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AN EMBODIED AND GROUNDED VIEW ON CONCEPTS AND ITS POSSIBLE IMPLICATIONS FOR EDUCATION.

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ABSTRACT

In the last years, Embodied and Grounded Cognition (EGC) Theories have been proved to successfully account for a great variety of phenomena pertaining cognitive processes as diverse as perception, action, and language comprehension. In this chapter we will overview and discuss recent evidence favouring an EGC approach to language and concepts, keeping in mind that one of the greatest problem that EGC has to face is the representation in mind of abstract concepts, such as FREEDOM or FANTASY. Since abstract concepts lack a single and concrete referent, the re-enactment of the different experiences connected to each concept could be more difficult than for concrete concepts. We argue that language can be the tool that helps us to keep together the variety of heterogeneous experiences evoked by abstract concepts. The input of others, who can help us to understand the word meaning, for example explaining it to us, can be more crucial for the acquisition of abstract than of concrete concepts. In the last part of the chapter we discuss the implications for educational theories and practice of an EGC view that highlights not only the importance of sensorimotor information but also of the bodily and social aspects of language. In our view not only sensorial and motor processes, but also linguistic and social experiences may be considered as constitutive for the individual cognitive development, in order to improve abstract reasoning and categorization.

Keywords: embodied cognition, grounded cognition, abstract words, concepts and action, language and action, education.

INTRODUCTION

Embodied and Grounded Theories

In the eighties and nineties of the last century, a new scientific perspective emerged within cognitive sciences: the Embodied and Grounded Cognition (from now EGC) Theory (for recent reviews, see Barsalou, 2008; Borghi & Caruana, 2015). Embodied cognition studies have seen an impressive growth in the last years, as recognized by many scholars (Chatterje, 2010; Gentner, 2010). This view stressed the importance of sensory-motor processes as constitutive for the experience and for the cognition itself. The underlying idea is that our cognitive system is influenced and controlled not only by our mind, but also by our brain and our body.

For many years, the dominant view had been the cognitivist one, according to which the so-called "higher" cognitive processes, like language and thought, consist in the manipulation of abstract and amodal symbols, detached from sensorimotor experience. This point of view took inspiration from the Cartesian conception of dualism, according to which mind and body were strictly divided, and was in line with strong modular accounts of cognition, as those proposed by Fodor (1983).

In the last 15-20 years, with the spread of Embodied Cognition theory, the idea that cognitive processes, such as those involved in language and memory (the "higher" processes), are grounded in the same systems as those of perception and action (the "lower" processes) has received a lot of empirical support. The embodied approach contributed to reintegrate the body in the general system of cognition, together with the mind and the brain. The novelty of embodiment is to consider psychological and physical phenomenon as two sides of the same unit.

In the past times cognitive sciences has been largely dominated by the cognitivist paradigm. Only recently the emerging EGC research field, that pointed out the need to reconsider the relation between mind and body, is becoming increasingly influential. Under the name of embodied and grounded cognition there are many theories, that differ in points of view and perspectives (for example, some EGC theories are representational, other reject the notion of representation), but are connected by the idea that cognition is multimodal and constrained and controlled by the body. One of the leading assumption of the embodied cognition theories is that our mental contents are represented and internalized through simulation (Barsalou, 1999; Gallese, 2009). With simulation is intended the re-enactment of inner states, perceptions and experiences acquired during and through the experience with the external world and environment. Simulations have also a predictive role, since they help us to prepare ourselves for acting in a situated world.

The neural basis that accounts for the theory of simulation, is constituted by the recently discovered canonical and mirror neurons system (Rizzolatti and Craighero, 2004). Mirror neurons are a specific class of visuo-motor neurons that, together with canonical ones, are responsible for simulation processes. While canonical neurons fire when observing an object that might be acted upon, mirror neurons fire whenever an individual sees an action performed by another individual with an object or entity. Many neurophysiological and brain imaging experiments indirectly suggest that the homologous of the mirror-neuron system

could have an active role in the comprehension of actions also in humans; importantly, these neurons would be located in the Broca's area, typically activated in a variety of tasks related to language production and sequencing (Buccino et al., 2004). The importance of the discovery of mirror-neuron system consists specifically in the attribution to generally defined "motor neurons" of characteristics which are strictly bounded to cognitive dimensions, like the prediction or the anticipation of an intent.

