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Inferential Communication in the Embodied Language Paradigm

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Abstract

The aim of this paper is to focus on a problem that has not been sufficiently attended to by researchers in the embodied language paradigm. This problem concerns the inferential level of communication. In real-life conversations implicit and inferential meaning is often the most important part of dialogues. However, embodied language researches, up to now, have not sufficiently considered this aspect of human communication. Simulation of the propositional content is not sufficient in order to explain real-life linguistic activity. In addition, we need to explain how we get from propositional contents to inferential meanings. A usage-based model of language, focused on the idea that speaking is acting, will be presented. On this basis, the processes of language production and comprehension will be analyzed in the light of the recent findings on action comprehension.

Keywords: Inferential Communication, Embodied Language, Motor Simulation

1 Some remarks on the Embodied Language Paradigm

According to many authors (Barsalou, 1999; Gallese 2008; Gallese & Lakoff, 2005; Pulvermüller, 1999, 2002) linguistic meaning is embodied. This means that the comprehension of an action-related word or sentence activates the same neural structures that enable the execution of that action. Gallese (2008) presented this hypothesis as the “neural exploitation hypothesis”. Language exploits the same brain circuits as action does. According to this hypothesis, our linguistic and social abilities are grounded in our sensory-motor system. The Mirror Neuron System (MNS) is the neural structure that supports both our motor abilities and our social skills, language included. Thus, in this account, actions and language comprehension are mediated by motor simulation. We understand actions such as John taking a bottle from the refrigerator and drinking some milk, at least in part, by simulating the same actions in the Mirror Neuron System; and we understand a sentence such as “John took the bottle from the refrigerator and

drank some milk”, at least in part, by simulating the corresponding actions in the same neural network that executes those actions.

This seems to hold true even for the understanding of abstract linguistic meanings. Indeed, in that case, *metaphorical thought* allows us to map from a sensory-motor domain to an abstract domain. This mechanism, according to Gallese and Lakoff (2005), is the basis for the construction and comprehension of abstract meanings and concepts.

Now, imagine entering a bar, you look at the barman and say: “Water”. Or imagine being a firefighter, you are in front of a building on fire and you scream out loud to your co-worker: “Water!”. Imagine getting lost in the desert. At some point you see an oasis and say aloud to your exhausted friend: “Water”. In each of these cases, the word ‘water’ by itself expresses a full proposition, and it is a different proposition in each case (Wittgenstein, 1953; Lo Piparo, 2007).

It is also very likely that, in all of these examples, linguistic comprehension implies a mental simulation by the interlocutor. And it is also very likely that in these three different contexts the very same word will enable three completely different mental simulations. In the first case the simulation will probably concern the actions of putting water in a glass and giving the glass to a customer. In the second case, the simulation will concern the action of pumping water on the building using a fire hydrant. And finally, in the last example the interlocutor will comprehend that very same word as an information, “there is water over there”, and as an invitation, “let’s go to drink some water”. His mental simulations will most likely concern these linguistic contents.

The very same word, then, can express full propositions with entirely different meanings. None of these possible meanings is literally present in the speech act. Indeed, propositions produced and comprehended in these examples are implicit and inferential. Considering that, in the simulative account, language comprehension is realized by means of an embodied simulation of the propositional content, how can we explain, in this account, the simulation of a full proposition starting only from the uttering of a single word?

Imagine now a boy that returns home. His father sees him and asks: “So?” and the boy answers with a smile: “It was fine”. This conversation can only be understood by someone who shares the same background knowledge as the participants. For example, the boy could have returned from an exam, a job interview, or from a date with a girl he really likes, and the father is asking about this. Thus, it is likely that in this case both the father and the son are performing a mental simulation. But is the mental simulation pertinent to the words “So” and “That’s fine” or to the implicit meanings that can be

inferred from those words? The latter is more likely. Consider that these very same words uttered in a different context by different people would have a very different meaning.

