Bergen, Benjamin. (2015). Embodiment, simulation, and meaning. The Routledge Handbook of Semantics, 142.

Embodiment, simulation and meaning

Benjamin Bergen

Bergen?

SKEPTICS SOCIETY
Distinguished Lecture Series

Dr. Benjamin K. Bergen

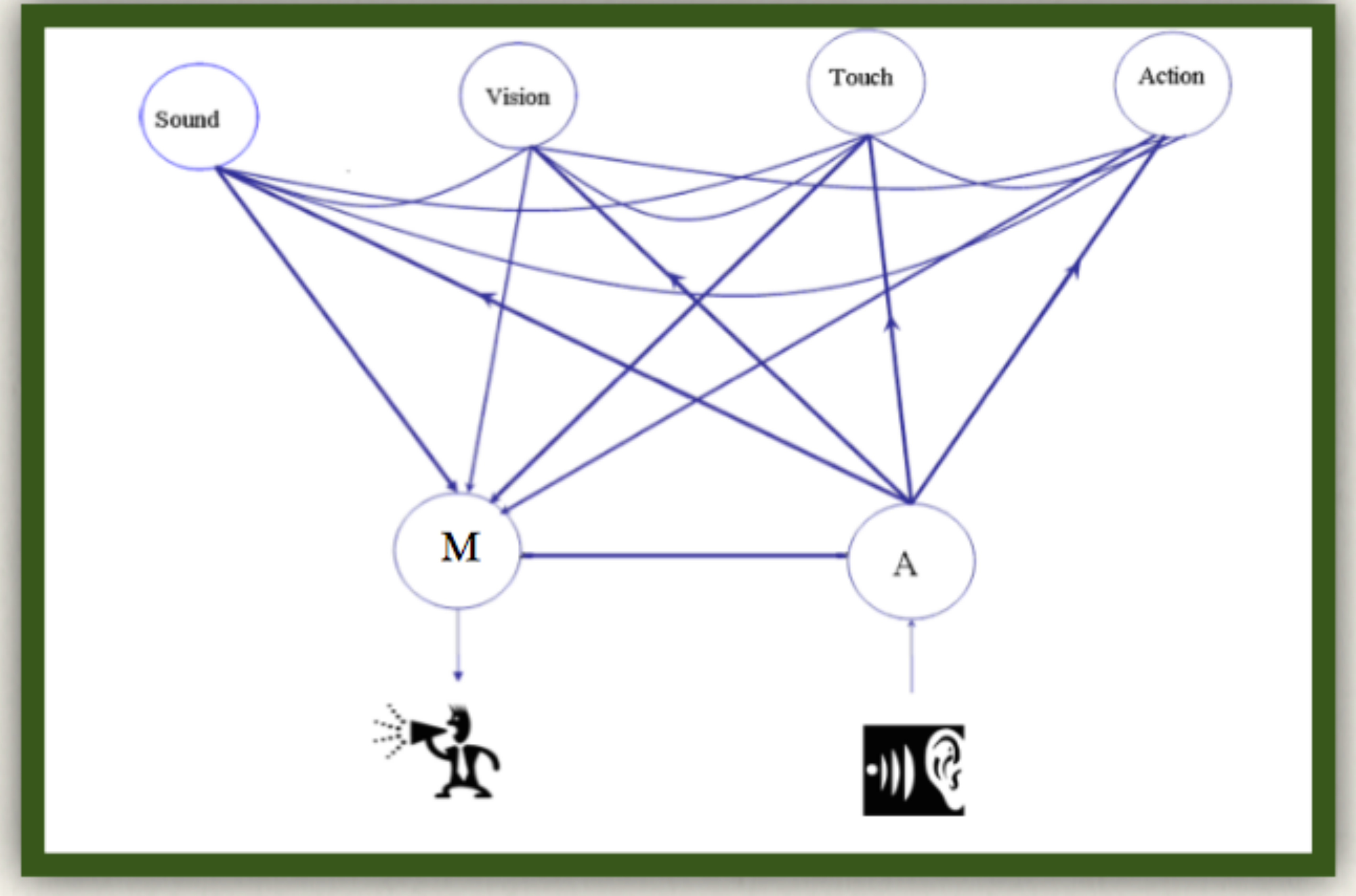
Louder Than Words

The New Science of How the Mind Makes Meaning

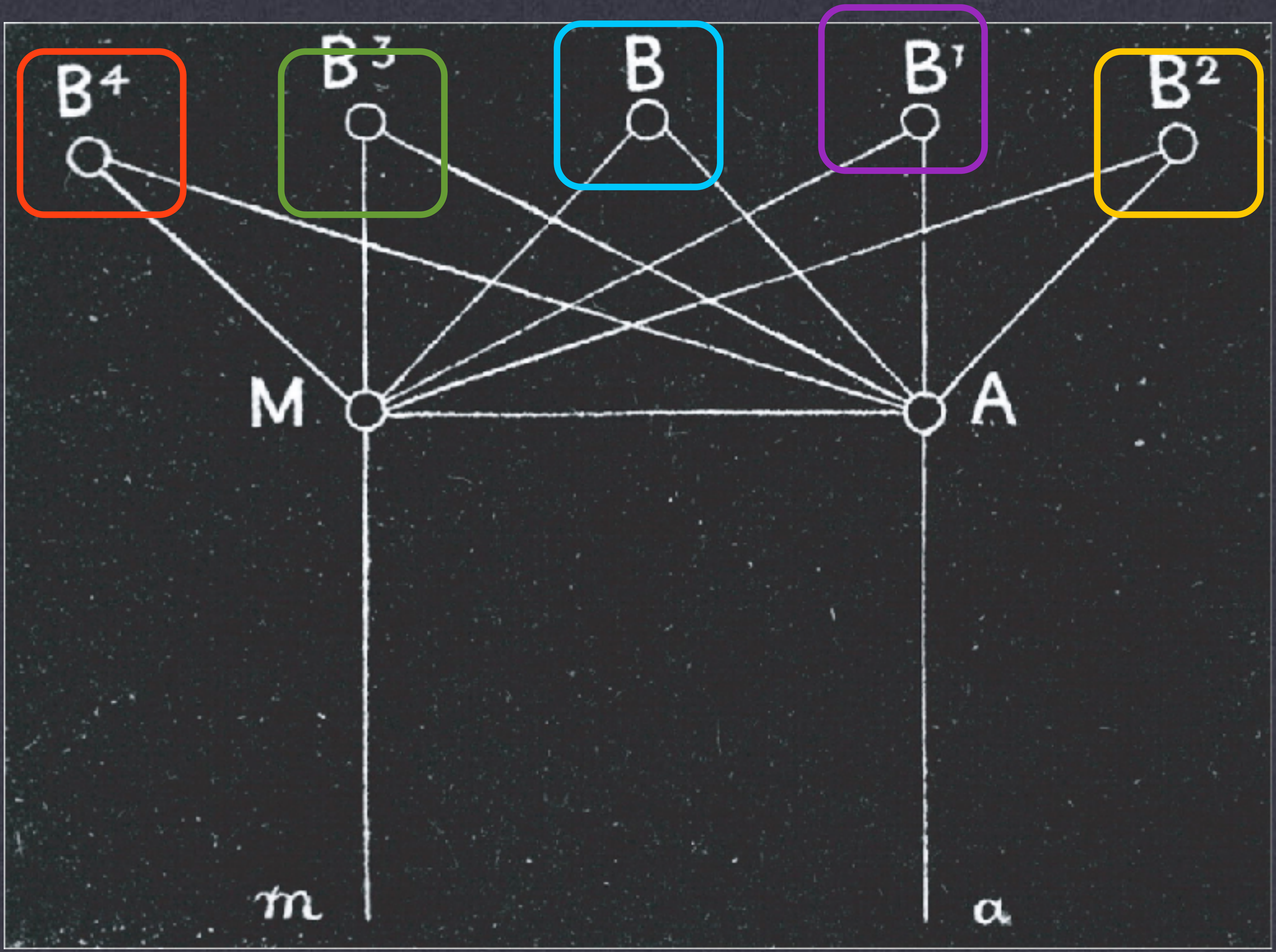
U.C. San Diego cognitive psychologist Benjamin K. Bergen draws together research in psychology, linguistics, and neuroscience to offer a new theory of how our minds make meaning. When we hear words and sentences, we engage the parts of our brain that we use for perception and action—repurposing evolutionarily older networks—to create mental simulations. Embodied simulation, as it's called, is the reason why it takes time to travel over distance, even in our mind's eye; why it's possible for us to become better baseball players by imagining a well-executed swing; and why it's so hard to talk on cell phones while we're driving on the highway. Rather than merely calling up abstract ideas to understand language, as others previously argued, our brains engage in a creative act to construct rich mental worlds in which we see, hear, and feel.

Carl Wernicke described the basic premise as well as anyone has since (and with remarkably little modern credit, as Gage and Hickok (2005) point out).

Gage, Nicole and Gregory Hickok 2005. Multiregional cell assemblies, temporal binding and the representation of conceptual knowledge in cortex: a modern theory by a classical neurologist, Carl Wernicke. *Cortex* 41: 823–832.



