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Embodied cognition and word acquisition: The challenge of abstract words

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Abstract

The chapter outlines a theoretical proposal on abstract concepts and words, called WAT: Words As social Tools. The proposal has four central principles: 1) both concrete and abstract concepts are embodied and grounded; 2) the linguistic mediation and the social influence is more crucial for acquiring abstract than concrete words; 3) abstract concepts activate more linguistic brain areas than concrete concepts; 4) linguistic variability affects more abstract than concrete concepts. The proposal is presented in light of recent supporting evidence.

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Introduction

According to embodied and grounded (EG) theories, the bodily control systems constrain cognitive processes, hence they cannot be explained without considering the bodily contribution. In keeping with the idea that some systems, as the action one, are re-used at a higher hierarchical level (Anderson, 2010), according to EG views language is "grounded" in the sensorimotor system. While it is not so difficult for such a theory to account for the representation of concrete concepts and words (CCs), such as "bottle", many problems arise when considering abstract concepts and words (ACs) as "phantasy" or "truth", which do not have a single, concrete object as referent. As recognized by both proponents and opponents to the EG views, the explanation of how AC are represented constitutes a real challenge for EG cognition (Arbib, 2008).
Aim of the chapter is to outline and defend a theoretical proposal on AC, called WAT: Words As social Tools. The proposal has four central tenets: both CCs and ACs are grounded in perception, action, and emotional systems (embodiment and grounding principle); the linguistic mediation and the social influence is more crucial for the acquisition of ACs than of CCs (acquisition principle); the way in which ACs and CCs are represented in the brain reflects their different acquisition modality, thus both ACs and CCs are grounded, but the last activate more the linguistic system (representation principle); due to the importance of language for ACs acquisition, linguistic differences affect more ACs than CCs (linguistic diversity principle). Presenting the proposal I will discuss supporting evidence, obtained in our and in other labs.

Embodiment and grounding

CCs are grounded in perception, action and emotional processes. This assumption is shared by all EG theories, independently of whether they promote forms of weak or strong embodiment. Whether this is true also for ACs, however, is debated.
Within EG views, different positions can be identified (for reviews, Pecher et al., 2011; Borghi & Pecher, 2012). According to some views, there is no principled difference between concrete and abstract concepts. Other views posit that ACs are less semantically rich than CCs. For example, according to Paivio (1986) they derive their meanings from associations with CCs, since, differently from CCs, they are represented only propositionally and not analogically. The influential conceptual metaphor theory (Lakoff & Johnson, 1980) states that AC derive their meanings metaphorically from their concrete correspondents – for example, the AC "category" is comprehended referring to the CC "container" (Boot & Pecher, 2011). Differently from Paivio's view, one limitation of this view is that it does not relate strongly to brain processes, since supporting evidence is mainly obtained in psychological and linguistics studies.

Further EG views posit a strong involvement of the motor system and of its predictive role for both CCs and ACs (Gaug et al., in press; Glenberg & Gallese, 2012). Other theories stress the fact that for ACs some kinds of contents play a major role: emotions (Kousta et al., 2011), introspective features and situations (Barsalou & Wiemer-Hastings, 2005), exemplifications (Borghi et al., 2005), and different dimensions of perceptual strength (Connell & Lynott, 2012).

All these theories share the problem of generalization: they might be effective for a subset of ACs, but not for all. It is well possible that subdomains of ACs differ in the content they elicit, and that fine-grained analyses of the contents of different ACs are required. As an example, Roversi et al. (submitted) found with a feature production task that institutional artifacts, be they concrete or abstract (e.g., check; ownership), elicited exemplifications, probably necessary to ground them. Abstract social entities (e.g., friendship), instead, elicited situations and mental associations.

At the same time, it would be important to develop a theory of ACs which is sufficiently general. In order to do so, I believe two aspects should be considered, that current theories have at least partially neglected: the role of conceptual acquisition and of the social dimension.

