Is Embodiment All That We Need? Insights from the Acquisition of Negation

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Simulation of propositional content does not sufficiently explain real-life linguistic activity, even for action-related language. In addition, how we get from propositional content to implicit and inferential meaning needs to be explained. Indeed, simulative understanding is immediate, automatic and reflex-like while an explicit interpretative act, even if not always needed, is still a part of many linguistic activities. The aim of this paper is to present the hypothesis that speaking is a complex ability realized by means of at least two different mechanisms that are likely developed at different and consecutive steps of cognitive and linguistic development. The first mechanism has a neural explanation grounded in the notion of embodied simulation. The second implies socio-cognitive skills such as Theory of Mind. In order to fully develop the second mechanism, a symbolic communication and interaction with a cultural community are needed. This hypothesis will be tested by looking at the acquisition of linguistic negation.

Keywords: embodied language; inferential meaning; mindreading; negation

1. Introduction

> There is an assumption, popular among philosophers, that the brain processes that make for cognition are one sort of thing and that the brain processes that contribute to motor control belong to an entirely different category.
> (Churchland 1986: 451)

It is interesting to note that philosophers such as Epicuro, Campanella, Vico, and Condillac all held the hypothesis that cognition is deeply grounded in our corporal and motor experience even though they did not have the knowledge of neurobiology that we have today.

However, since Patricia Churchland's book came out in the late eighties, experimental data (especially the discovery of mirror neurons in primates; Gallese *et al*. 1996; Rizzolatti *et al*. 2001, 1996) has confirmed the hypothesis that cognition and language are embodied. Consequentially, philosophers who still considered brain processes for cognition as radically different from processes for motor control have moved away from that bias. However, the embodiment of language and cognition might not fully explain human cognitive and linguistic

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abilities. The aim of this paper is to present the hypothesis that speaking is a complex ability realized by means of at least two different mechanisms that are likely developed at different and consecutive steps of linguistic and cognitive development. The first mechanism has a neural explanation grounded in embodied semantics and mental simulation (Gallese & Lakoff 2005). The second implies socio-cognitive skills such as Theory of Mind. In order to fully develop the second mechanism, a symbolic communication and interaction with a cultural community are needed. Hence, the origin of man's complex species-specific language and cognition is in both the brain and in culture (Deacon 1997; Tomasello 1999; Arbib 2009). This hypothesis will be tested by looking at the acquisition of linguistic negation.

2. The Acquisition of Negation in Normal Development

In first-language learning three broad categories of negation consecutively arise (see Dimroth 2010 for a review): (1) rejection/refusal, (2) disappearance/non-existence/unfulfilled expectation, (3) denial. According to many studies (Volterra & Antinucci 1979; Pea 1980; Choi 1988), rejection is the first category of negation to be acquired. Children use "no" to express refusal of something existing in their present context. However, we can find examples of rejection in human pre-linguistic gestures and even in animal behaviour. In fact, before the time children start to produce the single word "no" to express rejection, they have already expressed rejection non-linguistically. Rejection, according to Pea (1980) does not require abstract mental representations, while non-existence and denial do require them.

The second category of linguistic negation to arise is non-existence/ unfulfilled expectation. At this point, children are able to signal the absence or disappearance of an expected referent in the context of speech or to indicate something that violates their expectations, based on previous experience (for instance, malfunctioning toys).

Lastly, the third category to be acquired is denial. Denial implies negation of a predication. The referent is usually symbolically expressed. As Bloom (1970) argues, to deny children must have the ability to discern between their own knowledge of the world and the knowledge of their listener. In order to deny a sentence, children have to deal with two propositions, one affirming and one negating the same predication; and they have to ascribe one of these to the person they are speaking to. "To deny the truth of another person's statement entails the understanding that the other person may hold different beliefs, or that language is itself a representation of reality, not reality itself" (Tager-Flusberg 1999: 328). Denial is usually acquired by the age of two and a half years.

According to Antinucci & Volterra (1979) categories of negation are acquired according to the complexity of the inferences that they entail. At the beginning of this process, children are only able to make inferences about their present perceptual situation. Thus, at first, children can only negate (rejecting, prohibiting, or expressing non-existence) something currently present in the perceptual context of speech or something that was just present in the speech con-

text. Later on, as children start to express denial, they become able to read their listeners presuppositions. At this time, children rely both on perceptual and pragmatic context.

Choi (1988), in her longitudinal study on English-, French-, and Korean-speaking children aged between 1;7 and 3;4 (years;months), went into more depth in the description of semantic categories of negation. She identified nine functions of negation that usually arise in three different phases.

(1) a. Phase 1: non-existence, prohibition, rejection, failure.
b. Phase 2: denial, inability, epistemic negation.
c. Phase 3: normative negation, inferential negation.

(Choi 1988: 525)

In Phase 3, Choi introduced the category of inferential negation that indicates "the child's inferences about the listener" (Choi 1988: 524). She refers to an interesting example of inferential negation:

(2) (Kyle has broken a few crayons. The experimenter has been scolding Kyle for breaking crayons. Kyle picks up a broken crayon which he did not break and looks at the experimenter.)
K: I not broken this.

