



# Grounding meaning in experience: A broad perspective on embodied language



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## ABSTRACT

This work reviews key behavioural, neurophysiological and neuroimaging data on the neural substrates for processing the meaning of linguistic material, and tries to articulate the picture emerging from those findings with the notion of meaning coming from specific approaches in philosophy of language (the "internalist" view) and linguistics (words point at experiential clusters).

The reviewed findings provide evidence in favour of a causal role of brain neural structures responsible for sensory, motor and even emotional experiences in attributing meaning to words expressing those experiences and, consequently, lend substantial support to an embodied and "internalist" conception of linguistic meaning. Key evidence concern verbs, nouns and adjectives with a concrete content, but the challenge that abstract domains pose to the embodied approach to language is also discussed. This work finally suggests that the most fundamental role of embodiment might be that of establishing commonalities among individual experiences of different members of a linguistic community, and that those experiences ground shared linguistic meanings.

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## 1. Introduction

How do we understand the meaning of words, the basic elements of our linguistic practice? Asking this question might seem odd, as we live immersed in a linguistic environment. However, such a question has been extensively investigated since centuries. Philosophy addressed this issue earlier than modern linguistics. Nowadays, neuroscience brings key data into this inquiry, and time

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seems ripe for articulating those data with other approaches to language and linguistic meaning.

In this review, we will first summarize the main basic trends in philosophy of language about the issue of meaning. We will start by considering how this problem was originally dealt with in early philosophy of language (Frege, 1892; Russell, 1905, 1910) and then focusing on some late-twentieth-century developments in philosophy (Putnam, 1975; Searle, 1969, 1979). Namely, we will assess two fundamental streams in the philosophy of language, the so-called “externalist” perspective and the “internalist” approach. Does understanding the meaning of words resort to “external” (physical or social) entities or to “internal”, *embodied* experiences?

The central section of the review will focus on very recent findings in cognitive neuroscience strongly suggesting that the meaning of several classes of linguistic items (i.e. verbs, nouns and adjectives), especially when indicating *concrete* actions, objects and intrinsic features of objects relevant for action, is grounded in sensorimotor experience and related brain circuitries. The main idea emerging from these findings, in keeping with the embodied approach to language, is that the speakers understand linguistic material thanks to a reactivation of those sensorimotor systems involved in the experiences expressed by that linguistic material. Thus, we will discuss the aforementioned streams in the philosophy of language in the light of recent findings coming from neuroscience, and show how they offer evidence and arguments in favour of the “internalist” approach.

Then, we will briefly consider a recent proposal in linguistics (Dor, 2015) that stresses the *experiential ground* of linguistic meaning, i.e. the idea that words point at clusters of experiences the subject has had with the objects, actions or situations language is about.

A following section will deal with some implications of the perspective emerging from the previous sections, addressing the issues of (i) the meaning in more abstract linguistic domains, and (ii) the inter-subjectivity of meaning.

## 2. Meaning in philosophy of language

It may seem obvious that the meaning of a word is its *reference* (or “extension”), i.e. the thing, or set of things indicated by the word. However, modern philosophy of language – born with Frege’s (1892) “Sense and Reference” (see also Dummett, 1973; Colagè, 2013) – began questioning this point. Frege noted that two expressions with the same reference (e.g. “the morning star” and “the evening star”, both denoting Venus) do not necessarily have the same meaning. Indeed, compare “the morning star is the morning star” with “the morning star is the evening star”: if meaning were all about reference, these assertions should have the same meaning, which is not the case as the first is a mere tautology whereas the second conveys a past astronomical discovery. This led Frege (1892) to distinguish reference from *sense*. The sense of an expression is “the way in which it refers to its referent”, or the “thought” associated with it, and this is what distinguishes the above expressions and assertions. Moreover, for Frege, senses must be also disentangled from *subjective* representations (or “ideas”): the representation is private whereas the sense is public and can be shared among speakers. It is worth stressing that the distinction between sense and subjective representation, and the claim that the sense is public, intend to ensure the intersubjective nature of language, which would be impoverished if the meaning of linguistic expressions were to resort only to private representations (ultimately stemming from subjective experiences of the world).

This stance also characterizes another, more recent proposal in the philosophy of language. Putnam (1975) claims that the meaning of a word is given fundamentally by the *stereotype* and the *exten-*

