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Embodiment and language comprehension: reframing the discussion

Rolf A. Zwaan*

Department of Psychology, Erasmus University Rotterdam, 3000 DR Rotterdam, The Netherlands

The debate on whether language comprehension involves the manipulation of abstract symbols or is grounded in perception and action has reached an impasse, with authors from different theoretical persuasions unable to agree on the diagnostic value of empirical findings. To escape this impasse, I propose a pluralist view of cognition that encompasses abstract and grounded symbols. The contributions of these symbol types to language comprehension vary as a function of the degree to which language use is embedded in the environment. I distinguish five levels of embeddedness: demonstration, instruction, projection, displacement, and abstraction. Only through a closer analysis of context will we make significant progress toward understanding language comprehension and cognition in general.

Introduction

According to the traditional, symbolic view of human thought processes, cognition involves the manipulation of abstract, arbitrary, and amodal symbols. According to the more recent embodied view, cognition is grounded in the brain's systems of action, perception, and emotion. Over the past 15 years, the grounded view has risen to prominence. This rise, particularly in the study of language comprehension, is documented in several recent reviews [1–4]. The debate between the traditional and the grounded view seems to have reached an impasse, with authors from different theoretical persuasions unable to agree on the diagnostic value of virtually all the relevant empirical findings. This opinion is an attempt to: (i) articulate what I perceive to be the latent majority view among language researchers; and thereby (ii) reframe the discussion about embodiment. I argue that we can escape the impasse by paying closer attention to how language use is embedded in the environment and I suggest how this might be accomplished.

We can summarize the latent majority view of language processing as follows. We need mental representations. At least some of them need to be grounded in perception and action. Not all processing requires representations that are directly grounded in perception and action; sometimes, cognitive processes can be offloaded on external memory in the environment. Rather than contrasting models that claim that language comprehension is not embodied, we should examine the conditions in which the comprehension system uses symbolic and grounded mental representations or perhaps no representations at all.

Language comprehension involves the construction of a coherent mental representation of the state of affairs denoted by the linguistic input [5–9]. Language comprehension is situated in a specific context and occurs with a specific purpose in mind: to perform an action [10]. Sometimes the action is immediate and sometimes it is more distal: to commit information efficiently to long-term memory so that it can be retrieved and used for later action or thought. Sometimes, we comprehend language to disconnect from the immediate environment altogether and escape into a fictional world (even this can have a long-term impact on behavior [11]). How do the symbolic and the grounded view conceptualize language comprehension?

Two perspectives

Symbolic cognition assumes that cognitive processing involves a small set of rules that operate on a vast set of arbitrary, amodal, and abstract symbols [12–14]. Grounded cognition assumes that cognitive processing involves the re-instantiation and recombination of experiences via symbols that are grounded in the brain's systems of perception, action, and emotion [1,15]. These symbols are nonarbitrary, multimodal, and concrete.

Are these views mutually incompatible? Symbolic and grounded theories both accord a central role to mental representations in cognition [16]. The discussion is about the nature of these representations (and about the processes operating on them, although this issue has never been at the forefront of the discussion). Symbolic and grounded representation have a history of theoretical cohabitation in dual-coding theory [17] and grounded approaches to language comprehension [18,19] as well as in 'hybrid' theories of cognition [20,21], with the discussion mostly centered on the question of which does which share of the work.

As I detail below, at this juncture the most fruitful option is to adopt a pluralist perspective [21–23]. We need

Corresponding author: Zwaan, R.A. (zwaan@fsw.eur.nl, rolfzwaan@gmail.com).
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*Twitter: @RolfZwaan.

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both perspectives to solve two major problems that face cognitive theorizing: the grounding problem and the scaling problem.

Two problems and their proposed solutions

Cognition cannot exist as a free-floating set of symbols and rules; the symbols have to be connected to perception and action. This is the grounding problem that poses a threat to symbolic cognition [24]. Grounded cognition has arisen as an attempt to address the grounding problem, but the need to address the grounding problem is now also felt by researchers of other theoretical persuasions (e.g., [21,25]). The current discussion centers more on how and to what extent the grounding problem needs to be addressed. One possible view is that cognition exclusively involves grounded symbols. Not all proponents of grounded cognition subscribe to this view, because they accord a role to word-like representations in cognition [1,21,26]. Another view is that symbolic representations do all the initial work in terms of meaning activation and conceptual combination and that these symbols may then activate grounded representations; activation 'cascades down' from abstract symbols to grounded ones in primary sensorimotor areas of the brain [25]. A much more extreme way to deal with the grounding problem is to do away with symbols altogether [27]. However, both a view that does away with mental representations and a view that assumes that comprehension exclusively involves detailed mental simulations involving grounded representations encounter the scaling problem.