The aim of this paper is to focus on a problem that only very recently has started to be addressed by researchers working in the embodied language paradigm. This problem concerns the inferential level of communication. In real-life conversations, implicit and inferential meaning is often the most important part of a dialogue. However, up to now embodied language researches have not sufficiently considered this aspect of human communication.

Indeed the most influential model of language at work in embodied language researches is mainly based on the idea that we have semantic circuits in our brain where our linguistic knowledge, in terms of words meanings, is stored in a pretty stable way (Pulvermüller 2002). Language comprehension, thus, implies the activation of our semantic knowledge that is often coded in terms of action, perception or emotion knowledge, according to the Wittgensteinian idea that different word kinds imply different form of knowledge (Pulvermüller 2012). However, a semantic-based model of language understanding, that basically relies on a fixed and conventional repertoire of meanings, is not sufficiently explicative of what really happens when people speak. A simulation of propositional content does not sufficiently explain real-life linguistic activity. Indeed, the question that must be addressed is: what does it mean for the two utterances in the above dialogue to be subjected to a simulation of their propositional content. In addition, we need to explain how we get from the propositional content to the implicit content and inferential meaning. Simulative understanding is “immediate, automatic and almost reflex-like” (Gallese 2007). Pulvermüller (2012, 442) describes the brain processes that reflect comprehension as immediate, automatic and functionally relevant as well. However, can this definition of comprehension processes explain how we get from literal meaning to inferential meaning? This question should push us to reflect on the nature of automatic processes and to deepen our understanding of such processes. It could be that even automatic and subpersonal processes are sensible to the context. Findings from recent empirical studies support this hypothesis. Contextual effects on motor simulation during linguistic processing have been assessed in behavioural (e. g. van Dam, Rueschemeyer, Lindemann, & Bekkering 2010) and functional magnetic resonance imaging (fMRI) studies (e. g. Papeo, Rumiati, Cecchetto & Tomasino 2012; van Ackeren, Casasanto, Bekkering, Hagoort, & Rueschemeyer, 2012). These findings suggest that contextual information prevails over semantics. However, how precisely this

happens is still an open question. Anyhow, these data raise an issue that all semantic-based account of language understanding should address. Also, not trivial philosophical implications on our understanding of what semantics really is and how it works and on the notion of automaticity should be drawn from these data.

It is worth noting that in this paper it is not questioned the fact that language is embodied. Instead, the aim of the paper is to highlight the limitations that studies mainly focused on descriptive and action related usages of language inevitably have. These limitations have been mainly undervalued by researchers working in the embodied language paradigm. Even in those studies that addressed non-literal usages of language, experimental sets seem to miss a realistic pragmatic context that can trigger a process of inferential communication. They rarely take into account more pragmatically complex dialogues such as, for example, the one between the father and son previously discussed. Thus, if these kinds of stimuli, by far much closer to real-life linguistic activity, were taken into consideration, we would probably see that language production and comprehension imply the activation of the Mirror Neuron System in a peculiar, pragmatically-based, way. In other words, as some studies already suggest (Papeo et al. 2012; van Ackeren et al. 2012; van Dam et al. 2010), motor simulation occurring during linguistic comprehension is very likely contextually determined and not fixedly linked to the literal meaning of words.

Consequentially, there is a second related problem that it is worth noting here. It concerns the definition of meaning and semantics adopted, sometimes implicitly sometimes explicitly, in the embodied language paradigm.

The language model adopted in this paradigm seems to be that of the dictionary. In the *dictionary model* of language, there is a fixed repertoire of words and each word is associated to a meaning. Of course, language seems to also show some imperfections such as polysemy and homonymy, but even these facts can be explained by the model of the dictionary. Indeed, each acceptance of a polysemic or homonym word works as if it were a different word with its own related meaning that we can eventually find in the dictionary. The word's context allows the activation of the right meaning in any sentence. However, sometimes the context is too ambiguous, and this leads to misunderstandings. This appears to be the only room left for pragmatics in embodied language research (even when contextual effects are taken into consideration, these are considered as something outside the speaker that, in some way, interacts with fixed meanings stored in the speaker "heads").