The relevant aspect, for the purpose of this work, is that according to EGC theories, simulation arises not only when observing an action, but also during the comprehension and the production of language.

The aim of this chapter, which moves from an EGC perspective, is to focus on a novel view on language and on abstract concepts. In the final chapter we will discuss the possible implications of this EGC approach for theories of learning and more generally for educational science and practice.

EGC approach and language

How does the EGC approach consider language?

Beside the fact that we can speak thanks to our phono –articulatory apparatus, language has been considered for long as an abstract process, learned in infancy, and refined during adulthood, with no affection from the external world. According to the theories of simulation proposed by the EGC view, instead, when speaking or understanding we are not passively exposed to a flow of information. Our responsiveness to linguistic stimuli is greatly influenced by our previous experiences with the environment, so that the linguistic code acquires meaning in our brain by simulating relevant aspects of the referent of the word.

For a while, proponents of EGC criticized the view according to which language is a mere form of communication, as well as the traditional cognitivist view according to which concepts and words are represented through abstract and amodal symbols. In contrast with distributional views of language, according to which the meaning of words is given by associations between words, EGC scholars propose that the meaning consists in the relationship between the words and their referent in the world. For example, when we see a chair, neural areas supposed to be responsive to the object's shape and colour are activated. Moreover, according to Barsalou, the past experience of sitting on a chair, and the consequent sensation of comfort co-occur to form the idea of a chair, simultaneously. To highlight the idea that concepts and words are multimodal, rather than amodal, consider the following example: when hearing, reading or pronouncing the word "book" we would reactivate the visual experience of seeing a book, and the tactile one of flipping its pages (re-enactment) (Barsalou, 1999). The meaning of the word "book" consists in the re-enactment of this multimodal experience, clearly grounded in the sensorimotor system, not in the association between "book" and other associate words, as "pages", "reader", etc., as assumed by the distributional theories of meaning (e.g., Landauer & Dumais, 2007).

For many years, EGC theories have tried to show that words are grounded in sensorimotor experience. Some studies have shown how simulation intervenes consistently in the comprehension of utterances, and the most important evidence focused on the elaboration of verbs related to motor effectors. Some influential examples: Pulvermüller et al. (2005) developed a set of studies that confirmed that, when people were asked to read an action-referred word, their sensorimotor system was activated as to represent the meaning of the action. Specifically, verbs that convey action meaning involving arms, hands and legs activate

neural areas accountable for effectors' movement (see also Buccino et al., 2005; Scorolli & Borghi, 2007). In a behavioural study, Glenberg and Kaschak (2002), reported for the first time the so called *action-sentence compatibility effect;* according to the authors, sentences are understood by constructing a perceptual simulation of the events being described: specifically, participants were faster to respond moving away from the body when reading a sentence like "Open the drawer".

At an evolutionary level, embodied cognition theories rely on theories of reuse: the assumption is that some mechanisms and structures originally evolved for lower level systems, as the motor system, are used by higher level systems (Anderson, 2010; 2014); for example, Gallese (2008) with his neural exploitation theory proposes that key aspects of human language and of human social cognition are underpinned by brain mechanisms originally used by the sensorimotor system. Importantly, in the last years evidence is starting to emerge, that shows that processing words is not exactly the same as processing the objects or situations or actions they refer to. The mechanisms of the motor system are re-used but also transformed and modified, while passing from the sensorimotor experience to the linguistic one (Borghi, 2012). For example, in a variety of studies we have shown that during language processing we are sensitive to objects affordances (e.g., while reading the word "pencil" we simulate the possible way to grip a pencil), but that language recruits specific kinds of affordances, as those related to size and grip, and not those related to orientation (Borghi & Riggio, 2015; Flumini et al., 2015).