The scaling problem occurs because an account of most processes that we associate with cognition (language understanding, reasoning, problem solving, decision making) that does not rely on mental representations seems remote, if not impossible [22,26]. What we might call the secondary scaling problem is that it also seems unlikely that a system comprising solely grounded symbols can account for abstract thought [21,25,20]. Even for understanding a simple phrase like 'a thief having to pay for stolen goods', a 'tower of abstraction' has to be erected [20]. This tower rests on concepts such as ownership of property, theft, social compulsion, and payment via fines or imprisonment, the latter concepts resting on notions of money and freedom. The secondary scaling problem is that this tower of abstraction cannot be surmounted by systems that are equipped with grounded concepts only. Several researchers have proposed hybrid symbolic-grounded positions to address both the grounding and the scaling problem. These proposals differ in whether the symbolic representations are themselves grounded in perception of an action [1,19], whether they are at least in part amodal [21], or whether they are exclusively amodal, with activation cascading down to grounded representations [25].

We need abstraction to account for any form of meaningful language comprehension, but do the symbols also need to be amodal and arbitrary? Word-like representations, for example, can be considered multimodal, involving visual, auditory, tactile, and various motor representations; we can speak, sign, write, type, hear, and read words and some of us can even feel them [19].

Are words arbitrary? They certainly are in the sense that they are not analogous to the representation of the object or event in the world that they are denoting. However, words are nonarbitrarily related to their referents in terms of situational co-occurrence. Concrete words are often encountered in the presence of the entity or event they denote, which is a basis for word learning [28]. Similarly, recent evidence suggests that some abstract words acquire their grounding in emotional contexts [29]. Because words systematically co-occur with specific agents, objects, and events, links are forged between words and their referents in memory.

Referents do not occur in isolation and neither do words. Referents occur in spatiotemporal settings that include other agents, objects, and events that co-occur with some systematicity with these referents. Words are spoken and written in the context of other words and this also occurs with some systematicity. The systematicity in the word co-occurrences derives from the patterns of entity co-occurrences in the world [19]. This explains why particular 'grounding effects' such as geographical distances can be obtained by sophisticated analyses of word co-occurrences (or rather, the similarity of contexts in which certain words occur) [30]. It should be noted that this type of distributional (bag-of-words) semantics does not inform about issues that are central to language comprehension (e.g., predication, compositionality, anaphoric resolution) and therefore needs to be augmented with structural information [31] to avoid creating its own scaling problem.

The key point about word-like representations is that they are consistent with the idea that language comprehension does not necessarily invoke a sensorimotor simulation of the word's referent. In other words, they allow for abstraction. Accepting that we need both abstract and grounded symbols leads to a new set of questions. When do we need which and how do they interact? To answer this we need to consider the context of language use.

Context

A major problem with most of the work on embodiment and language (and with psycholinguistics in general) is that the focus has almost exclusively been on individual words and sentences [32]. Psychological experiments on language typically use decontextualized words and sentences as stimuli [33,34]. This is problematic because the resulting patterns of brain and behavioral responses that are obtained in experiments cannot simply be extrapolated to discourse comprehension. During discourse comprehension, people generate extensive mental representations [9], elements of which may form the context of an utterance and can override word-level patterns of association [35].

Context has been a sleeping giant in the discussion on embodiment. It is likely to be a major factor in mediating the relative impact of symbolic and grounded representations. Although action verbs may trigger pre-motor activation when presented in isolation [36] in literal expressions, this activation is diminished or eliminated in figurative expressions [37,38]. Conversely, reading narrative texts might lead to elaborate grounded representations that facilitate the formation of further grounded representations [39,40]. Thus, firm claims about the relative importance of symbolic versus grounded representations cannot be made without taking context into account [4].

Often the context will not be sufficiently constraining for the comprehension system to activate all the way down to a detailed grounded representation. Otherwise the system might commit to an overly specified representation that might be contradicted by subsequent input. Suppose a sentence states that 'There were 50 red roses in the vase.' There is no utility to a detailed visual representation of all 50 roses, even if it were possible to create one. A systematic activation (one that is roughly similar across different comprehenders) of grounded representations might just involve the visual (and olfactory) experience of a vase with red roses, no matter how many it contains.