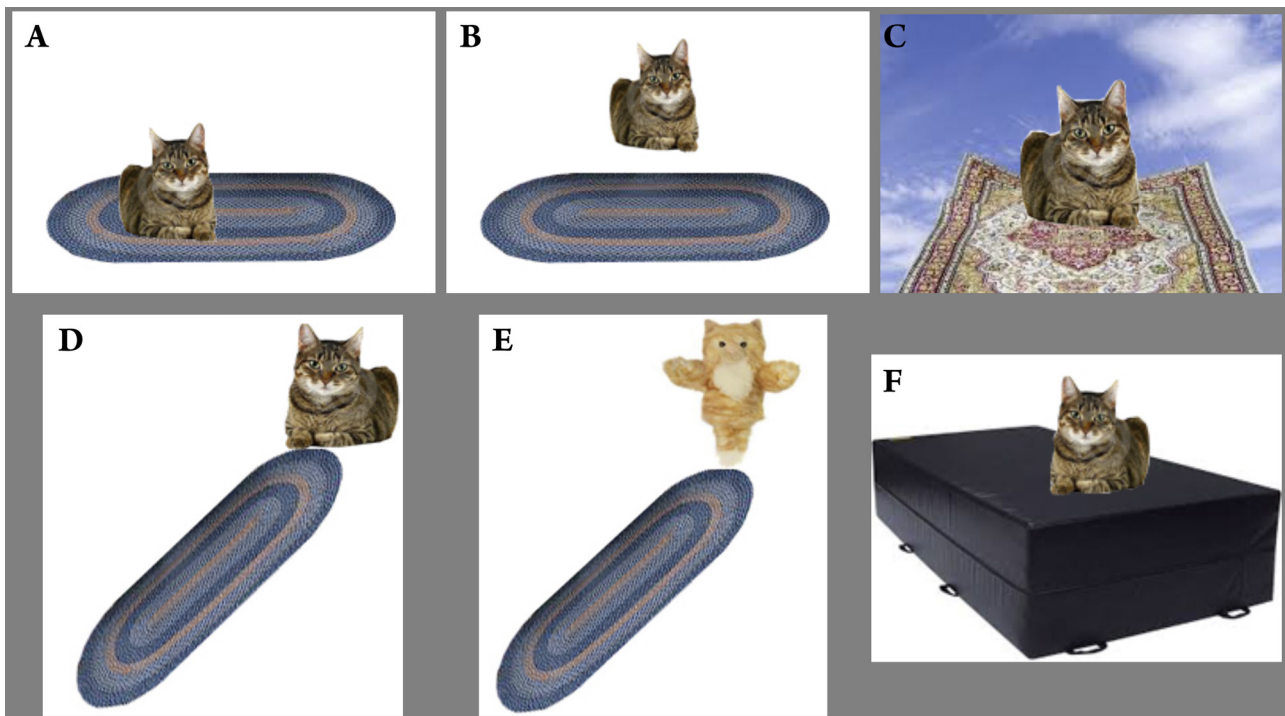
*sion*. The stereotype is a conventional, socially defined notion that gathers important and typical features of the extension of a word or expression. The extension is the set of items a word or expression refers to. A speaker *must* know the socially defined stereotype for acquiring the meaning. Moreover, under this perspective, the extension defines the stereotype and, consequently, the meaning of a word or expression. In Putnam’s view, this implies that the meaning does not depend on what the speakers think, perceive, experience etc., but on the “real nature”, the true (physical, chemical, genetic, etc.) “hidden structure” of what the expression refers to. This is so even when the speaker does not know such nature or hidden structure (Putnam, 1975 pp. 145–6 and 166). Therefore, the extension determines the conventional/social stereotype, and the stereotype is what speakers must grasp to understand meanings.

Despite differences between Frege’s and Putnam’s philosophy of language, the two positions share a rather “externalist” and disembodied conception of meaning. According to this conception: (a) meanings are supposed to be understood by grasping some kinds of (physical or social) *external* entities (like senses or stereotypes), and (b) “the psychological state of the individual speaker does not determine what he means” (Putnam, 1975 p. 192).

Soon after Frege’s proposal, Bertrand Russell (1905, 1910) reacted against both the notion of sense and the general idea that meanings are unrelated to real and concrete experiences. He claimed that we can understand only those expressions that are entirely composed of constituents we are *acquainted with*, where “to be acquainted with . . .” essentially means “to have been directly presented with . . .”, or simply “to have experienced . . .”. It is important to note that, in Russell’s view, we are not directly acquainted with *objects*, but with “sense-data” coming from our experiences with objects (Russell, 1910). Consequently, for example, we can understand the word “unicorn”, though we certainly cannot be acquainted with unicorns, if two conditions hold: 1) if we know (or are told, or read in, e.g., a dictionary) that a unicorn is a horse with a horn on the head, and 2) if we have experienced horses, heads and horns. Note that condition 2) should not be understood, from Russell’s standpoint, as meaning that we know the “essence” of such objects like horses, heads and horns, but that we are acquainted with certain clusters of sense-data coming from our experiences with horses, horns and heads. Moreover, if we learn the word “unicorn” because somebody explained it to us *verbally* (or as we *read* its definition on a dictionary), our understanding of “unicorn” also implies that *we have learnt* to associate the words “horse”, “horn”, and “head” to certain clusters of sense-data. In this way, the definition of unicorn as a horse with a horn on the head serves the task of linking together our past experiences of horses, horns, and heads.

This opens up a more “internalist” and embodied stance about meaning, according to which the meaning of linguistic expressions is fundamentally rooted in our *experiences*. We will see in Section 3 that such experiences can be understood in terms of the *neural activations* linked to actual sensory, motor and even emotional experiences (this obviously being a level of analysis not explicitly considered by Russell). Incidentally, it may be interesting to note that Russell’s focus on sense-data (and our proposal to generalize this so to include sensory and motor experiences as well as related *neural activations*) has still unexplored consequences in philosophy of language. Indeed, so-called reference theories of meaning in most cases tend to conceive reference as reference to objects, and not to real (sensory, motor or even emotional) experiences. The treatment of the wider implications of this point for philosophy of language falls outside the scope of the present work.

As far as the linkage between meaning and experience is concerned, however, John Searle provides further interesting insights. Let us take the assertion “Il gatto è sul tappeto”, an Italian expression that may be translated into English as “The cat is on the mat”, an example used by Searle (1979) that we shall recast a bit for



**Fig. 1.** Cats and mats.

Pictorial representation of possible interpretations of the Italian sentence “Il gatto è sul tappeto”. (A) A domestic cat on a dining-room mat (likely the usual interpretation of the sentence). (B) A cat suspended above a mat (note that although the English preposition “on” would prevent giving this interpretation to that sentence, in Italian, for example, the preposition “su” in the sentence “il gatto è sul tappeto” may correspond to both “on” and “above”). (C) A cat on a flying-mat. (D) A cat on a mat positioned unrealistically; (E) A cat-puppet on a mat positioned unrealistically. (F) A cat on a gymnasium mat. The fact that the interpretations depicted in B–E appear as eclectic depends on their being far from our usual experiences of cats on mats. To some extents, this holds true for F as well: though hearing the sentence “the cat is on the mat” in a gymnasium may readily prompt such an interpretation, this still depends on the sensory-motor experiences the hearer is having (or has had) in the gymnasium.