As argued elsewhere (Borghi, Scorolli, Caligiore, Baldassarre & Tummolini, 2013), showing that words activate their referents has been important to contrast traditional cognitivist views, but it has somehow led proponents of EGC to consider language only in its "referential" aspects and to conceive words as simple pointers to their referents.

Only in the last 5 years this limitation is starting to be overcome and a different view is beginning to emerge. Consider that the experiences of listening and of talking, just as the experience of walking, are corporeal experiences: we use our body to listen and to talk. EGC studies have shown that the same motor areas are involved during comprehension and language production: they are two sides of the same coin. Moreover, talking is a social and relational experience (Borghi & Cimatti, 2010; Borghi & Binkofski, 2014). But this is not the whole story: language - and internal language - is an important tool helping us to organize our thought and to control our actions (Dove, 2014; Lupyan & Bergen, 2015; Lupyan & Clark, 2015).

These issues bring us to reconsider the nature of language, and its method of acquisition: acquisition cannot be reduced to pointing a word to its referent, but it implies a holistic social and relational experience.

EGC and abstract concepts

Do we acquire concepts as "telephone" and "truth" in the same way? Intuitively, we are all tempted to answer "no" to this question. Here we will focus our attention on the acquisition of abstract concepts; indeed, it seems that to account for their acquisition, more questions arise, than to explain the acquisition of concrete ones.

According to the standard EGC approach, we comprehend concrete concepts through simulation. Many studies have collected a large amount of data showing that sensory and motor activation accompanies conceptual processing, so that, for instance, when we use the concept of HAMMER or comprehend and produce the corresponding word, the motor

information connected to the use of the hammer is retrieved. But consider concepts such as FANTASY or FREEDOM, the so called abstract concepts. For a theory assuming that concepts are strongly based on the sensorimotor system things become difficult if we want to know how concepts with no single and concrete referent, as FREEDOM, are represented. FREEDOM is an abstract concept, and like all the concepts that could be so defined, it lacks of a unitary definition, and it would be difficult to refer it to a single and concrete entity. A concept like BALL, on the contrary, refers to something perceivable, and we can experience it through our senses. Even if we do not assume that a dichotomy between concrete and abstract concepts exist, we can well consider FREEDOM and BALL as two good examples of abstract and concrete concepts, respectively.

Obviously, if we consider a concrete concept like BALL, we know that it implies a process of abstraction too. In fact, we know that balls can be very different: they can be rounded or elliptical, depending on the sport in which they are used, and of course they can be black and white, red or whatever other colour. So, the point is, what are the common features that allow us to assimilate all these exemplars to the concept of a ball? Maybe, one step back could be useful.

When we were child, someone has likely told us what a ball is. She/he probably indicated us a ball nearby, saying "this is a ball". With the growing experience with balls, we learned that a ball can be different from the first one we saw, but we have understood that a ball is something we use when we want to play. We can use it with hands, feet or whatever, but its primary use is connected to the dimension of playing. Differently from BALL, FREEDOM can indicate a higher variety of different situations, involving reasoning, experience and emotions. This really makes a difference between abstract and concrete concepts: the variety of experiences and situations referred to by an abstract concept, as well as the complexity of such situations: consider, for example, the difference in complexity between CAUSE and BOTTLE. It is due to these peculiar characteristics of abstract concepts, that explaining them is currently a crucial challenge for theories of embodied cognition. In fact, while for concrete concepts or words theories of simulation can explain how we reactivate the same neural areas involved during the use of the referent of the object, what happens with abstract ones is still unclear. A clarification should be made. We do not intend to claim that abstract concepts do not activate experiences and situations that involve the sensorimotor system. Even if such concepts and words do not possess single and concrete referents, they activate experiences and scenes that involve the sensorimotor system (e.g. for freedom, running on the grass, or flying in the sky), but these experiences are very heterogeneous and differ greatly depending on the participants and on the particular moment in which they use these concepts.