However, the fact that the story mentions the number of roses may hold significance for the continuation of the discourse; perhaps the recipient has just turned 50 years of age. This information can be gleaned from the sentence just based on word associations among '50', 'roses', 'vase', and 'red'. A detailed visual representation of exactly 50 roses would add nothing to the evolving representation. To develop this idea further, consider the following sentence: 'Several people entered the house.' What detailed representations might be relevant for understanding this sentence? How many people were there? How many men versus women? Were there any children? What was everyone wearing? Granted, there is no law against idiosyncratic activations of experiential representations, but detailed mental simulations of the number of people, their gender balance, and their respective appearances are not licensed by the text. So although representations may be grounded, they do not need to be detailed.

Once we consider language in the form of connected discourse, the division of labor between symbolic and grounded representations becomes clearer. Let us assume that the story continues with 'Among them was a young woman with long blonde hair in a red coat.' Now the activation of grounded symbols becomes more extensive (and similar across individuals). If the story continues with 'She held a white iPhone in a white case by her left ear', the activation of grounded representations becomes even more extensive. At some point the activation of grounded symbols may be so extensive that they would dominate the comprehension process. If the narrative shifted to a new situation, the reliance on symbolic representations may become greater again. In other words, questions regarding the interaction between symbolic and grounded representations cannot be answered by analyzing decontextualized snippets of language.

Suppose further that the story about the blonde woman is told in a conversation between two friends, a joint action that is situated in the world [10]. One of the conversation partners can pick up his own iPhone and hold it by his ear to demonstrate woman's action. How does this enactment of the story impact the comprehension process? Is a mental representation of the action still necessary, given that it unfolds before our eyes? We need to consider both the linguistic context and the communicative situation discourse context if we want to make informed predictions about the role of sensorimotor processes, grounded representations, and symbolic representations in language comprehension. Specifically, we need to know how a particular act of language use is embedded in the environment.

Five levels of environmental embeddedness

I distinguish different forms of language comprehension in terms of how deeply they are embedded in the environment. The level of embeddedness can be characterized in terms of the overlap between the communicative situation and the referential situation (the situation that the discourse is about). Situations are characterized by a spatiotemporal framework that involves agents, objects, and events [9]. Each sentence in discourse conveys a situation. When embeddedness is maximal, the referential situation overlaps completely with the communicative situation. The less the referential situation overlaps with the communicative, the more comprehenders will have to rely on their long-term memory to activate representations of the relevant agents, objects, and events.

Figure 1 depicts five levels of embeddedness; a more intuitive account follows here. The five levels rarely occur in their pure form; most forms of discourse are mixtures and comprehenders are highly skilled at shifting between these levels. Nevertheless, there is some conceptual clarity to be gained by distinguishing among them, particularly because it allows us to analyze more closely the relative contributions of the symbolic and grounded symbols as well as sensorimotor processes.

(i) Demonstrations are the most completely embedded level of language use. Agents, objects, and actions are all present in the communicative situation. An