In contrast, the pragmatic dimension of language is more extensive than the problem of polysemy and homonymy even though they are more complex than what has been sketched-out here. A more comprehensive account of language should be provided in order to address issues concerning the pragmatic dimension of language.

1.1 A Usage-Based Model of Language

Since the first half of the nineteenth century, researchers in the fields of the Philosophy of Language, Pragmatics, Linguistics, Discourse Psychology and even Anthropology have been outlining a usage-based model of language. The vast and very rich literature on this topic numbers among its contributors philosophers such as Wittgenstein, Austin and Grice, linguists such as Levinson and Horn, discourse psychologists as Barlow and Kemmer and anthropologists such as Sperber. Although partially different currents of thought can be identified among these researchers, their accounts present some common features. Hence, the next question to address is: what are the defining features of the usage-based model of language?

A good starting point is an examination of semantics and its role in the construction of linguistic meaning. The key to understanding the role of semantics is the distinction between *what is literally said* and *what is intended* by the utterance of a sentence (the sentence's meaning and the speaker's meaning, in Grice's words). This distinction in itself suggests that the semantic level only, with compositionality rules, is not sufficient in order to understand linguistic activity. A second, pragmatic, step of language comprehension seems to be necessary. However, the problem is to determine to what extent the first semantic level can be considered autonomous from the pragmatic level of language. In other words, is there a residual literal meaning that we can call semantics or, should meaning be always considered as contextually determined at every level? In the latter option holds true, language understanding does not proceed from a minimal, literal, proposition to the intended meaning. Pragmatic processes operate extensively at every level of language comprehension.

Currently, in the pragmatic debate these two different accounts of the semantic/pragmatic distinction are known as Minimalism and Contextualism. However, independently of this debate, neither Minimalism nor Contextualism accepts the idea that a consideration of semantics as a fixed repertoire of meanings, can sufficiently explain the process of language production and comprehension. Semantics does not seem to be enough. In fact, if we look at what usually happens in real-life conversations again,

we will see that linguistic meaning is tightly linked to the context of speech, to the background knowledge of the speakers, to their shared knowledge and to their aims in that context (Carapezza & Biancini in press). To know the dictionary definition of each word plus the rules of their composition is not sufficient in order to receive the speaker's meaning.

We all perfectly know the corresponding definition of the words 'so', 'that', 'is' and 'fine' in the dictionary. However, this knowledge is not sufficient in order to understand what the father and son in our example are talking about. Hence, to understand language we need to understand how, when, where, by who and why words are used. This idea leads to a definition of meaning that is very different from the one presented in the *dictionary model* of language. In this account, meaning is defined by the use of a word in a specific context.

We can now turn to another point. Linguistic meaning is the product of a mutual identification of communicative intentions. Without the possibility of understanding other people mental states, and in particular their communicative intentions, language would be a mere code. Indeed, it is the ability to understand other people's mental states and in particular their communicative intentions that makes irony, figurative language, jokes or even misunderstandings possible. If we only simulate the propositional content of an ironic utterance, how can we understand its ironic meaning? And how can we get the ironic meaning if we do not understand the presuppositions and implicatures of that sentence? And how can we understand the presuppositions and implicatures of a proposition if we do not understand other people mental states?

In other words, how can we get the meaning of this sentence without implying a complex mindreading ability?

This last point allows us to make a leap forward. Indeed, the key to understanding inferential communication is exactly a complex mindreading ability. The automatic, immediate and reflex-like form of mindreading realized by embodied simulation is not sufficient in order to explain inferential communication.

Questions concerning the identification of the functional mechanisms of mindreading involved in real-life conversations and their neural implementation are still open.

These issues will be discussed in the following paragraphs.

2 Becoming Ironic. How Do Children Develop an Understanding of Irony?

Irony is a very clear example to highlight the role of mindreading in language comprehension. Moreover, studies on the development of the ability to understand irony can help us to identify those steps of socio-cognitive development that we need to achieve in order to become ironic.