How can such diverse sensorimotor experiences be put together? Through language. Recent studies have shown that for the acquisition and representation of abstract words, linguistic and social experience plays a major role (Bergelson & Swingley, 2013), while for that of concrete concepts, the physical experience of the object referent is more crucial. In sum: there is no reason for not considering the comprehension of abstract words as an embodied and grounded process too, just like that of concrete ones. But their acquisition and representation at least partially differs. Recent evidence mimicking acquisition of novel words in adults has shown that during the acquisition someone has helped us in understanding what the word HAMMER and the word FANTASY stand for, but in the first case they typically accompanied the description with the object itself, creating a direct and observable link between the word and the referent. In the latter case, instead, they just explained to us what the word FANTASY means, and what is its use in the language (Borghi et al., 2011; Granito et al., 2015). As we will discuss below, this is due to the different nature of concrete and abstract concepts. Aside from these important differences, the acquisition of language, be it

concrete and abstract, is a situated experience: situated in the body and in the society and culture. This should be a starting point for an embodied view of education.

Current views on abstract concepts

Given the importance of the challenge to explain abstract concepts, researchers proposed many ECG theories trying to account for abstract concepts. Below we will briefly review the ones that we consider the prominent ones. Specifically, we will focus on the theories that, starting from the assumption that abstract words are embodied and grounded in perception, action and emotional systems, like concrete ones, seek at the same time to emphasize and underline the differences between concrete and abstract concepts.

Barsalou and Wiemer-Hastings (2005) argued that abstract concepts share with concrete ones some important similarities. Specifically, the authors claim that both kinds of concepts are grounded in a situational content. The main difference consists in the type of situations that they retrieve: concrete concepts would mostly refer to objects that we experienced, while abstract ones would be mainly based on events and social aspects of situations, and would elicit reflections and introspective properties. This theory points to a very interesting mechanism; its main limitation is that the evidence in its favour is still mainly limited to feature production tasks.

In the Vigliocco's (2013) and Kousta's (2011) AEA (Affective Emotional Account) proposal, the novelty is to consider emotion as central in learning and representing abstract words. While this recent theory is supported by evidence obtained with different paradigms, one possible limitation of it is that it included emotional concepts within the subset of abstract concepts, and this might create biases in the results (see Altarriba et al., 1999 for distinguishing between abstract and emotional words).

The influential theory of conceptual metaphor proposed by Lakoff and Johnson (1980) can represent a viable alternative. The authors think that metaphors can help explaining our conceptual thought: for example, the abstract notion of "category" would be represented through metaphorical mapping referring to the concrete concept of "container" (Boot & Pecher, 2011). The evidence supporting this theory comes both from cognitive linguistics and cognitive psychology; a lot of crosslinguistic evidence supports it. However, one important limitation is highlighted by the fact that children learn to use metaphors rather late, later than abstract concepts (Dove, 2009). Furthermore, it is difficult to think how to extend the evidence in favour of this theory: for example, how is it possible to account an abstract concept as FREEDOM in terms of the conceptual metaphor theory?

While these theories have inspired the planning and execution of clever experiments, we believe that it is important, in order to account for abstract concepts, to take into account the role played by language in their acquisition and representation (see for a similar but not fully embodied view Dove, 2011; 2014; see also Prinz, 2012). As described earlier, language cannot be reduced to associations between words, and words cannot be simply intended as pointers to their referents. Instead, in our view words influence the formation of concepts (Lupyan, 2012), in particular of abstract ones, since they help keeping together the various and diverse sensorimotor and emotional experiences abstract concepts refer to. In a nutshell, following the WAT (Words As social Tools) view we propose that both sensorimotor and linguistic experience play a role, but that the second is more crucial for abstract concepts representation, while the first for concrete concepts one (see Borghi & Binkofski, 2014, for a thorough overview, and for description of supporting evidence).

