sentences that were used in Experiment 4 were visually presented in a subject-paced reading paradigm. The visual stimulus depicted 12 shaded half ovals that were situated in a circle such that they resulted in illusory visual rotation around a center point. Each word was left justified two characters to the left of that center point. This was judged by the experimenters to create the strongest visual illusion during normal reading. Figure 2 presents a sample image–text pairing used in this experiment.

The direction of rotation implied by the visual stimulus was manipulated within subjects and between items. Implied rotation direction of the sentences was manipulated within subjects and between items. List (groups of items appearing under the same condition) was manipulated between subjects and between items.

Procedure. The experiment began with the subject seated in front of a computer monitor and a keyboard. At the beginning of each trial, subjects were instructed to press the spacebar to continue. After the first spacebar press, the first block of text was presented. Each subsequent spacebar press resulted in the presentation of the next block of text until the sentence was finished. On one third of the trials, the subject answered a yes–no question regarding the content of the immediately preceding sentence. After each trial, subjects pressed the spacebar again to begin the next sentence. Subjects read sentences by pressing the spacebar between blocks of text during the concurrent presentation of a visual stimulus. For the first half of the experiment, the visual stimulus depicted illusory rotation in one direction, whereas in the second half, it depicted illusory rotation in the opposite direction. Order was counterbalanced across subjects. Each subject read 48 sentences (16 experimental, 32 filler) during the experiment. Implied rotation direction was counterbalanced across subjects. A yes–no comprehension question pertaining to the content of the immediately preceding sentence followed half of the filler items. Each subject completed nine practice items before the experiment began.

Results

Five subjects were removed and replaced for having comprehension accuracy below 80%. We removed reading time outliers in two stages. First, latencies shorter than 100 ms and longer than 1,500 ms were eliminated. Next, latencies more than 2 SDs from a subject's condition mean were eliminated. In all, 2.6% of the data were eliminated. The remaining latencies were submitted to a 4 (sentence region) × 2 (match) × 2 (direction) ANOVA. The average reading times per region are displayed in Figure 1. Most relevant to our prediction, there was a significant interaction between sentence region and match, $F(3, 168) = 2.69$, MSE = 2,031, $p = .046$. The matching sentences were read significantly faster in the verb region than the mismatching sentence, $F(1, 56) = 7.65$, $p = .120$, whereas there was no match effect in any of the other three regions ($F$s < 1.06). Not relevant to our predictions, there

Figure 2. Illusory rotation stimulus used in Experiment 5.

Figure 1. Average reading times per sentence region (with standard errors denoted by the error bars) for Experiments 4 (top panel) and 5 (bottom panel). Pre-verb region preceding the target verb; Verb target verb; Post-verb1 the first word after the verb; Post-verb2 the second word after the verb.
Embodied Language Processing

Brain imaging evidence

• fMRI study looking at haemodynamic activation

• Carried out scans during leg, arm and face movements

• Also during silent reading of leg, arm and face related words
Embodied Language Processing

Brain imaging evidence

(A) Hemodynamic activation during tongue, finger, and foot movements (localizer scans).

(B) Hemodynamic activation during reading action words related to face (green), arm (red), and leg (blue) movements (p<0.001, k=33).

Results are rendered on a standard brain surface.

(C) Mean parameter estimates (in arbitrary units) for clusters differentially activated by subgroups of action words in the left hemisphere.

(D) Overlap of activation produced by “arm” and “leg” words with that produced by finger and foot movements, respectively. Numbers below separate slices label z coordinates in MNI space, and the color scales indicate t values for arm and leg word related activation separately.

activation produced by arm and leg words and the corresponding finger and foot movements but not for face word and tongue movement activation. This may be explained by the fact that the tongue is mostly involved in articulatory movements. The face words employed in the scanner, and these body parts are usually involved in movements performed with the whole arm in our study referred to a wider range of movements involving the jaw or the whole head (such as “bite,” or leg, such as in grasping or walking movements, re-

Embodied Language Processing

Clinical population evidence

• Evidence from clinical populations can be very useful in understanding cognition and the brain

• We can infer things about function from deficits

• When considering embodiment, you should see how individuals with perceptual or motor deficits may be useful