Irony has been a widely addressed topic of study for more than two millennia. In the 1st century AD, the Roman rhetorician Quintilian defined irony as a figure of speech consisting in intending the opposite of what is literally said – *contrarium quod dicitur intelligendum est*. This definition is still very popular along with many others different theories of irony nowadays available.

As Colston and Gibbs (2007) noted in their introduction to the edited volume “Irony in Thought and Language”, a host of different theories of irony have been presented and are currently discussed. And each of them seems to be able to explain only a part of this very complex phenomenon. For some researchers (Wilson and Sperber, 1992), irony implies an echoic reference to a desired or expected event while an undesired event is taking place. For others (Clark and Gerrig, 1984), irony is the realization of a pretence. The speaker is acting out the beliefs or behaviours of others and in doing so he is taking distance from them.

These two accounts are just examples, though influential, but by no means representative of the huge quantity of theories of irony that are presently discussed (see Colston and Gibbs, 2007 for a review of contemporary theories of irony).

However, despite the number of different definitions, irony is, beyond all doubt, a very good example of inferential communication. This is true for many reasons. In order to receive the ironic meaning of an utterance, we need to understand the presuppositions and implicatures of that utterance. Indeed, the use of irony implies, at least, a form of violation. Irony can express the violation of expectations (Colston, 2000; Kumon-Nakamura, Glucksberg, & Brown, 1995; Wilson and Sperber, 1992), the violation of relevance, appropriateness and manner (Attardo, 2000), or the violation of the Gricean Maxim of quality (Kumon-Nakamura et al., 1995). In any case, each of these forms of violation entails a presupposed shared knowledge. Indeed, in order to feel that something is the expression of a violation, we need to know, implicitly or explicitly, that something different should have been the case in that context. Speaker and addressee need to share this knowledge and they need to reciprocally know that

they share this kind of knowledge. If not, irony will not succeed. Moreover, if irony succeeds, we understand the meaning of the speaker's intentional violation. And this meaning is not explicitly expressed, the speaker and addressee need to implicate it. Thus, the processing of irony entails the ability to manage with presuppositions (the shared knowledge) and implicatures (meanings inferred from violations). Furthermore, the addressee needs to comprehend the goal of the speaker in order to understand his ironic meaning and to make reference to context (both the physical context of speech and the background knowledge of the speaker and the addressee). These issues hold true for many other language usages, but in irony comprehension they are particularly evident.

How can we explain the process of inferential understanding in an embodied account? That is, how can we explain the comprehension of something that is not literally present in the sentence but only presupposed and implicated by it? Can we hypothesize that it is a chain of simulations that leads to the inferential, ironic meaning? Does this chain of simulation need to start with the simulation of the propositional content or not? Does the process of inferential understanding need to be implicit or explicit? These are empirical open questions that are waiting for experimental studies.

A look at the development of irony-understanding might help to clarify these experimental questions. Indeed, developmental studies can help us to identify the cognitive mechanisms necessary for irony-understanding and this could make the task of looking for their neural implementation easier.

Why do developmental studies of irony matter? Developmental studies on irony tell us something about the step of cognitive development that is necessary in order to produce and understand irony. These studies are focused on the identification of the social-cognitive mechanisms needed in the production and understanding of irony. On the other hand, studies on the production and comprehension of irony in adults seem to be more focused on the pragmatic description of the phenomenon. Adults studies seem to be interested in the social functions of irony, in its communicative effects, in the role played by the context in the construction of ironic utterances and so on and so forth. They do not seem to be strictly focused on the identification of the social-cognitive mechanism underlining the use of irony as developmental studies would (Filippova and Astington, 2010).