Implications of the Words As social Tool view on education

Overall, the EGC perspective leads to reconsider the modality of learning, in terms of exchanges of information between body and mind. Educational sciences, considered as a necessary basis to constitute the individual identity, should be highly influenced by the EGC theories. Indeed, the role of the sensorimotor system and, in general, the role of the bodily experience doesn't improve only our motor ability, but seems crucial in the development of linguistic and social capabilities too. This is not surprising, if we consider ourselves as a complex unity of systems performing different tasks, mutually influenced one by another. The embodied approach is nowadays quite popular in developmental psychology, since for example the seminal work by Linda Smith and collaborators (Thelen& Smith, 1994; Smith, 2005), and by Tomasello and collaborators (e.g. Tomasello, 2002), showing a strict bond between sensorimotor processes, social processes and the development of cognition in toddlers. In contrast, its applications in learning, education and teaching, have not yet been fully explored (see for an exception Gomez Paloma, 2013).

The standard educational practice tends to focus on the intellectual part of learning, putting aside the importance of the physical experience. It seems to be implicitly assumed that the constitution of the self is only based on cognitive capabilities, forgetting that those are influenced and -we shall say- implemented by physical processes. In contrast, the idea underlying an EGC approach to education is to consider the psycho-physical unit of the self in its own entirety. As we have seen, most of our cognitive abilities, even the "higher" level ones, such as the capability to use abstraction, are strongly grounded in our systems of perception and action. But this is not the whole story: what is important to note, is that the role of the body is not reduced to the activation of perception and action systems. With an EGC view of education and learning, we mean the awareness of being part of a community that shares a peculiar tool allowing us to act in the world and with others: language, together with cultural and social attitudes provided by the experience and whatever is considered to construct the self-identity. We will report below a few examples showing how language and higher cognition learning is facilitated when adopting an EGC approach.

The role of the body for the growing of cognitive and social abilities is crucial since the first years of life. The idea is not entirely new: in the second half of the past century, Piaget argued that in early infancy sensorimotor experiences are essential aspects of learning, and that later cognitive processes develop from these sensorimotor abilities. He defined this period "sensorimotor stage", an initial phase of development in which children experience the world and gain knowledge through their senses and motor movements. While interacting with the environment, children go through an amazingcognitive growth in a relatively short period of time. The general idea emphasized in the developmental literature is that children are embodied learners, and that they use sensorimotor information to gain knowledge about the world.

More crucially for our view, in partial contrast with Piaget, Vygotsky has emphasized the importance of the social acquisition of language, and the fact that, once acquired in the social context, language can become an internal instrument, guiding our thoughts (Vygotsky, 1986).

In a more recent work, Iverson (2010) argued that the development of motor system contributes to the development of language in at least two ways: first, the acquisition of motor skills such as the rhythmic hand and arm movements allow infants to practice rhythmically

actions of the sort required for babbling; second, during the period of the first word onset, the fact of playing and manipulating toys, and their naming gesturally, let the children practice with meaning through action. In sum, Iverson claims that "the acquisition of motor skills provides infants with opportunities to practice skills relevant to language acquisition before they are recruited for that purpose". Of course, we are not assuming that motor development is sufficient for language acquisition, but we are stressing that a strict relation exists between the motor abilities and communicative capacities, that are related to each other by social skills, such as those involved in the development of joint attention.

Further evidence reveals the crucial role of motor-exploratory experiences for the development of sophisticated high cognition abilities. Bornstein et al. (2010) predicted that more advanced motor-exploration competence in early infancy would result in more advanced academic achievement in adolescence. In their 14-year longitudinal controlled study, they found that motor- exploratory competence in infancy affects subsequent levels of children intellectual functioning, shaping academic achievement in adolescence. "A more motorically mature and actively exploring baby seems to elicit more opportunities for interactions, richer contacts with novel aspects of the environment, more joint attention and more exposure to referential language."