the purposes of this review. In common circumstances, everybody attributes to that expression a meaning roughly represented in Fig. 1A (i.e., a common domestic cat on a dining-room mat). However, that expression may have several different interpretations. Fig. 1B–F depicts some of these possible, alternative interpretations of this sentence. It is worth underlining that Fig. 1B may be unclear to an English speaker, as the English preposition “on” implies being in direct or indirect contact with a supporting surface. However, in the Italian language, the preposition “su” stands for the English prepositions “on” and “above”, respectively, so that the situation depicted in Fig. 1B may be still expressed with the statement “Il gatto è sul tappeto”. Now, why do we usually understand the sentence properly (i.e. roughly as in Fig. 1A)? Searle’s answer might be summarized by saying that the meaning we usually (and, in most cases, properly) attribute to this expression is the one associated with the usual *experiences* that we have of, e.g., cats, mats and the condition of being on. This point may be spelled out by means of Searle’s notions of *network* and *background* (Searle, 1983). The network constitutes the subject’s general state (including current thoughts, perceptions, desires, memories, emotions, etc.) according to which s/he understands (or uses) linguistic expressions. This is utterly relevant for grasping meaning of words (and of the sentences they compose): our understanding of the word “mat” changes if we think or see that the utterer is in the dining room or, instead, at the gymnasium (compare Fig. 1A with Fig. 1F that depicts a cat on a *gymnasium*-mat). In other words, as the sentence “il gatto è sul tappeto” is often used in relation to a domestic setting, one usually understands it in the sense depicted in Fig. 1A (i.e. the usual experience of cats on mats). Further elements should be conveyed (explicitly by the speaker, or implicitly by a different context) for that sentence to be understood in a possible alternative meaning. The background indicates all those abilities and presup-

positions that Searle (1983, pp. 143–44) finely distinguishes into a local and a deep background. The local background gathers the usual practices about socially and culturally characterized items, such as to know how to manipulate technological artefacts, how to sit on a chair, conventions about foods, etc. The deep background concerns abilities rooted in the *biological makeup* of our species (e.g., because of bio-mechanical constraints, we can do some movements with our limbs but not other ones) and in implicit presuppositions about fundamental features of the world (e.g., objects tend to fall on the ground). The deep and local background clearly affect the way we understand the meaning of linguistic expressions. For example, as we have seen, Fig. 1B–E represent possible interpretations of the sentence “il gatto è sul tappeto”; these interpretations, however, would violate basic aspects of our experiences of the world; thus, such experiences constrain the interpretations we would be ready to give to the sentence. In other words, the background constrains the understanding of all the terms constituting the sentence (i.e., “mat”, “cat” and “being on”). The reader should also note that, although “il gatto è sul tappeto” is a declarative sentence, the same reasoning could apply to the question “Il gatto è sul tappeto?”, irrespective of the answer we are supposed to give.

Resorting to Searle’s notions of network and background makes it clear that the speakers’ “internal milieu” is essential for grasping the meaning of linguistic expressions. The notions of network and background also emphasize the importance of taking into account the actual (sensory, motor and even emotional) *experiences* of the speakers as an indispensable root of the *meaning* of words.

In the next section, we will review recent neuroscientific findings highlighting the linkage between linguistic meaning and the brain correlates of sensorimotor experiences, thus supporting an “internalist” and embodied conception of meaning.

### 3. Neuroscience, “embodied” language and meaning

In the last decades, the theory of “embodied language” has been widely discussed in the neuroscientific literature (Glenberg, 1997; Barsalou, 1999, 2008; Pulvermüller, 2002; Gallese, 2003; Gallese and Lakoff, 2005; Zwaan and Taylor, 2006; Jirak et al., 2010). The theory claims that the same neural structures involved in making sensory, motor and emotional experiences are also involved in understanding linguistic material related to those experiences. This approach contrasts with the “classical view” claiming that language is essentially a-modal and mastered with specifically dedicated neural structures (e.g.: Fodor, 1975; Pylyshyn, 1984; Mahon and Caramazza, 2005, 2008; Chatterjee, 2010). The embodied approach has achieved significant empirical results.

#### 3.1. Understanding verbs

Brain imaging studies show that the presentation of verbs expressing actions performed with a specific biological effector (e.g. the hand or the foot) activates motor and pre-motor areas where a motor representation of that biological effector is present (Hauk et al., 2004; Tettamanti et al., 2005; Aziz-Zadeh et al., 2006; Kemmerer et al., 2008; Desai et al., 2010).

Electro-encephalography (EEG) and magneto-encephalography (MEG) studies show the recruitment of motor and pre-motor areas during the processing of *verbs* expressing concrete actions (Pulvermüller et al., 2001; Pulvermüller et al., 2005a; Pulvermüller et al., 2005b; for review see Pulvermüller et al., 2009). This recruitment is quite early, occurring just 150–170 ms after the visual or auditory presentation of linguistic stimuli.

Complementary to this, behavioural studies where verbs were used as language material have shown that within the first 200 ms participants give slower motor responses if they have to solve a semantic task at the same time (Buccino et al., 2005; Boulenger et al., 2006; Sato et al., 2008; Dalla Volta et al., 2009; see also de Vega et al., 2014). By means of MEG, a very recent paper (Klepp et al., 2015) has shown that this early slowing down of motor responses is due to a suppression of beta rhythm weaker than that found during the preparation and execution of actual movements in the same time window.

Other behavioural studies have demonstrated that the execution of a motor response is facilitated by the comprehension of sentences that describe actions taking place in the same direction as the motor response (e.g. Glenberg and Kaschak, 2002). This action-sentence compatibility effect (ACE) occurs when the response is performed soon after the comprehension of the sentence or right before its end (Kaschak and Borreggine, 2008). More specifically, Taylor and Zwaan (2008) have observed that, within the sentence, ACE is time-locked to the comprehension of the verb that defines the action or to a post-verbal adverb that does not shift focus from the action. In comparison with the studies quoted above, where the recruitment of the motor system during language processing has been shown to occur at 150–170 ms after stimulus onset, the action compatibility effect appears to be a later phenomenon. These data have been interpreted as resulting from an interaction between activation of the motor system for language understanding and activation for motor responses. Additionally, there is fMRI evidence (Baumgaertner et al., 2007) that Broca’s area (namely, left pars opercularis of the inferior frontal gyrus) a) activates in a similar way when actions are presented visually (video-clips) or in the auditory-linguistic modality (sentences describing actions), and b) processes high-level conceptual aspects of action understanding (see also Sub-Section 4.1).