Meaning and sensory-motor representations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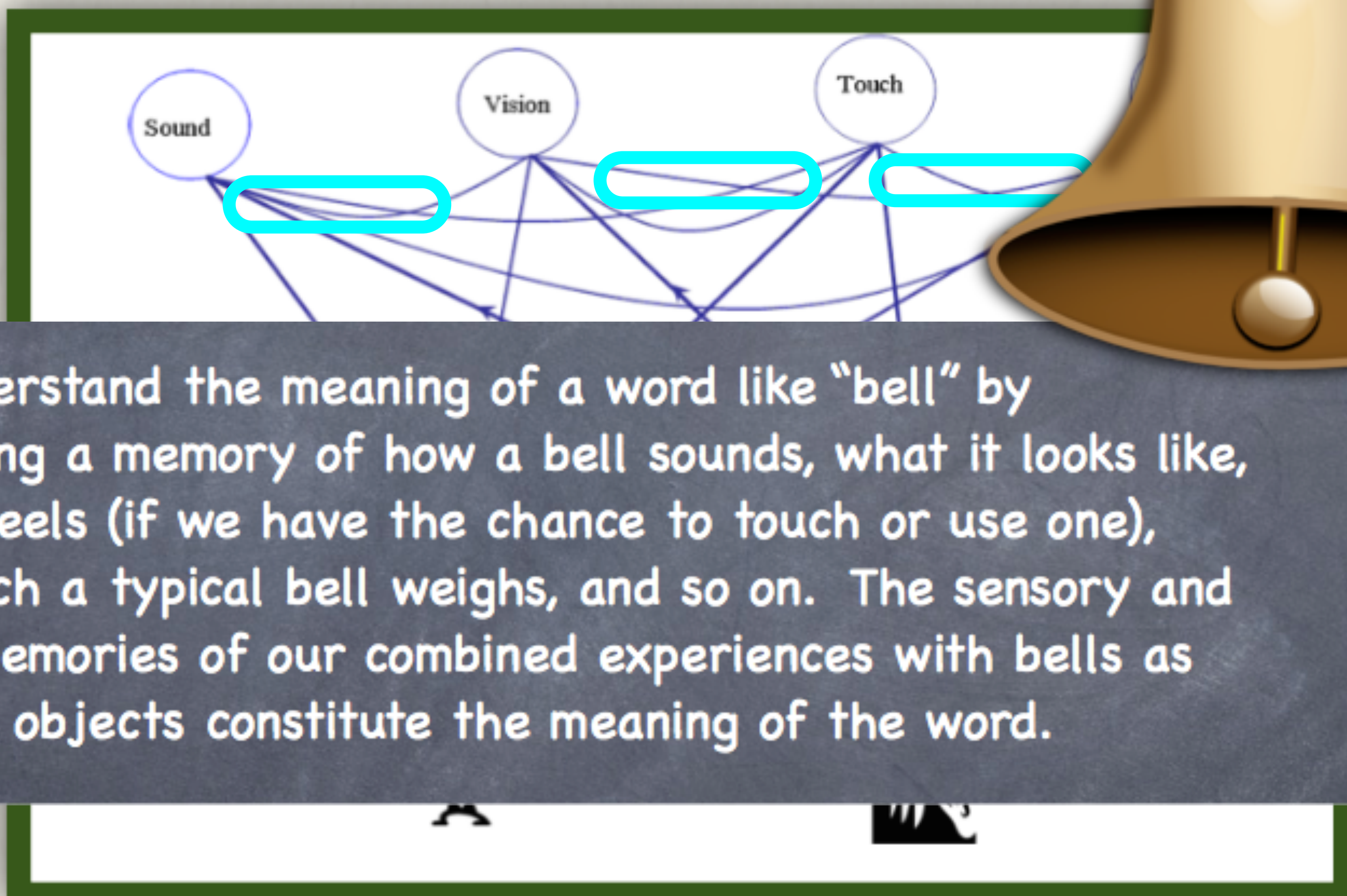
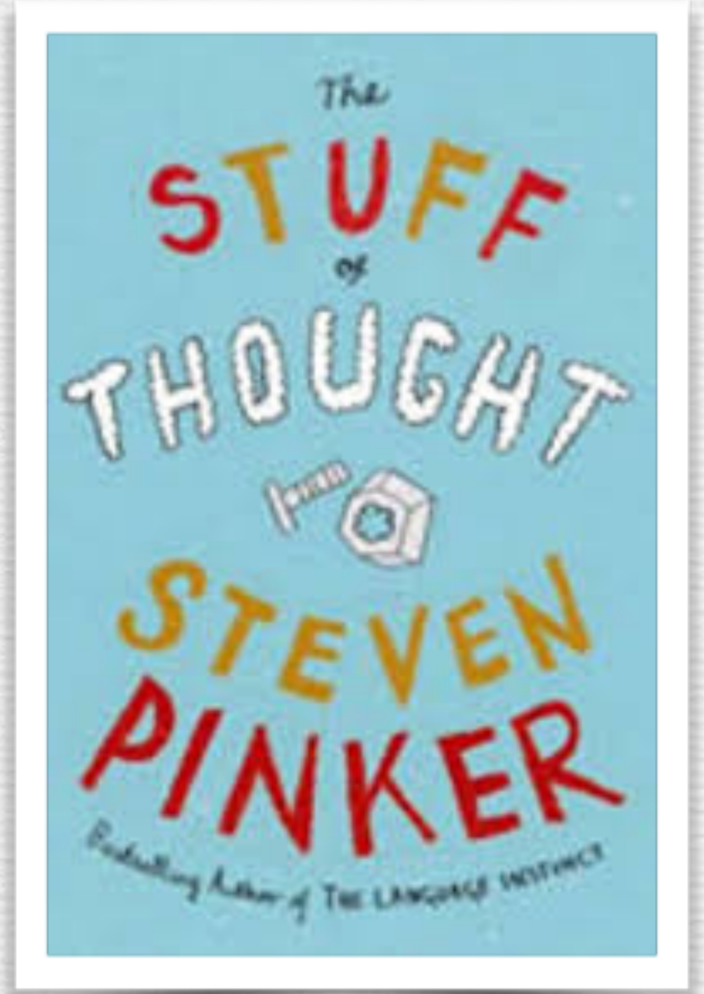


Meaning and sensory-motor representations

We understand the meaning of a word like “bell” by contacting a memory of how a bell sounds, what it looks like, how it feels (if we have the chance to touch or use one), how much a typical bell weighs, and so on. The sensory and motor memories of our combined experiences with bells as physical objects constitute the meaning of the word.



Skeletal concepts like "go", "place" and "agonist" maintain connections to physical reasoning….Yet as they take part in moment-to-moment thinking, they are abstract symbols, and need not drag with them images of hunks of matter rolling around".