Some other motor-related processes, such as joint attention and intention reading, emerge in the first years of life, and play an important role for the acquisition of social abilities, of language and of abstract concepts. Prelinguistic infants appear to use attributed intentions as a basis for word learning, through eye-gaze. When children (9-12 months) hear a word, they will take it to be the label for what the speaker is looking at (Baldwin, 1995), and they're sensitized to the presence or absence of joint attention, using it as a guide to establish new word-object mappings. Moreover, it seems that the amount of time infants spend in joint engagement with their mothers predicts infants' earliest skills of gestural and linguistic communication. (Carpenter et al., 1998). Most crucially for us, the acquisition of the ability to comprehend and use abstract words has been recently related to the development of social abilities, as those necessary to engage in joint action (Bergelson & Swingley, 2013).

Embodied effects can also appear in early reading comprehension and recall: specifically, 6- and 7 year-olds' accuracy in comprehension and recall of stories is enhanced when they are allowed to interacting with physical objects and characters of the story compared to when they simply have to rehearse the story (see Glenberg et al. 2011). This higher accuracy in story recall is also present when children are required to interact with objects on a computer screen.

The influence of motor experience does not end after infancy: embodied effects on cognition can be also seen in adulthood, and a wide range of studies has recently investigated the relation between motor processes and educational sciences. It has been demonstrated how gestures can influence thought and subsequent learning, and how motor experience can facilitate the understanding of complex concepts such as physical or mathematical ones.

Recent research has tried to apply an EGC approach to the learning of complex matters, as physics and numerical cognition: for example, Kontra et al. (2012) attempted to use specific motor training to simplify the learning of a physics item, the angular momentum and torque. Undergraduates were pre-tested on a torque judgment task to evaluate their starting knowledge about angular momentum. Researchers created two groups of students, and gave a motor and experiential training to the first group (together with a verbal description) during which students had to manipulate a pair of bicycle wheels on an axle under various conditions. Students in the second group were only given the verbal description, and they observed another student manipulating the wheels. Both groups then completed a post-test to verify what they had learned during the training session. Results showed that students in the "action" group improved significantly in accuracy at post-test, while students in the

"observation" group did not. It seems that motor simulation offered support in understanding a non experiential concept like angular momentum.

As to math, Nuñez and collaborators (1999) have stressed the idea that, as all the cultural and social products, mathematics should not be considered as completely abstract; rather, since basic mathematical ideas showed a surprising stability over thousand years, a common set of neural and bodily structures with which to connect mathematical concepts to everyday experiences are required. Authors identify those structures in the embodied conceptual structures provided by the experiences of the surrounding environment. Concepts like motion, spatial relations, space and time can account for mathematical concepts like the continuity of a function (for a recent review, see Winter, Marghetis & Matlock, 2015). According to the authors, the mathematical definitions of continuity given in textbooks are misleading, because they lack of the experiential part of the definition; consistently, they claim that mathematics should be conceived as a product of adaptive human activity, made meaningful through language, but ultimately based on our biological and bodily background. The crucial point, in the perspective of the authors, is to consider how the human creation of mathematics is not arbitrary, but is rather bodily grounded.

Conclusion

In this chapter we have presented and defended an EGC perspective, focusing in particular on language and abstract concepts. We have tried to show that language is grounded in perception, action and emotional systems, and that, in line with theories of reuse, language reuses structures and mechanisms of the motor system. However, we have shown that this is not the whole story. Words are not only grounded, as first EGC theories seemed to claim. Words are not simply pointers to their referents: they are tools, allowing us to interact with the physical and social environment. Language provides us with a sophisticated means that guides our actions. We have shown that the challenge to account for abstract concepts, critical for EGC theories, can be solved thinking that not only sensorimotor information, but linguistic and social experience matter too.

Which implications has this view for educational sciences and practice? The implications are many and pivotal. As we have seen, since our infancy our action capabilities, constrained by our peculiar kind of body, influence the development of cognition. Sophisticated cognitive abilities, such as those involved in abstraction, are grounded in our bodily, social and linguistic experiences. The time has arrived, that educational practice takes into account this simple but crucial fact.

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