As Filippova and Astington (2010) have recently claimed, much of the research that has been carried out in the developmental line of study (e. g., Happé, 1993, 1995; Sullivan, Winner, & Hopfield, 1995; Winner, Brownell, Happé, Blum, & Pincus, 1998; Winner

& Leekam, 1991) has highlighted the fact that the ability to make second-order mental state attributions is required in order to be able to produce and comprehend irony. This claim is so strong in developmental studies that the production and comprehension of irony is often used as a test for evaluating the possession of a sophisticated mindreading ability, i. e. a full Theory of Mind. Indeed, Theory of Mind, the ability to attribute mental states to other people and to understand them shows a gradual development. It is possible to identify different levels of Theory of Mind. The first entails the ability to implicitly attribute intentions, mainly motor intentions, to others. The second level implies the capacity to explicitly reason about other people mental states (desires, beliefs, intentions, etc.). A third level implies the ability to reason about other people mental states concerning, in their turn, other people's mental states (e. g. "I know/believe/predict that John knows that Mary knows"). Accordingly, different kinds of Theory of Mind tests, such as the false-belief test, are usually run. Clements and Perner (1994), using an anticipatory looking paradigm, showed false belief understanding in 2 years and 11 month-old children; in Southgate et al. (2007), the age of false belief understanding was lowered to 25 months using the same experimental paradigm. Recently Buttelman, Carpenter and Tomasello (2009) carried out a study using an active helping paradigm. This study showed false belief understanding in 18 month-old infants. In these studies, children are not requested to explicitly and verbally reason about other people's intentions. Their helping behaviours and their eye gaze directions seem to suggest false belief understanding.

A false-belief task can also be explicit and verbal and it can test first and second order mental representations. Indeed, in the "Anne and Sally" test (Wimmer and Perner, 1983) the experimenter asks children about Anne's (false) belief or asks about what Sally knows that Anne knows. The former is a first-order mental representation test, it is passed by children around the age of 4 years; the latter is a second-order mental representation test and children are usually able to pass the test only after their 4th birthday. The use of irony is considered as a proof of a full Theory of Mind ability. In fact, many studies carried out with both typically and atypically developing children seem to suggest that the understanding of second-order mental representations is needed in order to acquire irony (Happé, 1993, 1995; Sullivan, Winner, & Hopfield, 1995; Winner, Brownell, Happé, Blum, & Pincus, 1998; Winner & Leekam, 1991). Although there is not a general agreement on the exact age at which children start to use irony, this is, beyond all doubt, a later achievement in language acquisition. According to some researchers (Demorest et al. 1983, 1984) children become competent ironists

at about 13 years of age. According to others (e. g., Harris & Pexman, 2003; Sullivan et al., 1995; Winner & Leekam, 1991; see Filippova and Astington 2010 for a review) children of 6 years of age can already comprehend some form of irony. As Filippova and Astington argue, this difference may be due to the fact that those studies looked for different aspects of irony understanding. Moreover, they might show evidence of a gradual development of irony comprehension. In any case, even the results attesting irony competence at six years of age are fully compatible with the claim that irony entails second-order mental states understanding. Indeed, results by Perner and Winner (1985) attest understanding of second-order mental states at around the age of six or seven years.

Very briefly, we can say that irony entails the ability to go beyond the propositional meaning of an utterance, which sometimes can be literally true and sometimes can be literally false, and to grasp a speaker's intended meaning through the recognition of a form of violation. In order to carry out this inferential process, a complex mindreading ability seems to be necessary. Indeed, psycholinguistic studies carried out in typically and atypically developing children verify the necessity of a second-order mindreading ability in order to produce and comprehend irony.

Irony is then a paradigmatic example of inferential communication. Studies on the development of irony understanding offer us some hints about the socio-cognitive mechanisms that are necessarily involved in the development of inferential abilities in language production and comprehension. Most of the studies on embodied language seem to still disregard the question of how this inferential process works during linguistic activity and where and how in the brain it is implemented.

2.1 Speaking is Acting

In a recent article by Friedmann Pulvermüller (2012), the sketch of a neurobiological model of language is preceded by an introduction about semantic theories. Importantly, Pulvermüller introduces pragmatic concepts in the embodied language research. Indeed, the ideas of the philosopher Ludwig Wittgenstein are given plenty of room in this introduction. In particular, Wittgenstein's notions of "meaning as usage" and "word kinds" are presented. There are different kinds of meaning that lead to different kinds of words and, Pulvermüller says, each kind leads to the activation of a different area of the brain. So, for example, we have object-words, action-words or emotional words.