As a whole, these findings may lead to the conclusion that the modulation of the motor system during language processing changes over time, going from an early interference, operating

between 100 and 200 ms after stimulus onset, to a subsequent facilitation, operating later than 200 ms after stimulus presentation (Chersi et al., 2010). Note that this late recruitment of the motor system, leading to a motor facilitation, has been interpreted by some authors as a side effect, at the motor level, of distinct, causal and upstream cognitive processes underlying language processing. According to these authors, at most it may represent a way to colour conceptual processing, enrich it and provide it with a relational context (Mahon and Caramazza, 2005, 2008; Tomasino et al., 2007). Indeed, this interpretation appears less plausible when considering an early recruitment of the motor system (150–170 ms after stimulus presentation). Although also in this case one cannot completely rule out that the recruitment of the motor system occurs because of upstream cognitive processes, it may be reasonably excluded that it follows as a side effect due, for example, to motor preparation or motor imagery of the verb content or just to provide it with a relational context.

In addition, increasing evidence of a causal role of the motor system recruitment in language processing come from lesion studies. By using six different tasks aimed at probing knowledge of action concepts in a large group of brain-damaged patients, it has been shown that lesion sites associated with impaired lexical and conceptual knowledge of action included brain regions within the fronto-parietal sensorimotor systems (Kemmerer et al., 2012).

A very recent study (Desai et al., 2015) tested manual and semantic abilities in chronic stroke patients. The authors found that the degree of impairment for action word processing showed correlation with the impairment in manual performance. In keeping with this, another recent work showed that reversible inactivation of hand pre-motor cortex (obtained with repetitive Transcranial Magnetic Stimulation, rTMS) in healthy individuals may hinder the comprehension of sentences expressing hand actions (Tremblay et al., 2012). Moreover, several studies (Bak et al., 2001, 2006; Cotelli et al., 2007; Fernandino et al., 2013; Cardona et al., 2013) have shown that lesions affecting the motor system even at subcortical level may lead to impairment in action word processing, thus supporting the notion of a close and causal relationship between sensorimotor and conceptual systems of the brain. Taken together, these results show that the brain motor system, including the mirror neuron system, is crucially, and possibly causally involved in processing action verbs.

A strict relationship between action and the evolution of language has been put forward (Corballis 1992, 2002), and further supported by the discovery of the so-called mirror neurons (Rizzolatti and Arbib, 1998; Arbib, 2005, 2013). The mirror neurons (Rizzolatti et al., 1996a, 1996b; Gallese et al., 1996) are active both when a subject performs an action upon an object (e.g. grasping a cup) and when the subject observes the same action executed by another individual (Rizzolatti and Craighero, 2004; Fabbri-Destro and Rizzolatti, 2008). Therefore, the mirror neuron system is not just a motor system but subserves broader tasks such as understanding others’ actions. Additionally, some mirror neurons also respond to the typical sound of some actions (e.g. nut-cracking), suggesting that the mirror neuron system may be engaged by multi-modal inputs, i.e. by visual as well as auditory information (Kohler et al., 2002). This is a key observation as language is usually mediated by auditory inputs (as well as by visual inputs in the cases of sign languages and reading). Moreover, the mirror neuron system displays a somatotopical organization: mirror neurons for different biological effectors are segregated in distinct parieto-frontal regions (Buccino et al., 2001; Wheaton et al., 2004; Sakreida et al., 2005; Dalla Volta et al., 2015). Therefore, the mirror neuron system seems to be able to discriminate action domains in relation to the involved biological effector; discrimination of action domains may also help discriminating semantic domains (e.g. “kick” vs “grasp”). Taken together, these considerations make reasonable to hypoth-

esize that understanding the meaning of action verbs may rely on the mirror neuron system in the human brain, thus contributing to support the view that linguistic meaning is rooted in the brain circuits engaged in actual sensorimotor experiences.

The role of the mirror neuron system in processing verbs has been also highlighted in a recent paper (Kemmerer and Castillo, 2010) aimed at reviewing empirical data supporting the so called two-level theory of verb meaning (Levin and Rappaport Hovav 2005; Pinker, 2007). According to this theory, verbs have two distinct levels of meaning. One level reflects the uniqueness of every verb and is called the “root-level”. The other one is a common representation shared by all verbs belonging to a specific “action-structure” class (e.g. the verbs to spray, to splash and to squirt all have the same action-structure as in “Carol sprayed/splashed/squirted the flowers with water”). This common structure is captured by the “template-level”. In their article, Kemmerer and Castillo propose that the root level (i.e. essentially the one we discuss in the present review) may have its neural counterpart in mirror neurons somatotopically organized in different sectors of the premotor cortex. The template-level may be processed in Broca’s region in the inferior frontal gyrus, where a few studies have found a common representation for verbs describing actions actually performed by different body parts (Tettamanti et al., 2005; Baumgaertner et al., 2007), or presented through different modalities (either verbally or acoustically).

At this point, it should be mentioned that the role of the mirror neuron system in action understanding and language processing has been recently disputed (Hickok, 2009, 2013). As a whole, the criticisms mainly point to some weaknesses of the current research on mirror neurons. In our opinion, these criticisms should be regarded as an invitation to deepen, refine or circumscribe the role of mirror neurons and mirror mechanisms in action understanding and language processing. Considering those criticisms as a clear indication to abandon this research line would instead require more solid empirical data as well as the proposal of empirically-based alternative hypothesis on the neural mechanisms underpinning cognitive functions like action understanding or language processing.

### 3.2. Understanding nouns

Behavioural studies (Glover et al., 2004; Tucker and Ellis, 2004) have shown interaction between the activity of the motor cortex and the presentation of *nouns* as linguistic stimuli, in clear analogy with the findings about verbs (see Sub-Section 3.1). Nouns of objects graspable with precision grip or whole-hand prehension were used as stimuli. Participants were requested to deliver their responses by means of command-handles involving the same kinds of prehension (i.e. either precision grip or whole-hand prehension). The results showed that there is response facilitation when the kind of prehension required for manipulating the named objects is coherent with that actually used on the command-handle; on the contrary, there is interference when the kinds of prehension are incongruent. There is also evidence that when the pragmatic features (affordances) of graspable objects are modified (e.g., a mug with a broken handle), a corresponding modulation in the involvement of the motor system occurs (Buccino et al., 2009; Makris et al., 2011). These studies employed a TMS paradigm where the magnetic stimulation was applied at 200 or 300 ms after presentation of whole or broken objects (see also Sub-Section 4.2).