Motivating the modern incarnation of the idea that cognition is embodied

1) The "symbol-grounding" problem

2) Cognitive semantics or cognitive linguistics

3) Action-oriented approaches to robotics and artificial intelligence

Current research on simulation (Better heading: some background to current experimental work).

1) Tethering a symbolic representation to the real world

Symbol: “ball”

Concept

Tethering a symbolic representation *to other symbols*

Words are used in combination with other words

On this account, exemplified by distributional semantic approaches like HAL (Lund and Burgess 1996) and LSA (Landauer et al. 1998), to know the meaning of a symbol, you need only know what company it keeps. However, as Glenberg and Robertson (2000) demonstrate, these word- or world- based approaches to grounding both fail to make correct predictions about actual human processing of language.

HAL hyperspace Analogue to Language (or HAL), which is a computer simulation of human memory. HAL has a lexicon of 70,000 items and learns its representations as a function of the contexts in which words occur. This is accomplished with a concept-acquisition process that requires no supervision using an input of 320 million words of text. Word meanings (broadly based) are represented in a 140,000 dimensional space (thus, Hyperspace Analogue to Language). The model accounts for a wide range of semantic, language, grammatical, and syntactic phenomena. New areas of exploration for the model involve commercial and forensic applications as well as memory disorders in deep dyslexia, schizophrenia, Alzheimer's and normal aging, deception, web semantics, and dolphin language.

Latent Semantic Analysis (LSA) is a theory and method for extracting and representing the contextual-usage meaning of words by statistical computations applied to a large corpus of text (Landauer and Dumais, 1997). The underlying idea is that the aggregate of all the word contexts in which a given word does and does not appear provides a set of mutual constraints that largely determines the similarity of meaning of words and sets of words to each other. The adequacy of LSA's reflection of human knowledge has been established in a variety of ways. For example, its scores overlap those of humans on standard vocabulary and subject matter tests; it mimics human word sorting and category judgments; it simulates word–word and passage–word lexical priming data; and... it accurately estimates passage coherence, learnability of passages by individual students, and the quality and quantity of knowledge contained in an essay.

2) Parsimony

3) Introspection

Relevant evidence

Action-sentence compatibility effect (ACE)

For example, processing a sentence about moving one's hand toward one's body (like *Scratch your nose!*) leads to faster reactions to press a button close to the body. Conversely, sentences about action away from the body (like *Ring the doorbell!*) lead to faster responses away from the body (Glenberg and Kaschak 2002).

Meaning involves “mental simulation”

compare with

Meaning involves “mental imagery”

Example: John opened the door in a hurry and rushed from the room.

Imagery versus simulation?

Reliability of evidence?

J Exp Psychol Gen. 2015 Dec;144(6):e116-41. doi: 10.1037/xge0000125.

Just out of reach: On the reliability of the action-sentence compatibility effect.

Papesh MH

Abstract

The action-sentence compatibility effect (ACE; Glenberg & Kaschak, 2002), a hallmark finding in Embodied Cognition, implicates the motor system in language comprehension. In the ACE, people process sentences implying movement toward or away from themselves, responding with actions toward or away from their bodies. These processes interact, implying a linkage between linguistic and motor systems. From a theoretical perspective, the ACE has been extremely influential, being widely cited evidence in favor of embodied cognition. The present study began as an attempt to extend the ACE in a new direction, but eventually became a series of attempts to simply replicate the effect. Across 8 experiments, I tested whether the ACE extends to a novel mouse-tracking method and/or is susceptible to higher-order cognitive influences. In 3 experiments, attempts were made to "disembody" the ACE by presenting participants' names on the computer screen (as in Markman & Brendl, 2005). In each experiment, the ACE could not be disembodied, because the ACE did not occur. In further experiments, the ACE was not observed in reading times, regardless of response mode (mouse movements vs. button-presses) or stimuli, including those from the original research. Similarly, no ACE was observed in physical movement times. Bayes Factor analyses of the current experiments, and the previous ACE literature, suggest that the evidence for the ACE is generally weak: Many studies considered as positive evidence actually support the null hypothesis, and very few published results offer strong evidence for the ACE. Implications for the embodiment hypothesis are discussed.

One of the most interesting features of this literature is that there are various experiments in which the priming effect appears—superficially—to reverse itself.

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Seeing, Acting, Understanding: Motor Resonance in Language Comprehension

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EXAMPLE SENTENCES

Counterclockwise

While driving/to work/he/approached/the/intersection/and/turned left/ onto the/street.

When/the annual/time change/in the/fall/occurred/he/set back/the/ clock.

After/lighting/the candles/for the/romantic/evening/he/dimmed/the/ lights.