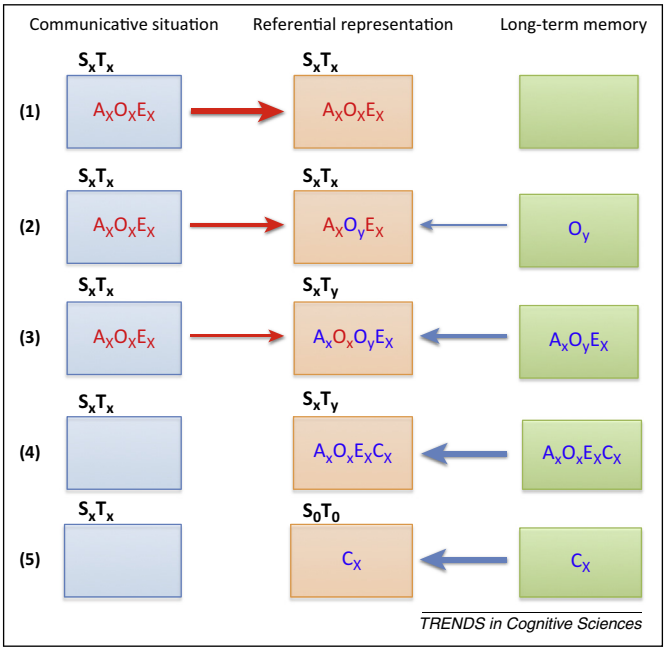

Figure 1. Five levels of situational embeddedness for language use. The columns depict: (1) the communicative situation (where the communication occurs); (2) the referential representation (what the communication is about); and (3) the comprehender's long-term memory (LTM). The thickness of the arrows indicates the extent to which the referential representation draws on the communicative situation and long-term memory for referential information. S and T denote a spatiotemporal framework. A, O, and E refer to agents, objects, and events, respectively. C refers to abstract concepts (e.g., democracy). At Level 1, all relevant referential information is derived from the communicative situation. At Level 2, one referential element is derived from LTM. At Level 3, the referential situation is in the same location as the communicative, but is situated at a different time, which involves different situational elements (e.g., different objects). At Level 4, there is a different spatiotemporal framework and all representational information is derived from LTM and may involve abstract concepts. At Level 5, there is no spatiotemporal framework as an abstraction is represented.

example is a cooking show in which the chef gives a concurrent account of his actions. The bell pepper he is talking about is the bell pepper he is cutting at this moment. If deictic terms like 'here', 'now', and 'you' are used, they refer to the situation that the chef is in.

(ii) Instructions describe a desired or required state of the world that (slightly) differs from the present one. The chef might tell his sous-chef to fetch him a parsnip. For this to work, the sous-chef needs to have a grounded representation in long-term memory of what a parsnip looks like to recognize it among the assembled vegetables in the refrigerator.

(iii) Projections map a past or future state of the environment on the current one. Therefore, they retain the spatial component of the communicative situation but have a different temporal one, located either in the past or in the future. A tour guide might explain what the Coliseum looked like in its heyday when it was filled with spectators, bears, gladiators, shields, and swords, but this requires access to even more memory representations because agents, props, and actions (not to mention important parts of the Coliseum itself) are missing. Similarly, a contractor may explain to his clients what the house will look like after a proposed renovation. Some objects and spatial relations may remain unchanged (e.g., windows) whereas others (e.g., walls) will be broken down.

(iv) Displacements describe an environment that is unrelated to the current environment, as is the case in narratives (e.g., jokes, novels, news reports, historical accounts). Here, deictic terms do not refer to the reader's environment but to some distal one. Grounded representations are very common at this level but share the stage with symbolic representations, which often function as placeholders until more grounded information accumulates over the course of the discourse.

(v) Abstractions do not refer to any environment in particular – they do not have a spatiotemporal framework – but describe a constellation of mostly abstract concepts (e.g., scientific articles, philosophical treatises, legal documents). The primary vehicle for comprehension will be abstract symbols. However, when the author assumes it is beneficial to comprehension, he or she may invoke grounded representations by using metaphors and similes.

A further assumption is that symbolic and grounded symbol systems are simultaneously active – along with perceptuomotor processes (e.g., eye movements) – each operating in accordance with their own constraints as well as constraining each other. Which system dominates the comprehension process depends on the level of embeddedness.

In demonstrations, perceptuomotor processes dominate and the mental representations (grounded and symbolic) that resonate may have only a small role to play. Interestingly however, this passive resonance process that occurs during demonstrations (and instructions and projections) is a major mechanism for word learning [28]. During sensorimotor interaction, grounded representations are formed or, when already formed, may resonate with the perception of actions and object, leading to slight modifications of object and action representations.

Returning to the culinary domain, suppose that Jamie Oliver uses a device to shave something from the zest of a lemon. He calls the device a 'zester'. If we did not already know what a zester was, we have now formed a connection between an auditory event 'zester' coupled with a visual event involving a tool, an action (removing the zest), and a result (lemon zest, which is subsequently used in a marinade). We now know what a zester looks like, how it should be used, and what it is for. We may not have had an up-close look at the zester – it was partly covered by Jamie's hand and he was moving quickly – but we may have glimpsed enough to recognize a zester when we see one in a store on a later occasion.

The new visual experience of a zester modifies our representation of this nifty tool. Moreover, the act of recognition activates the word representation (we might even 'hear' Jamie say the word), which might prompt us to exclaim 'ah, a zester!', producing a new articulatory and auditory event that will strengthen the link between word representation and visual object representation even further. Each time we see someone using a zester, grounded and symbolic representations will resonate, which may lead us to make predictions. For example, when Jamie picks up his zester, we anticipate seeing a lemon, lime, or orange in his hand and we can predict what he is going to do with it and how and what the result of that action will be.