Bak et al. (2001)
Embodied Language Processing

Clinical population evidence

- Patients with Motor Neurone Disease
- Test of the Reception of Grammar
  - Participants identify picture from word/sentence
  - Followed by reverse

Bak et al. (2001)
### Embodied Language Processing

#### Clinical population evidence

<table>
<thead>
<tr>
<th></th>
<th>MND Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TROG</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td>54.7 (20)</td>
<td>30–86</td>
</tr>
<tr>
<td><strong>Naming</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nouns</td>
<td>57.5 (15.5)</td>
<td>35–70</td>
</tr>
<tr>
<td>Verbs</td>
<td>31.3 (22.9)</td>
<td>5–55</td>
</tr>
<tr>
<td><strong>Comprehension</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nouns</td>
<td>86.1 (12)</td>
<td>60–100</td>
</tr>
<tr>
<td>Verbs</td>
<td>62.6 (12)</td>
<td>50–83</td>
</tr>
</tbody>
</table>

All results show the percentage of correct answers.

Bak et al. (2001)

Big deficit overall compared to Alzheimer’s (95%) and control (98%) group.
Embodied Language Processing

**Clinical population evidence**

- Patients with Parkinson’s disease
- Motor disease, associated with loss of dopamine-generating cells
- Control group, Parkinson’s patients on ON phase and OFF phase of L-DOPA (dopaminergic treatment)
- Lexical Decision Task with either same-word or consonant string prime

*Boulenger et al. (2008)*
Embodied Language Processing

Clinical population evidence

Consonants

GHSDFB 50ms
↓
150ms
MONKEY timed

Identical

MONKEY 50ms
↓
150ms
MONKEY timed

Boulenger et al. (2008)
Embodied Language Processing

Clinical population evidence

Consonants

YGSJPV 50ms
↓ 150ms
JUMPED timed

Identical

JUMPED 50ms
↓ 150ms
JUMPED timed

Boulenger et al. (2008)
Embodied Language Processing

Clinical population evidence

RT (ms)

Controls

<table>
<thead>
<tr>
<th>PRIME</th>
<th>Nouns</th>
<th>Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>consonants</td>
<td>850</td>
<td>750</td>
</tr>
<tr>
<td>identical</td>
<td>800</td>
<td>700</td>
</tr>
</tbody>
</table>

Boulenger et al. (2008)
Embodied Language Processing

Clinical population evidence

Boulenger et al. (2008)
Embodied Language Processing

![Clinical population evidence graph](image)

- **RT (ms)** on the y-axis
- **PRIME** on the x-axis with categories: consonants and identical

**Patients OFF**
- *Significant net priming effect (i.e., significant difference between reaction times in the identical-prime and the consonants-prime). (*)
- **ns** for non-significant priming effect

**Boulenger et al. (2008)**
Embodied Language Processing

Clinical population evidence

- Good evidence that activation of dopamine receptors influenced word processing
- Embodied theories of language processing make sense of this
- Lack of dopamine leads to problem with motor system which causes problem integrated sensorimotor factors into word recognition
- This is evident for verbs in particular, supporting MND findings
- Action words more embodied?

Boulanger et al. (2008)
Embodied Language Processing

Clinical population evidence

Production task

Control and Parkinson’s groups

Had to name pictures of either objects or actions

Cotelli et al. (2007)
Embodied Language Processing

Clinical population evidence

Production task

Cotelli et al. (2007)
Embodied Language Processing

Clinical population evidence
Production task

Figure 1  Examples of manipulable and non-manipulable actions.

Cotelli et al. (2007)
Embodied Language Processing

Clinical population evidence

We have evidence here of motor involvement in language processing.

But if cognition (and hence language) are body-based, shouldn’t we also see effects on nouns?

or are some more embodied than others?
Against Embodiment

We talked about this last time:

- What do push and hammer make you think of?

- What about contemplate and sophisticated?

If sensorimotor factors are required for grounding to work, how do abstract concepts work?
If sensorimotor factors are required for grounding to work, how do abstract concepts work?

Some argue that is is where embodied theories fall down (Mahon & Caramazza, 2008)

A theory that can’t account for a huge number of words would require two mechanisms for word processing, one with sensorimotor, one without.
Dealing with abstract terms

Theoretically, abstract concepts could be “grounded” in concrete concepts.