Another recent behavioural study concerned a linguistic categorization task (i.e., choosing whether nouns name abstract objects or objects to be used with the hand or the foot). The subjects had to respond with their right or left hand. The response was requested early (150 ms) or late (1150 ms) after presentation of linguistic stimuli. The results show that interference occurs only

at the early timing, and only when the response is given with the right hand, which is controlled by the motor cortex in the left, language-dominant hemisphere (Marino et al., 2013). In another study (Gough et al., 2012), the subjects had to read names referring to either graspable or non-graspable artefacts (e.g. hammer or airplane) or natural (e.g. orange or ocean) objects. TMS was applied on the hand motor cortex at 150 ms after noun presentation. The results show that nouns referring to graspable artefacts, as compared to nouns expressing natural objects, differently modulate the motor system, as revealed by motor evoked potentials (MEPs). Similar findings have been collected by means of fMRI (Rueschemeyer et al., 2010). Words expressing functionally graspable objects elicited greater activation in the fronto-parietal sensorimotor systems as compared to words of graspable objects that do not have any specific functional use. Considering that artefacts and natural objects are supposed to be represented in distinct neural structures (Peeters et al., 2009), these results may suggest a similar modulation of the motor system during the processing of nouns and pictures of objects corresponding to those nouns. A very recent behavioural study strongly supports this view (Marino et al., 2014). Participants were presented with both photos and nouns of graspable and non graspable objects, respectively. Scrambled images and pseudo-words were used as controls. They had to decide whether the presented items were objects present in the environment around us or not; responses were to be given with either right or left hand. Slower responses were found for both photos and nouns of graspable objects as compared to non-graspable objects, independent of the responding hand. These findings suggest that processing seen graspable objects and written nouns referring to graspable objects similarly modulates the motor system. In turn, this support the view of a common semantic system for both nouns and their corresponding objects (Ganis et al., 1996; Vandenberghe et al., 1996; Van Doren et al., 2010).

In analogy with the idea that action-verb processing recruits the mirror neuron system, it may be suggested that processing nouns of concrete objects relies on the fronto-parietal system of so-called canonical neurons. Canonical neurons, first discovered in the monkey brain (Rizzolatti et al., 1988; Jeannerod et al., 1995; Murata et al., 1997; Raos et al., 2006), activate both when individuals actually manipulate an object and when they just observe it (Binkofski et al., 1999; Chao and Martin, 2000; Grèzes et al., 2003a, 2003b). These neurons are most likely involved in sensory-motor transformations linking the physical properties of objects (e.g. shape, position, potential *affordances*, etc.) with the motor strategies required to manipulate (e.g. reach, grasp, displace, etc.) them.

Taken together, these considerations suggest that understanding the meaning of nouns indicating objects may rely on the sensorimotor, canonical neuron system in the human brain. As in the case of the mirror neuron system (Sub-Section 3.1), the early recruitment of the canonical neuron system after presentation of nouns suggests a possible role in comprehending their meanings, and not just a side-effect generated by upstream cognitive processes. To the best of our knowledge, however, no study so far has systematically investigated an impairment of noun processing following lesions of the fronto-parietal sensorimotor systems, which would allow one to claim for their causal role in this cognitive task. Very few works have shown that noun processing is impaired in Parkinson’s disease patients (Cotelli et al., 2007; see Cardona et al., 2013 for review).

### 3.3. Meaning and experience

There is further preliminary evidence that what we have reported for action verbs (see Sub-Section 3.1) and for nouns expressing graspable objects (see Sub-Section 3.2) might also be

true for adjectives and emotion-related linguistic items. A recent study (Gough et al., 2013) considered adjectives expressing pleasant (e.g. soft) and unpleasant (e.g. thorny) motor (pragmatic) features, and applied TMS to a hand-closing or a hand-opening muscle. The results show that unpleasant adjectives modulate the hand-opening muscle (which would avoid contact with the unpleasant stimuli), whereas pleasant adjectives modulate the hand-closing one (which would induce contact with the pleasant stimuli). Moreover, processing words expressing emotions recruit the same neural structures (anterior cingulate, insula, amygdala, and ventral pre-motor cortex) that are involved in *feeling* emotions (Niedenthal, 2007; Citron, 2012).

The findings reviewed above in this section and the just-mentioned preliminary evidence begin making a substantial case for a direct causal link from the brain processes involved in sensorimotor experiences to the attribution of content to linguistic material associated with those experiences, in line with an internalist view on linguistic meaning (see Section 2). A recent review of behavioural, electrophysiological, neuropsychological and imaging data (Vigliocco et al., 2011) suggests that even the distinction between word categories (e.g., nouns vs. verbs) may be primarily rooted in semantic processing (i.e. words content) grounded in sensorimotor experience, and not in a priori syntactic categories.

A recent proposal in the field of *linguistics* (Dor, 2015, spec. pp. 44–46) seems to reach similar conclusions. This proposal defines a linguistic sign (typically, a word) as a “discrete instructor of imagination” whose basic function is to point at a certain set of personal *experiences* of the speakers. In other words, in actual events of linguistic *communication*, the words have the primary role of expressing, on the utterer’s side, a set of experiences that the utterer wants to focus on or convey, and of raising, on the hearer’s side, an analogous set of personal experiences. Obviously, the links between linguistic items (such as words or larger expressions) and experiential clusters is established along the course of repeated events of actual linguistic communication occurring concomitantly to those experiential clusters: this is what Dor calls “experiential mutual-identification” (2015, pp. 35–44). This is a key point as it stresses that the meaning of words is not constituted by an external object or by an external abstract entity but by clusters of personal experiences. For example, according to this proposal, the meaning of the word “chair” is not a particular chair or a set of chairs, and not even the stereotypical chair as a socially-defined entity that each speaker is supposed to grasp in order to understand the meaning of that word. On the contrary, the word “chair” points at a cluster of chair-related real and concrete experiences that the speakers (both utterer and hearer) have had in their daily life. This proposal in linguistics is “internalist” by nature: meanings cannot be reduced to external abstract entities like senses, socially agreed stereotypes, or to external objects which are supposed to be grasped ideally or a-modally. Under important respects, the notion of meaning implied by this linguistic approach and by the embodied approach to language are extremely close to one another, and the neuroscientific data reviewed above may lend support to this linguistic theory.