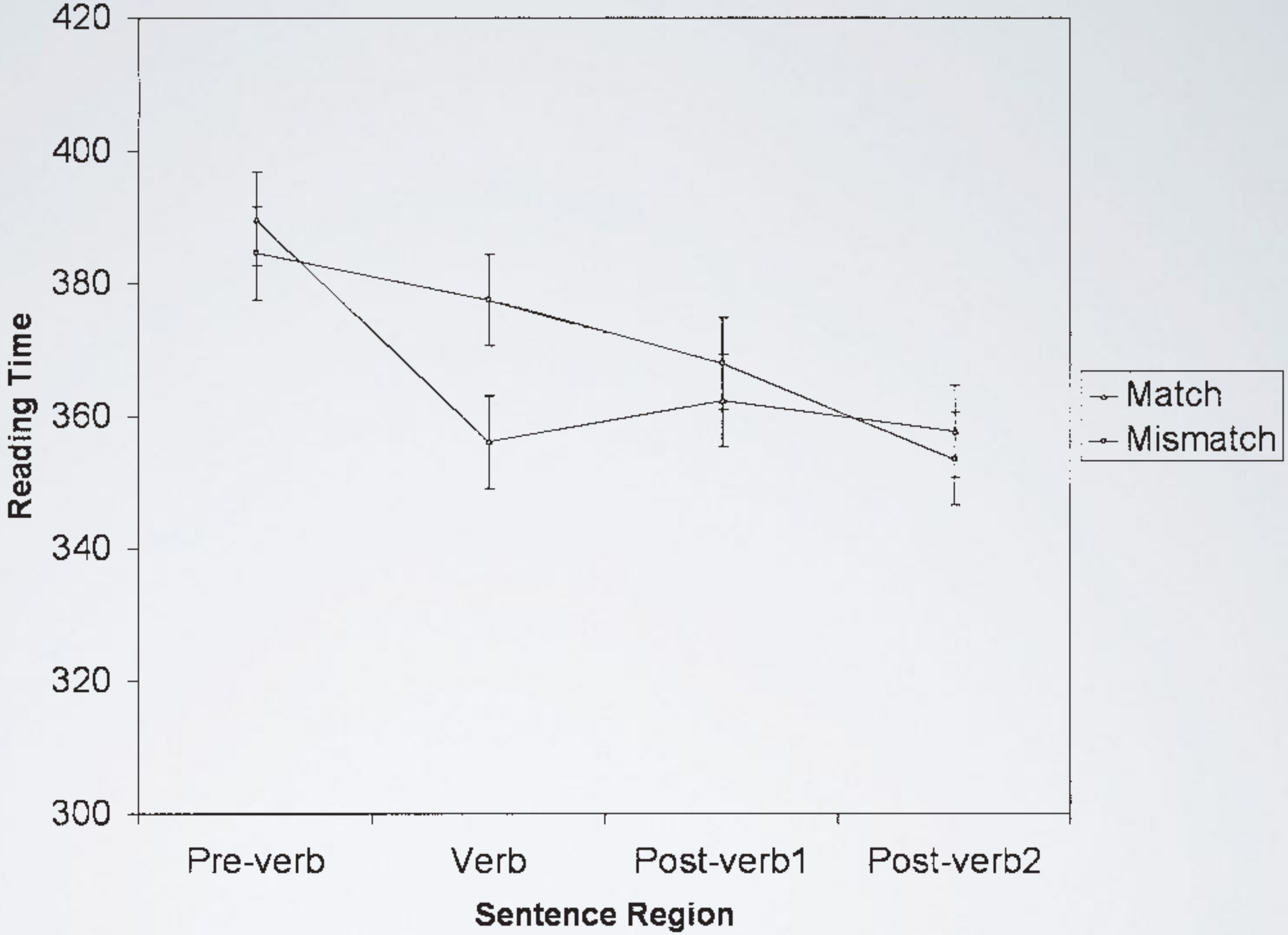
Clockwise

Before/the/big race/the driver/took out/ his key/and/started/the/car.

To attach/the boards/he/took out/his/ screwdriver/and/screwed in/the/

screw.

The lamp/was off/and he/wanted/to read/so/he/turned on/the/lamp.


420
400
380
360
340
320
300
Reading Time
Pre-verb
Verb
Post-verb1
Post-verb2
Sentence Region
Match
Mismatch

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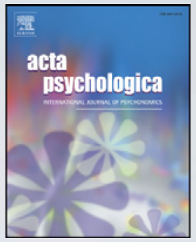