Lakoff’s (1992) theory of metaphor argues for this approach to metaphors.

Something that can’t be handled, such as “time” is conceptualised (and hence verbalised) as if it had properties of something concrete (like distance).

“Christmas is so far away!”

Could this help with embodied theories?
Dealing with abstract terms

Could this help with embodied theories?

Examples:

More is up, less is down
Linear scales are paths
Passing time is motion
Mental/emotional states as locations
Awareness/Knowledge is light
Confusion/ignorance is dark
Happiness/excitement is bright
sadness/boredom is dull
Love is warmth

Could what we’d normally call associations actually be vital sensorimotor aspects of understanding?
Dealing with abstract terms

Could this help with embodied theories?

Could what we’d normally call associations actually be vital sensorimotor aspects of understanding?

Little evidence in favour of these abstract terms - perhaps future research

Then again, no real evidence of a mechanism for transduction from perceptual to amodal representations in the classic view of cognition

But, it is perhaps clear to many of you, that some associations and weaker than others

And some may have none
Dealing with abstract terms

Could this help with embodied theories?

A theory that can’t account for a huge number of words would require two mechanisms for word processing, one with sensorimotor, one without.
Dealing with abstract terms

Concrete VS Abstract?

Or could it be more of a continuum?

Connell & Lynott (2009, 2012)
Dealing with abstract terms

Perceptual strength

Distinct from concreteness

Connell & Lynott (2009, 2012)
Dealing with abstract terms
Perceptual strength

“to what extent do you experience something being WORD?”

“to what extent do you experience WORD?”

Rating out of 5 for all senses

Connell & Lynott (2009, 2012)
Dealing with abstract terms

Perceptual strength

Table 1
Sample words, used in Studies 1 and 2, for which perceptual strength matches or mismatches ratings of concreteness and imageability.

<table>
<thead>
<tr>
<th>Word</th>
<th>Perceptual strength</th>
<th>Concreteness</th>
<th>Imageability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Auditory</td>
<td>Gustatory</td>
<td>Haptic</td>
</tr>
<tr>
<td>Strongly perceptual, high concreteness/imageability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hen</td>
<td>3.53</td>
<td>1.12</td>
<td>2.35</td>
</tr>
<tr>
<td>Soap</td>
<td>0.35</td>
<td>1.29</td>
<td>4.12</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.15</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Strongly perceptual, low concreteness/imageability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fear</td>
<td>2.18</td>
<td>0.71</td>
<td>1.88</td>
</tr>
<tr>
<td>Noisy</td>
<td>4.95</td>
<td>0.05</td>
<td>0.29</td>
</tr>
<tr>
<td>Quality</td>
<td>3.06</td>
<td>3.41</td>
<td>4.06</td>
</tr>
<tr>
<td>Weakly perceptual, high concreteness/imageability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>1.06</td>
<td>1.47</td>
<td>2.12</td>
</tr>
<tr>
<td>Atom</td>
<td>1.00</td>
<td>0.63</td>
<td>0.94</td>
</tr>
<tr>
<td>Hell</td>
<td>2.47</td>
<td>0.24</td>
<td>1.06</td>
</tr>
<tr>
<td>Weakly perceptual, low concreteness/imageability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>1.88</td>
<td>0.50</td>
<td>0.80</td>
</tr>
<tr>
<td>Factor</td>
<td>1.31</td>
<td>0.38</td>
<td>0.31</td>
</tr>
<tr>
<td>Republic</td>
<td>0.53</td>
<td>0.67</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Note: perceptual strength ratings range from 0 to 5, concreteness and imageability ratings range from 100 to 700.
Dealing with abstract terms

Reports of classic concreteness effects. For example, based on the concreteness coefficient in the model for lexical decision RT, the difference between a fully abstract word of rating 100 and a fully concrete word of rating 700 would amount to approximately 28 ms, which is similar to previous factorial studies (e.g., 33 ms: Binder et al., 2005; 17 ms: Kroll & Merves, 1986, Experiment 2; 49 ms: Schwanenflugel & Shoben, 1983, Experiment 2). For comparison, the predicted RT difference between a low- and high-imageability word (ratings 100–700) was larger at 37 ms, whereas the difference between a weakly- and strongly-perceptual word (ratings 0–5) exceeded both at 59 ms. The respective differences for word naming RT followed the same trajectory, with concreteness at 5 ms, imageability at 17 ms, and perceptual strength at 28 ms.