#### 4. Possible objections and perspectives

The view of linguistic meaning considered so far on the basis of recent neuro-scientific data cannot as yet be considered as a complete and final answer to the question about meaning. There are serious challenges that it should face. In this section we would like to focus on two possible objections, and show how they might be overcome in the future thanks to further empirical and theoretical work.

##### 4.1. Abstract linguistic domains

The first objection has to do with abstract linguistic domains. The data reviewed in Section 3 mainly concern concrete verbs and nouns. How can the embodied view and the “internalist” understanding of meaning be extended to abstract linguistic items? This is a key question, which scholars within the embodied approach to language are aware of (e.g. Gallese and Lakoff, 2005), although no definitive answer can be given to this question at present. However, we would like to suggest that the embodied approach to language is not forced to postulate an immediate and simple link between abstract concepts and brain correlates of sensorimotor experiences.

Abstract concepts are, by definition, far from single, actual experiences. Rooting the meaning of abstract terms in concrete experience should take into account that abstract concepts are symbolic constructions that much more strongly resort to the *lexical-semantic* dimension of language; in a sense, they are more “language-specific” than concrete terms are. Nevertheless, it is in principle not impossible to think that the meaning of abstract terms is rooted in actual experiences. We have seen in Sub-Section 3.3 that also according to linguistics, the meaning of words points at experiential clusters. Yet, the meaning of words is also defined by establishing lexical-semantic webs of relations among words (see also Dor, 2015). This is what *dictionaries* are all about. We often grasp the meaning of an unknown term (i.e. a term about which we do not have, or even cannot have, direct experience) when, passing from word to word, we eventually connect the unknown term with some clusters of previous *actual experiences* (recall the example of the word “unicorn” in Section 2). Dictionaries also report *uses* of words, i.e. social conventions about when, where and how employing an expression. Even in this case, dictionaries point to possible concrete situations and experiences (take, e.g., “anger”). The same may also be true for abstract terms like “virtuous”. We do not understand the meaning of “virtuous” by way of grasping some kind of socially defined abstract entity; we rather connect that term with our experiences of virtuous persons or virtuous actions, the feelings they generated in ourselves, the comments we heard about them, etc. Certainly, we might have made such experiences directly, and/or we might have been exposed to reports of similar experiences (e.g. from tales, newspapers, books, TV news, sacred texts, etc.). The depth with which we understand abstract terms like “virtuous” is in some sense proportional to the amount and vividness of related experiences we have had: the meaning we attribute to terms like “virtuous”, “sad”, or “lucky” changes in the course of our life, on the basis of our experiences.

Clearly, given the complexities of real, ordinary linguistic communication (as opposed to more or less simplified contexts addressed in the laboratory), finding out direct empirical evidence unveiling the brain mechanisms involved in all this is a matter of future research. However, the path is open, and studies aimed at addressing more complex linguistic situations are already under way.

A TMS study (Glenberg et al., 2008), for example, has shown a similar recruitment of the hand motor area during the processing of sentences expressing a transfer action (moving away from one’s body) for both concrete (e.g. “I give you some *pizza*”) and abstract (e.g. “I give you my *opinion*”) objects, thus suggesting similar mechanisms for the two categories. In a similar vein, in an fMRI study (Boulenger et al., 2009) the comparison between brain activation due to abstract sentences (such as “He grasped the *idea*”) and concrete sentences (“He grasped the *cup*”) led to the activation of similar brain regions including parieto-frontal areas. A stronger activation for abstract sentences as compared to concrete sentences was found in the inferior frontal gyrus (Broca’s region).

Within the embodiment framework, some studies point to a specific role of areas known to be involved in coding emotions

when processing abstract words. In a behavioural study (Kousta et al., 2011), it has been demonstrated that abstract words differ from concrete ones because of their emotional content. In keeping with this, in an fMRI study (Vigliocco et al., 2014), the comparison between abstract and concrete words led to the activation of anterior cingulate bilaterally, an area known to be involved in coding emotions (Etkin et al., 2006). Therefore, available empirical evidence seems to suggest a recruitment of specific areas in the brain also for abstract words, including emotional areas besides (and beyond) sensorimotor ones.

Moreover, there are interesting preliminary results about processing of words explicitly related to emotional contents, such as “fear” or “spite”. Using event-related fMRI, Moseley et al. (2012) found that emotion words activate brain areas involved in face or arm motions usually involved in *expressing* emotions. Consequently, motor knowledge may be crucial for understanding abstract emotion words. As the authors explicitly note, this is related to Wittgenstein’s (1953) proviso that words expressing “internal states” cannot be treated by classical reference theories of meaning as the “objects” they refer to (i.e. the “internal states”) are radically private. In line with Wittgenstein’s positions, instead, Moseley and colleagues suggest that the use of emotion words is learnt in social contexts where those words are used concomitantly with the actual expression of emotions through face- and arm-movements.

Therefore, the social dimension may play a more relevant role for the meaning of abstract and/or emotion-related words (Scorolli et al., 2011). The so-called “words as social tools” (WAT) theory (Borghi et al., 2013) stresses that words are social entities that we use (as tools, indeed) *to do* things in collaboration with other individuals. According to this theory, the meaning of concrete terms is embodied directly in sensorimotor experience about the objects denoted by those terms, whereas the meaning of abstract terms is embodied mainly in the intrinsically *social* experiences of using them, and are acquired through exposure to such uses by others (Borghi and Cimatti, 2009, 2012).