Semantic knowledge, in these word kinds, is coded in our brain respectively in terms of perception knowledge, action knowledge or emotional knowledge.

However, despite the interesting discussion of these wittgensteinian notions, the account of semantics that Pulvermüller proposes is completely describable according to the dictionary model of language. In fact, his account is grounded on the idea that semantics is made up of the binding of a word form and a kind of meaning knowledge. And that language comprehension is the act of connecting the word form to the right knowledge, i. e. to a pattern of neural activation. Pulvermüller does not really look at usages of words in speech act contexts, that was one of Wittgenstein main concerns and one of the most interesting aspects of his philosophical legacy. The problem of how intentions, background knowledge, context, etc. . . . , come together to construct meaning is not addressed by Pulvermüller nor by most of the other reserchers working in the embodied paradigm.

Boulenger, Hauk and Pulvermüller (2009) carried out a fMRI study on idiom comprehension, considered as examples of non-literal meaning. This study compared the comprehension of literal and non-literal sentences (idiomatic) containing action-related words. The authors found that the comprehension of both literal and idiomatic sentences containing action-related words led to somatotopic activation along the motor strip. These findings were further confirmed in a later study carried out by Boulenger, Shtyrov and Pulvermüller (2012) using a different technique (MEG – MagnetoEncephalography) that affords more temporal information about brain processes. Data from this second study revealed somatotopic activation of precentral motor systems during the processing of both literal and idiomatic sentences containing action-related words.

However, despite the fact that these studies take into consideration forms of non-literal meaning, they seem to be very far away from the goal of understanding inferential communication in real-life linguistic activity. Indeed, participants of both studies read sentences (e. g. “Pablo kicked the habit” and “Pablo kicked the ball”) on a computer screen, without any contextual information. This means that participants did not have to face any pragmatic task that could have triggered inferential understanding and, consequently, for example, a different modality of recruitment of the motor system. If we utter the sentence “Pablo kicked the habit” in a real-life conversation in order to talk, for example, about a friend that has stopped smoking, would the pattern of neural activation be exactly the same? We can hypothesize that, on the basis of our background knowledge, the idiom is interpreted as “Pablo stopped smoking” and the somatotopic

activation in the motor system could, thus, pertain to the action of smoking and not the action of kicking.

It is now possible to turn to another issue of pragmatics studies that seems to be undervalued in the embodied language researches when it might be very important in order to understand how language works. This issue concerns the definition of language as action. To speak is never just a mere neutral description of states of affairs. Speaking always implies the carrying out of both a physical and a social action. By using irony, we can ridicule or praise someone; with a declaration we can start a war, a love affair, or a hearing in the court; with words we can apologize, we can get married, we can name children or boats. And the list could go on infinitely because the social actions carried out by language are potentially countless. It is important to note that speaking is also an action in the physical sense. Indeed, speaking implies the movement of the oro-facial muscles and often of the hands, which can be involved in co-speech gesturing (or hands and co-sign mouthing in the case of sign languages).

Therefore, this should lead researchers to look at language as the performance of physical and social actions. Speaking is acting in a broader sense than just naming objects, actions or abstract concepts. By speaking, we always want to do something. In fact, many of the actions that make us human can only be carried out in language. Speaking implies some kind of background knowledge, goals and intentions; it implies physical movements and it has social effects. On the whole, non-linguistic intentional actions seem to share these very same features. And besides, linguistic activity entails communicative intentions, mainly not present in non-linguistic and non-communicative actions.

However, often linguistic actions are undervalued and what is taken into account is only the process that links a sign, i. e. a word form, to a meaning.

The definition of language as action has been widely discussed by philosophers of language like Austin and Wittgenstein. However, researches working in the embodied language paradigm, despite the fact they were greatly responsible for the discovery of empirical evidence in support of the claim that language is deeply grounded in the brain systems for action and perception, seem not to consider speaking as being an action itself. When I say “Pablo kicked the ball” or “Pablo kicked the habit” I have an intention and I expect my action to have an effect in the real world. And I presuppose that you share the knowledge with me that will allow you to understand what I am saying.