Acquisition

I propose that CCs and ACs are acquired in a different way (for details, Borghi & Cimatti, 2009; 2012). Learning and language learning are social phenomena. However, the contribution of others, hence the role of the social dimension, is more crucial with ACs than with CCs, since with the first it is necessary to rely more on other people's knowledge. Consider for example the AC "democracy": to represent it, we may access a series of visual scenes, but also recall and rely on the opinion of authoritative people (Prinz, 2002). ACs do not have a single referent, but activate a sparse variety of situations, mental states, events – and language can be crucial to keep them together. Literature on Mode of Acquisition (Wauters et al., 2003) demonstrated this: learning of CCs such as "book" is mainly perceptual, since children hear the word in presence of its referent. ACs words as "grammar", instead, are acquired mainly through linguistic explanations.

In a recent study with adult subjects we mimicked the acquisition of CCs and ACs (Borghi et al., 2011). Participants either manipulated novel objects (CCs) or observed groups of objects moving and interacting in novel ways (ACs). The underlying idea was that, differently from CCs, ACs do not refer to single objects but to complex interactions, they are not grouped in categories on the basis of perceptual similarities and are not manipulated during acquisition. Due to fact that their referents are diverse, having a unifying label might be crucial. We tested whether participants were able to form categories independently from language, then we verified whether being told the category name and being explained its meaning modified the learned categories. ACs were more difficult to learn, as it happens in experiments with real concepts.

Moreover, participants produced more perceptual properties with CCs, as in real feature listing tasks. The most important result was obtained in a property verification task in which participants could respond either with the hand, by pressing a key on the keyboard, or with the mouth, by saying "yes" on the microphone. Responses to ACs were faster with the microphone, responses to CCs with the keyboard. Importantly, the difference was more marked when the meaning of words was explained.
These results support the WAT proposal. They reveal that the acquisition modality of ACs and CCs influence their representation and indicate that linguistic information is more important for ACs than for CCs. At the same time, they suggest that linguistic information does not suffice to represent ACs, but that other sensorimotor information is crucial as well: indeed, a control experiment revealed that the effect was not present when linguistic and perceptual information contrasted. Hence, the results disconfirm not EG multiple representation theories according to which, differently from CCs, ACs are not grounded (Dove, 2011).

Representation

I propose that, due to their peculiar acquisition modality, CCs and ACs are differently represented in the brain: both ACs and CCs activate sensorimotor and linguistic networks, but the second play a major role for ACs.
Behavioral and neural (Transcranial Magnetic Stimulation and fMRI) evidence collected in our lab support this hypothesis (Scorolli et al, 2011; 2012; Sakreida et al, under review). In three studies we used the same material, consisting of 4 kinds of phrases, two compatible combinations (abstract verb and noun, concrete verb and noun), and two mixed combinations (abstract verb + concrete noun, concrete verb + abstract noun): for example, to describe an idea /a flower, to grasp a flower/an idea. Concrete verbs were action related and abstract verbs were not; concrete nouns referred to graspable objects, abstract nouns to not graspable entities. In the behavioral and TMS study participants read phrases composed by a verb followed by a noun, and evaluated whether they made sense or not by producing a motor response. TMS single-pulses were delivered 250 after each word presentation. In both studies response times analyses showed an advantage of compatible over incompatible combinations, in line with the idea that ACs and CCs are processed in parallel systems, the motor and the linguistic one (see also Barsalou et al., 2008). TMS results showed an early activation of the motor system in phrases with concrete verbs. Analysis of motor evoked potentials (MEPs) of the hand muscles revealed that, in contrast with phrases containing concrete verbs, those with abstract verbs elicited larger peak-to-peak MEPs amplitude with a late than with an early pulse. This result suggests that also ACs are grounded. Moreover, it allows the speculation that the effect is due to an early activation of mouth-related motor areas with ACs, having a delayed effect on the topologically near hand-related motor areas.
The results of the fMRI study further support this interpretation. Both concrete and abstract phrases activated the core areas of the sensorimotor neural network, thus

confirming that both CCs and ACs are grounded. In addition, concrete phrases activated left frontopolar/orbitofrontal cortex and the right frontal operculum, whereas abstract phrases activated areas within the language processing system as the anterior middle temporal gyrus bilaterally and the left posterior supramarginal gyrus.
Overall, the behavioral, the TMS and the fMRI study confirm that, while both CCs and ACs are grounded in the sensorimotor system, linguistic areas are recruited more for ACs than for CCs processing. Further behavioral support to WAT, according to which linguistic information is more crucial for ACs processing, is provided by Recchia and Jones (2012). The authors analysed the effects of 3 different measures of semantic richness on lexical decision and naming tasks. They found that a rich linguistic context, given by the high number of semantic neighbors, facilitated processing of ACs, while the number of features, but not the number of semantic neighbors, facilitated CCs processing.