In analysis of independent effects, only perceptual strength emerged as a unique predictor of variance (see Fig. 5). When concreteness had already been included in the model, perceptual strength still accounted for an extra proportion of variance in lexical decision raw RT (i.e., the only model in which concreteness was a useful predictor), as well as in all other measures except naming accuracy. Similarly, perceptual strength acted as an independent predictor in models that already included imageability: both where imageability had performed well as a simple predictor (lexical decision data), and where it had not.
Dealing with abstract terms

Perceptual strength

Fig. 4. Simple effects of each predictor in Study 2, showing proportion of explained variance ($R^2$ change in %) of Elexicon reaction time and accuracy data, over and above a basic model of contextual diversity, word length in letters, and number of syllables ($^*p < .1$, $^*p < .05$, $^{**}p < .01$). Flatline bars (e.g., concreteness in naming RT) represent 0% contribution.

Connell & Lynott (2009, 2012)
Dealing with abstract terms

Perceptual strength

So, perceptual strength seems a better indicator of speed and accuracy than “concreteness”

A sign that perceptual embodiment is influencing processing across all words, but to varying degrees.

*Not essential, but always a factor.*

*Connell & Lynott (2009, 2012)*
Is the brain imaging evidence all it’s cracked up to be?

I’ve shown some intriguing examples so far.

But there are varying methods, measures and standards used in brain imaging.

Add to that variance in conclusions (Watson et al. 2013; Bedny et al., 2008)
Against Embodiment

Is the brain imaging evidence all it’s cracked up to be?

BUT

The behavioural evidence of sensorimotor and language is strong

Add to that the clinical populations studies
Against Embodiment

So, do the behavioural findings mean what we think?

We have seen lots of behavioural evidence for embodied language processing.

But can these be accounted for by disembodied theories (amodal theories)?

Some argue (Caramazza, 2014) that an amodal concept could have associative sensorimotor influences after the concept is retrieved.
Against Embodiment

So, do the associations mean what we think?

MATCH

“Opened”

Activation

Time

© Can Stock Photo
Against Embodiment

So, do the associations mean what we think?

Activation

Time

“Opened”

MISMATCH

© Can Stock Photo
Against Embodiment

So, do the associations mean what we think?

![Diagram](© Can Stock Photo)

- Activation
- Time
Against Embodiment

"Opened"

Cognition for Action and Amodal account
Against Embodiment

So, do the associations mean what we think?

Perhaps a stronger threshold of evidence required

But even if we decided on amodal - why?

Symbol grounding problem still an issue
Amodal Vs. Embodied

Is there middle ground?

Most researchers don’t go “full embodied”

Supporters of amodal processing mostly accept sensorimotor influence - just not at conceptual level.

Danger of arguing against extremes
Amodal Vs. Embodied

Is there middle ground?

Barsalou (2008),
Lowers & Connell (2011)

Two streams for concepts: superficial linguistic (amodal) and simulation (embodied)

Taylor & Zwann, (2009)

Sensorimotor important, but non sensorimotor system also can make up for this

Barsalou (2016)
Solve abstraction by:
Multimodal compression

Mahon & Carramazza (2008)
Core concepts are amodal and (arbitrarily) symbolic

sensorimotor used to enrich and facilitate meaning

It looks like these ideas are converging
Amodal Vs. Embodied
Is there middle ground?

It looks like these ideas are converging

- Sensorimotor factors are clearly important in language processing
- Are they a core component of our concepts?
- or are they supportive?
Overview

• Traditional Cognition

• Cognition for action
  • Theoretical basis
  • Supporting evidence
  • Problems with this concept

• Body-based cognition
  • Symbol grounding problem
  • Perceptual symbol systems
  • Behavioural evidence
  • Brain imaging evidence
  • Evidence from clinical populations

• Problems with embodiment
  • Abstract concepts
  • Brain imaging data
  • Alternative explanations of phenomena

• Middle ground approaches
  • Sensorimotor important
  • But one of a number of factors
  • Helpful or core to forming concepts?
References


References