Imagine that I want you to hire Pablo in your company, but you do not agree with me because Pablo has been having trouble with alcohol. I come to your office and say: "Pablo kicked the habit". This utterance is sufficient to let you understand my request. Without a sophisticated and mutual recognition of intentions and beliefs, this linguistic exchange could not work. Furthermore, how could I perform this action of requesting without language? Humans, then, have a very complicated kind of action, linguistic actions. Hence, we should look at language from the same perspective we use to understand action.

This leads us again to the problem of the mindreading systems needed in order to understand action/language.

3 Comprehending Others' People Actions

If speaking is acting (the speaker is performing an action and the addressee has to interpret the speaker's action), studies on action understanding can help us to clarify language production and comprehension. In particular, these studies could help us in the task of understanding how the mindreading ability is involved in the construction of meaning. How do we get inferential meaning out of literal sentences and what is the role of mindreading in the construction of inferential meaning?

Recently, many works have been devoted to the task of identifying the neural mechanisms that support our ability to understand other people mental states. This ability seems to be necessary for action understanding (see Frith and Frith 2006 for a review). In fact, as Frith and Frith argue (2006, 531), mental states determine actions.

Very often the inferential process of mentalizing is carried out automatically. This means that it does not entail conscious thought or deliberation.

Often, when we are involved in the task of understanding other people actions, implicit and automatic inferences are carried out in the Mirror Neuron System. However, simulations carried out in the Mirror Neuron System cannot always explain the full process of understanding others' goals and intentions (Frith and Frith, 2006; Mitchel, Macrae and Banaji, 2006). For example, as Mitchel, Macrae and Banaji argue (2006), motor simulation cannot explain long-term attitude. The question is still under debate. Despite the fact that mindreading seems to be a very important function, its neural implementation seems to be still controversial. In particular, while the role of the Mirror Neuron System is less controversial in order to understand motor intentions of familiar actions, the possibility of a different neural implementation is under consideration for

a more sophisticated form of mindreading that would allow for the understanding of non-familiar actions.

Following Brass *et al.* (2007), it is possible to say that we have two different accounts of the systems that allow us to interpret other's behaviours. According to one of them, based on the process of motor simulation, we understand others' actions by simulating them through the activation of the mirror neuron system. According to a second account, action understanding is realised by means of inferential processes implemented in non-mirror circuits of the brain (Brass *et al.*, 2007). The findings of Brass and colleagues (2007) support the idea that action understanding in novel and implausible situations is primarily mediated by an inferential interpretive system rather than the mirror system. Following the authors, an action is implausible if its goal is not obvious but required context-based inferencing. According to the authors, implausible action understanding activates a brain network involved in inferential interpretative processes that lack mirror properties (Brass *et al.* 2007). No differential activation was found in the mirror neuron system in relation to the contextual plausibility of observed actions.

Then, in this model the comprehension of implausible action is the result of a context-sensitive inferential process of mentalizing.

Turning again to the problem of language production and comprehension, what kind of mindreading mechanism is at work when we produce and comprehend linguistic actions? And in particular, what kind of mindreading mechanism is at work in the understanding of inferential communication (e. g. irony, jokes or the daily conversations such as the one previously discussed)?

In light of the findings of Brass *et al.* (2007), it is reasonable to hypothesize that in the understanding of inferential meaning in daily communication we also need a more complex and inferential form of mindreading that should be involved, being an integral part of it, in the dynamic process of the construction of meaning. It is plausible that this mechanism interacts with other mechanisms also involved in linguistic comprehension, such as the mechanism of motor simulation. These considerations push us to deepen our understanding of the role of contextual effects on language and action understanding. Furthermore, these considerations push us to reflect more on the role of these contextual effects on automatic mechanisms such as the mechanism of motor simulation. Only further empirical studies can help to clarify these issues.

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