Verb gapping: An action-gap compatibility study

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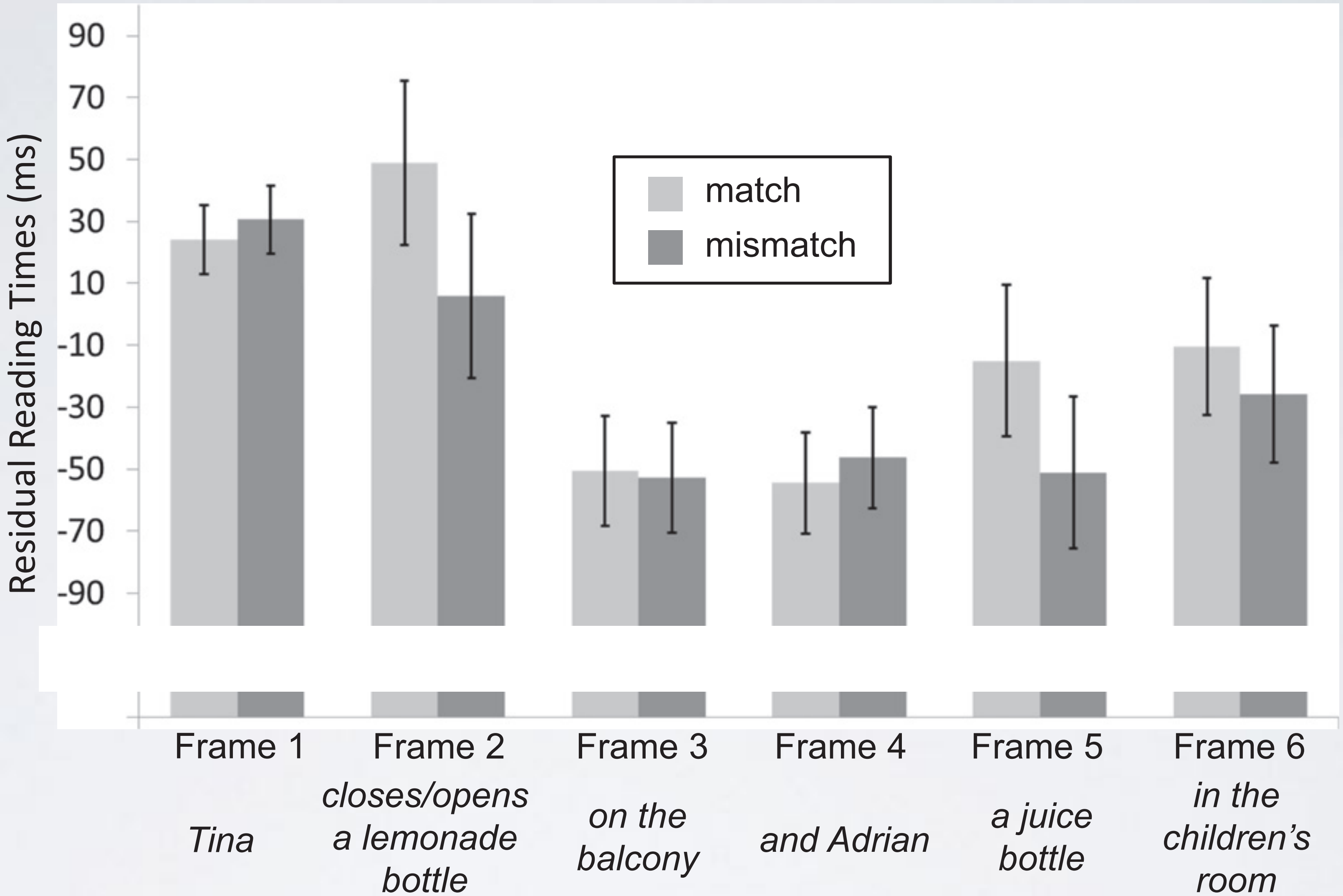
Setting: working at a petrol station | Christian opens/closes a petrol cap on a car and Martin a petrol can next to the car wash facility. (Christian öffnet/schließt einen Tankdeckel an einem Auto und Martin einen Benzinkanister neben der Waschanlage.)



Analyses were performed on the reading times per frame of the gapping sentences and were based on residual reading times, adjusted for frame length in terms of number of characters

One major weakness of reaction time studies like these is that they present a perceptual stimulus or require a physical action that matches the linguistic content or not.

This raises the concern that it might only be this feature of the experimental apparatus that induces simulation effects.

That is, perhaps people only think about the orientation of toothbrushes in the context of an experiment that systematically presents visual depictions of objects in different orientations. Perhaps the experiment induces the effects.

One way to methodologically circumvent this concern is with the use of eye-tracking. Several groups have used eye-tracking during passive listening as a way to make inferences about perceptual processes during language processing. For instance, Spivey and Geng (2001) had participants listen to narratives that described motion in one direction or another while look- ing at a blank screen, and while the participants believed the eye-tracker was not recording data. The researchers found that the participants' eyes were most likely to move in the direction of the described motion, even though they had been told that this was a rest period between the blocks of the real experiment. Another study (Johansson at al. 2006) first presented people with visual scenes and then had them listen to descriptions of those scenes while looking at the same scene, looking at nothing, or looking at nothing in the dark. They found that people's eye movements tracked with the locations of the mentioned parts of the scene. Both studies suggest that even in the absence of experimental demands to attend to specific aspects of described objects, actions, and scenes, people engage perceptual processes. This is consistent with the idea that they perform simulations of described linguistic content, even when unprompted by task demands.

Spivey and Geng

Table 1 Pre-recorded scene descriptions from Experiment 1 (text in italics indicates sentences during which eye movements were analyzed)

Upward story	"Imagine that you are standing across the street from a 40 story apartment building. At the bottom there is a doorman in blue. *On the 10th floor, a woman is hanging her laundry out the window. On the 29th floor, two kids are sitting on the fire escape smoking cigarettes. On the very top floor, two people are screaming.*"
Downward story	"Imagine you are standing at the top of a canyon. Several people are preparing to rappel down the far canyon wall across from you. *The first person descends 10 feet before she is brought back to the wall. She jumps again and falls 12 feet. She jumps another 15 feet. And the last jump, of 8 feet, takes her to the canyon floor.*"
Leftward story	"Imagine a train extending outwards to the left. It is pointed to the right, and you are facing the side of the engine. It is not moving. *Five cars down is a cargo holder with pink graffiti sprayed on its side. Another six cars down is a flat car. The train begins to move. Further down the train you see the caboose coming around a corner.*"
Rightward story	"Imagine a fishing boat floating on the ocean. It's facing leftward from your perspective. *At the back of the boat is a fisherman with a fishing pole. The pole extends about 10 feet to the right beyond the edge of the boat. And from the end of the pole, the fishing line extends another 50 feet off to the right before finally dipping into the water.*"
Control story	"Imagine you are on a hill looking at a city through a telescope. *Pressing a single button zooms a specific block into view. Another button brings a gray apartment building into focus. Finally a third button zooms in on a single window. Inside you see a family having breakfast together. A puppy appears and begs for a piece of French toast.*"