In instructions, grounded representations interact with perceptuomotor processes. An object is referred to that is not within view. Recognizing it requires a grounded representation. Once the object is retrieved and brought into view so it can be acted on, grounded representations may recede into the background. For example, infants use motor actions to make a linguistically denoted object visually more salient by moving it closer to the eyes, an action that leads to better learning [41]. The so-called visual-world paradigm often employs instructions in which people's eye (and hand) movements are simultaneously affected by the linguistic input and the visible and actionable context. We often spatially index aspects of the visual world without encoding the objects, because they can be readily accessed in the environment via an eye movement to the indexed location [42,43].

In projections, there is a mixture of sensorimotor and grounded representations. The sensorimotor processes (e.g., eye movements) are used to identify specific locations in the environment and grounded representations are then used to project on those locations (e.g., a long-deceased gladiator or an envisioned curtain). Projections are likely to involve mental imagery, which can be viewed as a conscious use of grounded symbols [1,4].

In displacements, both grounded and symbolic representations are active. One possibility is that symbolic and grounded networks are interactive and constrain each other to enhance processing fluency [44]; another is that activity cascades down from symbolic to grounded representations [25]. In reading comprehension, sensorimotor processes (eye fixations and saccades) are used to acquire the linguistic input, but in listening comprehension they can be used for indexing purposes [45].

Finally, in abstraction, symbolic representations predominate. Relatively few grounded representations might be activated or they might be activated only weakly due to being indirectly connected to grounded representations. Interestingly, however, recent research suggests that abstract words achieve their grounding via emotional states [29].

Comprehenders are highly adept at switching between these levels. For example, abstractions can instantaneously turn into demonstrations through the use of gestures and enactments and the use of diagrams and doodles. Abstractions can also invoke grounded representations by making use of metaphors. Importantly, however, demonstrations and metaphors are used in the service of abstraction, meaning that successful comprehension requires abstracting away from them, although the demonstration or metaphor itself can be stored as a helpful mnemonic device and be retrieved into working memory on a later occasion to help 're-simulate' the abstraction.

The degree to which language comprehension is grounded depends on the level of environmental embeddedness. Another important factor to consider is the depth of comprehension.

Comprehension is fault tolerant

Comprehension is not all or none. Whether people build coherent mental representations using grounded and symbolic representations during demonstrations depends on their processing goals, their linguistic skills and knowledge, and their (sensorimotor) experience. If we watch a cooking show for relaxation, we might not construct very elaborate mental representations and allow sensorimotor processes to do the bulk of the work, simply taking in the information and following along. However, if we watch the show to learn how to cook a certain dish, we are likely to construct a more elaborate representation that will be stored in long-term memory, which (possibly with the help of a recipe) will allow us to prepare the food on a future occasion.

If someone has extensive experience with a domain, more grounded representations will be activated compared with a novice [46]. An expert might form a full-blown first-person mental simulation of the described actions (involving many grounded representations), a domain novice might form a shallow representation based on word-like representations, and someone with limited language proficiency might form a rudimentary interpretation based on the closed-class words and bound morphemes. Even the third group will have achieved some understanding. Comprehension is fault tolerant [47].

Box 1. Outstanding questions

- How does the level of environmental embeddedness impact the role of grounded representations in language comprehension?
- Do grounded representations become more detailed over time during discourse comprehension?
- How are comprehenders able to switch back and forth between levels of embeddedness?
- What are the cognitive costs and benefits of these switches?
- Do comprehenders generate more detailed representations than is licensed by the discourse?

Concluding remarks

Reframing the discussion about language and embodiment leads us to ask fundamentally different research questions about language comprehension and embodiment than have been asked over the past 15 years (Box 1). Rather than trying to find evidence for or against a particular theoretical framework and argue over the diagnostic value of a particular experimental finding regarding the explanatory superiority of a particular framework, the proposed reframing prompts us to ask when and how the different types of process and representation interact. A more detailed analysis of the levels of embeddedness is likely to yield novel predictions about the relative contributions of sensorimotor processes and grounded and symbolic representations in language comprehension. This move will help us explain that most human of all cognitive feats: understanding language.

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