However, stressing too much that words in general, and abstract words in particular, are external social entities (Borghi and Cimatti 2009; Borghi et al., 2013) may turn out to be a rather “externalist” position (see Section 2). On the other hand, we have seen that even webs of semantic relations and/or reports of words uses (as outlined by dictionaries) serve the task of pointing at experiential clusters, or of suggesting novel combinations of familiar sensorimotor or emotional experiences (see Sub-Section 3.3).

Therefore, embodiment and the “internalist” approach to linguistic meaning implies that at the two extremes of the communicative chain between utterer and hearer are their personal experiences. In-between there are, of course, all the lexical, semantic, social and conventional features of language. However, the utterer’s personal experiences are at the root of what s/he means, and the hearer’s understanding is grounded in his/her own personal experiences.

#### 4.2. The problem of solipsism

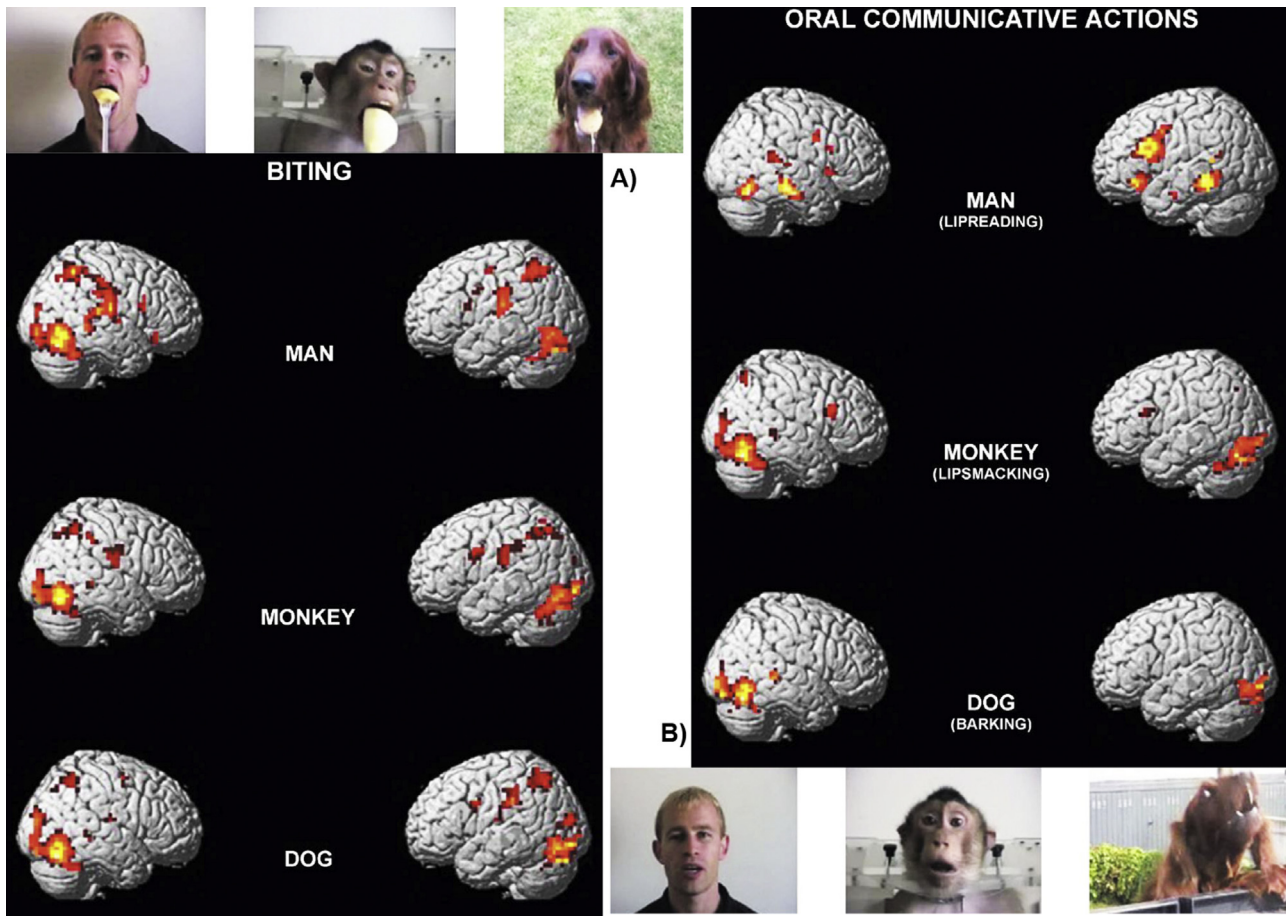
Resorting to personal experiences as the ground of meaning takes us to the second possible objection. If linguistic meaning is ultimately rooted in the speakers’ personal experiences, how can one reach a true intersubjective level? And, how are solipsism and radical incommunicability overcome? After all, if meaning is rooted in the speakers’ personal experiences, and if these experiences were really private, the risks of solipsism and incommunicability would indeed be concrete. However, the “internalist” and the embodied approaches, if correctly understood, may have resources to reply to this objection too.

The point is that the experiences of different subjects may nonetheless have common aspects. These commonalities importantly (though not exclusively) depend on a shared “internal” organization ultimately rooted in a *common biological and neural constitution*. One’s experiences of grasping cups, for example, intrinsically depend on the constitution of one’s biological effectors and one’s neural structures implicated in controlling those effectors; but the features of biological effectors and the neural structures and mechanisms controlling them are shared with possible interlocutors.

From this perspective, the discovery of the monkey mirror neurons and the human mirror neuron system plays a crucial role as it may shed light on how the private character of one’s own experiences is actually broken up, and how those experiences may be shared on the basis of the common, species-specific structure and functioning of the (human) brain. Indeed, the mirror neuron system, at a very basic level, ensures that experiences may be shared among different individuals, thus establishing links among the “private” experiences of several members of a community (Rizzolatti and Arbib, 1998). As it is well known, the mirror neuron system mainly concerns actions; however, there is increasing preliminary evidence about the existence of other “shared circuits” in the brain concerning sensations and emotions (Gallese et al., 2004; Keysers and Gazzola, 2006). More generally, *intersubjective* experiential links among distinct individuals may be established by means of the common biological and neural makeup of individuals pertaining to the same species.