Cognitive Science 30 (2006) 1053–1079

Pictures and Spoken Descriptions Elicit Similar Eye Movements During Mental Imagery, Both in Light and in Complete Darkness

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Received 7 December 2004; received in revised form 28 April 2006; accepted 5 June 2006

You will soon hear a pre-recorded, spoken description. The description will describe a two-dimensional picture. We want you to listen to the description as carefully as possible and to imagine it as thoroughly as possible. During this description we will measure your pupil size. It is important that you do not close your eyes, but you may look wherever you want on the white board.

Neuroimaging

When people are processing language about motor actions, there's an increased signal in motor areas, as compared with language not about motor actions. This signal in the motor system observed during motor language processing is weaker than when people are actually moving their bodies, and overlaps but may not be fully co-extensive with the area in which a signal is observed while people are performing intentional imagery of motor actions. But the signal is present even when people are not asked to think deeply about the meanings of the sentences they're presented with.

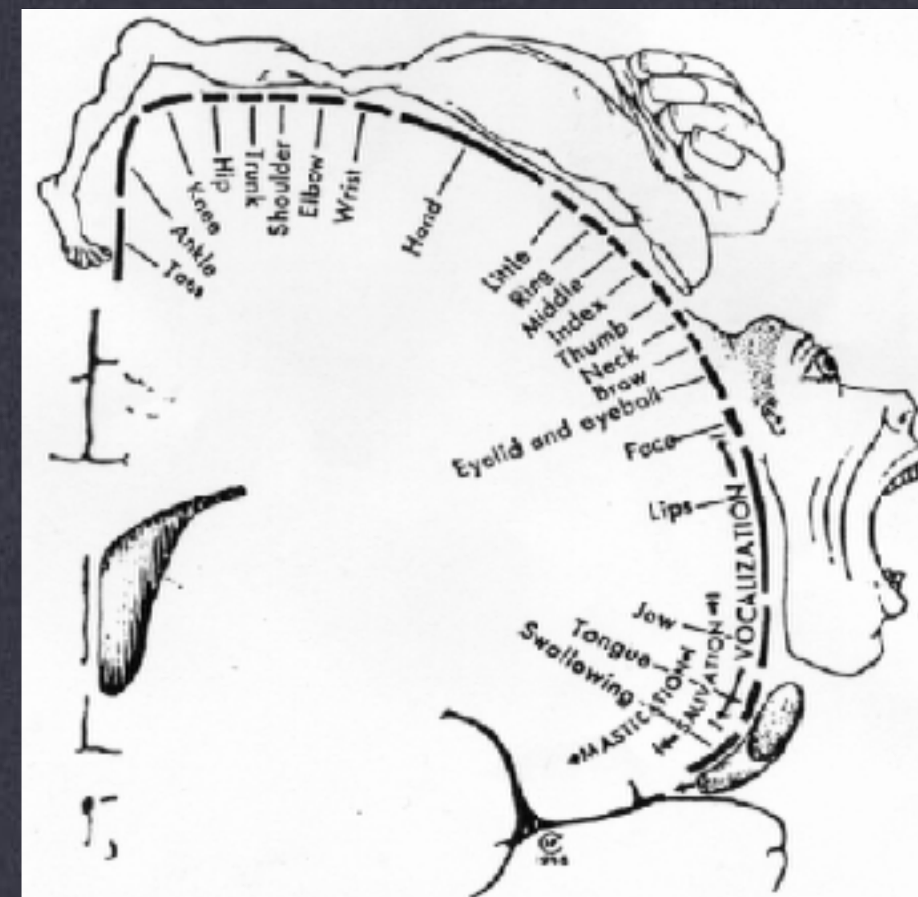
MEANING IS GROUNDED IN SENSORIMOTOR REPRESENTATIONS.

MARCO TETTAMANTI ET AL

I KICK THE BALL

I GRASP A KNIFE

I BITE THE APPLE



CONTROL CONDITION: ABSTRACT SENTENCES LIKE I APPRECIATE SINCERITY.

Problems?

We do not know what kind of information these regions are actually computing in response to language.

Also, fMRI is sloooowwww.