Linguistic diversity

A natural consequence of the fact that for ACs representation linguistic information plays a major role is that their meaning should be more variable across cultures and languages compared to that of CCs. In keeping with this idea, Gentner and Boroditsky (2001) distinguished between cognitive and linguistic dominance. Cognitive dominance refers to words in which the sensorimotor basis prevails, as concrete nouns; linguistic dominance concerns instead words such as determiners and conjunctions, for the formation of which language plays a major role. Below I will discuss recent evidence showing that, while the meaning of CCs is less variable depending on the spoken language, for ACs meaning the story is completely different. Due to space reason, I will limit the analysis to a few examples.
In a seminal study on categorization Malt et al. (1999) asked Chinese, Spanish and English speakers to label containers and to sort them. Despite the great variety in the naming pattern, similarity judgments were consistent across groups and not strongly influenced by linguistic variations. The evidence of a dissociation between the experience and the naming pattern is not limited to concrete objects domains. Further examples are given by motion and locomotion verbs (for a review, see Malt et al., 2010). Even if English and Spanish motion verbs differently encode the manner and the path of motion, this does not differently influence memory (Gennari et al., 2002). A similar case is given by locomotion verbs. In an analysis on different languages (English, Japanese, Spanish and Dutch) it was found that beyond two broad categories formed on the basis of biomechanical constraints, to walk and to run, there is room for variation, since every language partitions locomotion events into different sub-categories (e.g., the English words “jog”, “run”, and “sprint” correspond to a single Japanese word).
Overall, these data suggest that, when the stimulus space has a precise structure, there is less room for influence due to language diversity. This is often not the case for ACs,

where different languages partition the stimulus space in different ways. One example concerns the AC of time, and its relation to space. Boroditsky (2001) hypothesized that spatial metaphors for time characterizing languages such as Chinese and English influence time representation: she demonstrated that Chinese and English speakers organize the timeline following a vertical vs. a horizontal dimension. Further recent evidence shows that the spatial organization linked to different writing directions influences the way in which time is organized: past on the left and future on the right in Western cultures, but not in Eastern ones. Overall, the idea that the abstract domain of space can be conceptualized in terms of the more concrete domain of time has received a lot of experimental support (for a review see Bonato et al., 2012). Whether this is due to the different metaphors characterizing each culture or to the influence of the writing directions, what counts is that ACs such as time are highly sensitive to the different cultural and linguistic milieu. A further example is given by mental state concepts: Goddard (2010) showed that, beyond a limited number of meanings which are common across languages, i.e. think, feel, want, and know, the majority of words concerning emotion and language are language specific: for example, the words “sad” and “unhappy” in English do not have a correspondent concept in Chinese, that distinguishes between “fatalistic sadness”, “confused sadness/malincholy”, and “ethical and altruistic grief”.

Reporting these examples I do not intend to deny that the diversity of meanings across languages is pervasive, characterizing different domains. Language diversity affects ACs and CCs as well. I simply intend to suggest that the influence of linguistic variability is stronger for ACs than for CCs.

Conclusion

ACs explanation represents a real challenge for EG views. In order to account them, in their variety, I have tried to demonstrate that it is important to consider the developmental dimension, i.e. their acquisition modality, which is mainly linguistic and social. As to their representation in the brain, while both ACs and CCs are embodied and grounded in perception and action system, the first activate more linguistic brain areas. Further research is needed to explore the hypothesis that their brain representation is due to their peculiar acquisition modality. Given that for ACs acquisition language and the social dimension counts more, I have reported evidence consistent with the view that they are more impacted by linguistic diversity. Overall, further developmental, neural, and cross-cultural evidence is needed to better explore this fascinating area of human cognition.

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