Along this line, it is worth stressing that even the comprehension of seen actions seems to be strictly related to the kind of experience that the observer has of the seen actions (sensory, motor and even emotional) and the correspondent neural representations, subserving that experience. An fMRI study (Buccino et al., 2004) recorded brain activity of human subjects to whom video-clips of mouth movements performed by other humans, macaque monkeys and dogs were showed. The mouth movements were either biting or communicative gestures such as silent speech for humans, lip-smacking for monkeys, and barking for dogs. The results showed that the observation of biting activated the same cortical areas (in the left inferior parietal lobule and in the left pars opercularis of the inferior frontal gyrus) even when biting was performed by monkeys and dogs (See Fig. 2a). As for the oral communicative gestures, instead, observation of barking, lip-smacking and silent speech activated comparable areas in the occipital (visual) cortex, but only silent speech strongly activated left pars opercularis, whereas lip-smacking caused a very small bilateral activation in pars opercularis, and barking induced no frontal activation at all (See Fig. 2b). The authors forwarded that an action like barking, for which humans have no personal motor experience, is possibly processed (and understood) in brain systems different from the motor one (for discussion on this point see also Hickok, 2009), for example in the superior temporal sulcus region where biological actions are coded in pure visual terms (Pelphrey et al., 2005; Saygin, 2007). In the same vein, an fMRI study (Calvo-Merino et al., 2005) assessed that the recruitment of the mirror neuron system during action observation is affected by the motor competence of the observer. Thus, for example, capoeira dancers, compared to ballet dancers, recruit their motor system to a greater extent during the observation of capoeira dance; conversely, classical ballet dancers, compared to capoeira dancers, recruit their motor system to a greater extent during the observation of classical ballet sequences.

One implication of these studies is that the motor system resonates preferentially or exclusively to the observation of actions that are within the motor repertoire of the observer. This in turn means that the agent and the observer must share common experiences and the neural structures sub-serving them. In



**Fig. 2.** Shared motor experiences.

A) Activation foci in humans observing video-clips showing another human being, a monkey, and a dog biting food. B) Activation foci in humans observing video-clips showing another human being silent-speaking, a monkey lip-smacking, and a dog barking. Note that barking does not lead to any premotor activation. See Sub-Section 3.2 for details. Adapted from Buccino et al., 2004.

apparent contrast with this interpretation are the results of a very recent behavioural study (Vannuscorps and Caramazza, 2016). The authors investigated the capacity to perceive and understand actions in a group of individuals with congenitally absent or shortened upper limbs. Despite the fact that they had no (or very limited) capacity to execute upper limb actions, these individuals could understand and memorize upper limb actions as typically developed individuals do. The authors interpreted their results in favour of the notion that action understanding/processing is independent of action execution or motor experience, and, as a consequence, that the first task is “disembodied” because it does not require the second one. Indeed, if one considers the notion of experience at the basis of our capacity to process and understand actions and verbs, as outlined in this paper (see especially Sub-Section 3.3 and 4.1), no wonder that these individuals could understand and process actions: they saw actions, they listened to them and/or they spoke about them. In other words, they built up their own “experience” coded in specific neural systems (maybe not in the motor system, as the authors seem to argue) whose reactivation, in turn, could allow them to process and understand those same actions.

Similar considerations may be applied to objects’ intrinsic features that are relevant for action: the so-called affordances (Gibson, 1977; Gibson, 1979/1986; see also Buccino et al., 2009 and Sub-Section 3.2). Affordances are particular features of objects that automatically recruit in the observer specific action representations to interact with the seen objects. Obviously, the affordances depend not only on the physical features of the objects, but also

on the constitution of the individual that interacts with those objects: his/her perceptual and motor capabilities, the conformation of his/her limbs and other biological effectors, etc. Something perceived as an affordance by a human being may not be perceived as such by a monkey or a bird, and vice versa. This suggests that already our way of perceiving the world around us is constrained by our species-specific biological and neural makeup, and therefore by the *potential* experiences we may have with external objects.

In the light of what seen in this Subsection, the “internalist” and embodied approach to language may overcome the objection of solipsism by showing that the individual experiences of the speakers are not, after all, completely private. No need to resort, as an “externalist” and disembodied approach would do, to the postulation of external abstract entities like senses, stereotypes, or the “hidden nature” of things. The common, shared (and shareable) aspects of the speakers’ experiences depend on their common species-specific biological and neural makeup.

## 5. Conclusion

This review has first sketched (Section 2) two main approaches to the issue of meaning in philosophy of language, identifying an “externalist” (disembodied) perspective, and an “internalist” (embodied) one. Section 3 reviews key findings in the neuroscience of embodied language, and shows how these findings are supportive of the “internalist” view. In the same Section the connections between the reviewed findings and a recent theory in linguistics are



also highlighted. In Section 4, two possible basic objections to the embodied approach and the “internalist” view of linguistic meaning are discussed, sketching some perspectives for their solution.

This work unveils how recent advances in the study of the neural substrates seemingly subserving the understanding of the meaning of concrete linguistic items may shed light on the debate about meaning in philosophy of language as well as on recent developments in linguistics.

The key point of this review is the suggestion that the roles of embodiment as far as linguistic meaning is concerned are actually twofold. On the one hand, the findings reviewed in Section 3 provide evidence for a causal role of brain somatosensory circuits for attributing content and meaning to (at least certain classes of – see also Sub-Section 4.1) words. On the other hand, the most fundamental role of embodiment (see Sub-Section 4.2) might be that of establishing commonalities among individual experiences of different members of a (linguistic) community. In other words, grounding linguistic meaning in individual (sensorimotor) experiences also implies that those experiences have shared (or shareable) aspects from the start; otherwise the inter-subjectivity characteristic of linguistic communication (and of communication more generally) would be impossible. Therefore, grounding meaning in experience requires both that the activation of sensorimotor circuits has a causal role in attributing content to words, and that personal sensorimotor experiences are already intersubjective to some extent.

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