Neuropsychology

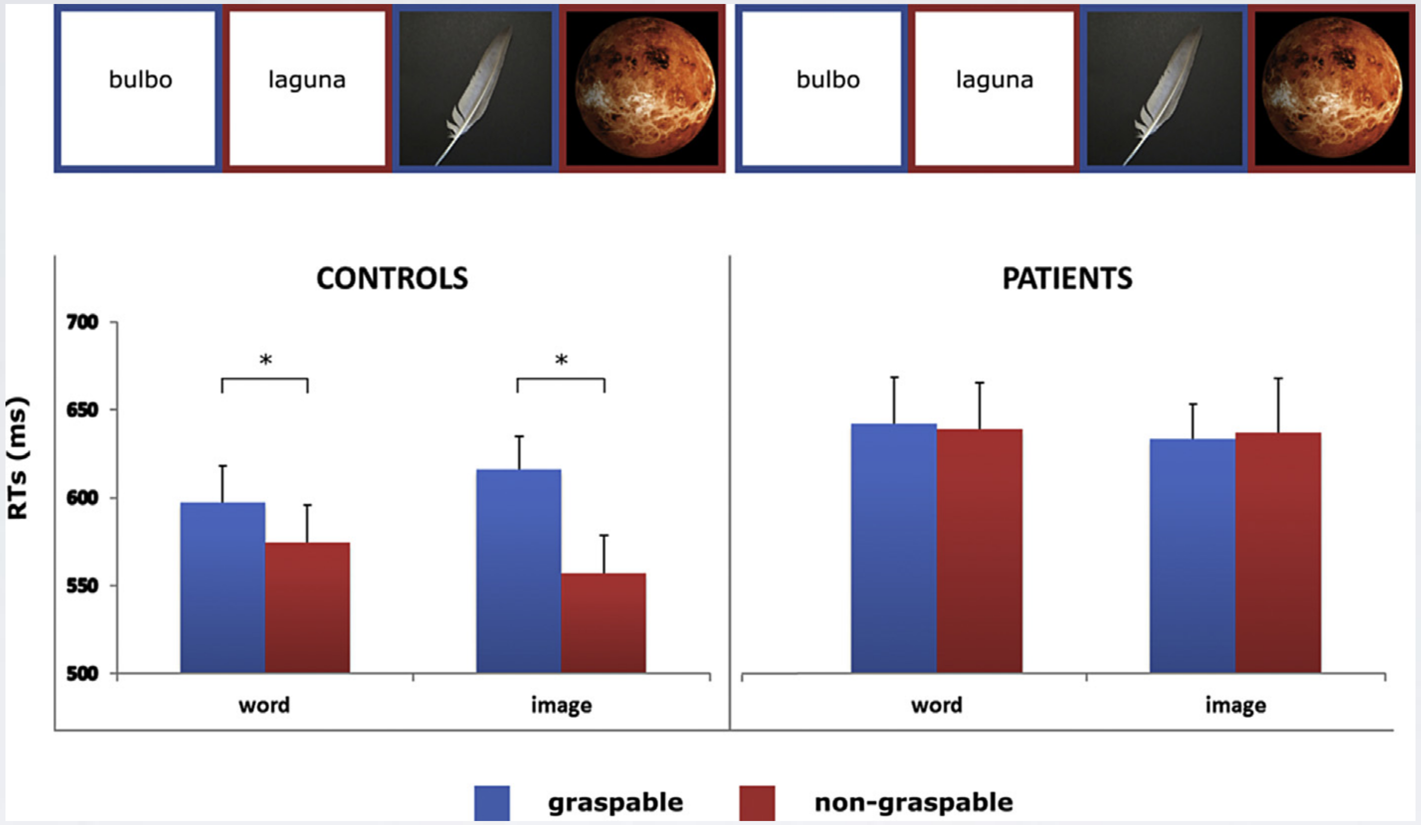


Fig. 1 – Mean Motor Responses (RTs) of controls (left side) and patients (right side) in relation to the different kinds of stimuli (upper row) used in the study. Bulbo is the Italian word for bulb, laguna is the Italian word for lagoon. Examples of a pseudoword and a scrambled image, which did not require a motor response, are not shown. Asterisks mark significant differences.

Participants were instructed to give a motor response, as fast and accurate as possible, by pressing a key on a computer keyboard centred on participants' body midline with their right index finger. They had to respond when the stimulus referred to a real object, and refrain from responding when it was meaningless (go-no go paradigm).

Limits to the idea

Abstract concepts how grounded in experience?

WHAT ABOUT ABSTRACT WORDS?

George Lakoff-- the mind is "embodied". Human cognition, including the most abstract reasoning, depends on and makes use of such concrete and "low-level" facilities as the sensorimotor system and the emotions.

THE MEANING OF AN ABSTRACT WORD LIKE "ARGUMENT"

"Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature."

METAPHOR -- AN ARGUMENT IS LIKE WAR OR FIGHTING.

- He *won* the argument.
- Your claims are *indefensible*.
- He *shot down* all my arguments.
- His criticisms were *right on target*.
- If you use that *strategy*, he'll *wipe you out*.

According to Lakoff, the development of thought has been the process of developing better metaphors.

Language depends hugely on context

The lawyer enjoyed the newspaper

The goat enjoyed the newspaper

As a consequence, it appears to be that in general, meaning construction is an active process that involves the interplay of knowledge of context, encyclopedic knowledge, and prior expectations. All of this conspires to constrain what goes into the content of simulation. None of this is compatible with an account in which word- associated simulation *is* the meaning of a word

Goals of the listener?

Lift the cellphone

As in: Lift the cellphone and give it to me

Use the cellphone

What then is simulation for?

Inferences?

Preparing to act?

An epiphenomenon?

Metalinguistic intuitions—for instance, the feeling that the word *one* means precisely and not approximately one—are not easily dealt with through simulation alone. Simulation is clearly not sufficient for meaning, any more than visual perception is sufficient for what we know about objects. Work thus far has focused on expanding what we know about when simulation happens and what it does, while relatively less scrutiny has attended to what has to surround it—what other mechanisms must be in place alongside and integrated with simulation to account for all that humans do with respect to meaning. These appear to be productive directions in which the field is headed.