(Choi 1988: 525)

This example clearly requires false belief understanding. In fact, when Kyle says "I not broken this", he is reasoning with the experimenter's belief. Specifically, Kyle supposes that the experimenter believes that he has broken that crayon while this was not the case (false belief). This example of inferential negation was recorded when Kyle was 2;8.

After the one-word utterance period, when children start to utter their first sentences, according to Bloom's (1970) study, non-existence is the first category of negative sentences to arise, not rejection. Denial is still the last category to be acquired, despite the fact that the syntactic structure of denial is less complex than non-existence. According to Bloom, denial requires more cognitive effort from children.

Hence, according to the data we have seen thus far, we can say, following Pea (1980: 165) that the expression of negation, from simplex to complex forms, requires underlying cognitive representations of increasing complexity. The first expression of negation does not require internal abstract representation because the rejected object is present in the perceptual scene; later on, with the expression of a disappearance, abstract mental representation is required because the negated object or person is no longer present in the speech event context; finally, when truth-functional negation is used to deny a predication, a second-order abstract representation is required.

Nevertheless, Pea (1980) does not agree with the opinion of Antinucci & Volterra (1979) that, in order to deny, children must attribute a presupposition to their listener. Many times, he argues, children express negation without addressing a person. Moreover, he claims, there is not enough independent experiment-

al evidence supporting Antinucci & Volterra's assertion that two-year-olds are able to infer other people's mental states.

However, we know that the development of Theory of Mind begins early. During the second year of life, for example, language acquisition seems to heavily rely on the ability of reading other people's intentions (De Villiers 2000). Furthermore, children start to use mental verbs like *think*, *know*, etc. in their third year of life (i.e. before they are able to pass the false belief task). Currently, we also have evidence showing that even 15-month-old children can understand false beliefs (Onishi & Baillargeon 2005).

Moreover, it is worth noting that linguistic negation, at least denial, is a metalinguistic operator. Negation cannot be referentially used. Even in a negative descriptive sentence (e.g., *It is not raining*.), negation does not have its own referent. Negation never concerns a fact in a real or fictional world, nor an abstract concept like "elegance" or "rationality", nor an action. Negation is metalinguistic because it implies an operation on a proposition. That is to say, negation is the operation of setting a false value for the proposition it is referring to (and this is the same operation we also make in the more complex linguistic action of lying). Thus, negation, or at least denial, seems to imply a second order mental representation. In fact, by expressing a denial toward a listener, the child is representing a content, negating that content (by setting a false value) and attributing the negated content to the listener.

Thus, following the considerations of Antinucci & Volterra (1988), we can argue that the complex forms of negation, which are metalinguistic in their nature, regardless of what different names they may be called, entail the ability to attribute mental states to others and even to understand false beliefs.

Thus, psycholinguistic studies on linguistic negation show that negation can express very different functions that arise at different steps of language acquisition and that have different cognitive requirements. In what follows, it will be argued that we need two different mechanisms in order to account for the acquisition of these different functions of linguistic negation.

3. What Model of Linguistic Development can Account for the Acquisition of Negation?

So far, we have seen that there are at least three steps of increasing complexity in the acquisition of linguistic negation. The question that will be addressed now is: What model of linguistic development can account for the acquisition of negation?

A two-level model for language acquisition will be presented. In particular, the hypothesis that we can account for the first categories of negation, rejection and non-existence (the first step of language competence in this model) and even for the comprehension of the negated content of a denied sentence in a simulative paradigm will be proposed. Embodied simulation, however, does not sufficiently explain denial (the second step of language competence). While in a simulative account, based on motor simulation, our understanding of others is "immediate, automatic and almost reflex-like" (Gallese 2007), and our comprehension of

action-related language is realized by means of a neural simulation of the pertinent action, as neuro-imaging and Transcranic Magnetic Stimulation studies have widely shown (Buccino *et al*. 2005; Tettamanti *et al*. 2005), an explicit interpretative act is needed in order to explicitly attribute negated/simulated information to someone else. Hence, simulation of the propositional content is not enough to explain denial. We need to introduce more complex inferential abilities that are not only the product of our brain, but also of our interaction with a cultural community.

The latter claim about the explicitness of denial could be challenged by saying that there is not any need to envisage an explicit act in order to attribute the negated information to someone else. Indeed, recently Gallese & Sinigaglia (2011) have argued that by means of embodied simulation a given content can be implicitly attributed to others because embodied simulation entails a functional, non-representational form of mental state attribution. However, what characterizes linguistic denial is exactly the explicit negation of someone else's mental state. Thus, in this case by accepting the claim that an explicit attribution is not necessary to denial because an implicit functional attribution of mental states can be realized by means of embodied simulation, it would follow that when denying we are explicitly negating a content that is implicitly attributed. And this means that, at some point, that content should become explicitly accessible. Then again, even if we buy into Gallese & Sinigaglia's proposal about the functional and non-representational nature of mental state attribution realized by means of embodied simulation, we still need to introduce an inferential process that acts on explicit accessible content. This, obviously, does not happen for every inferential activity in which we are involved. But it is necessary for some human activities, and denial seems to be among them.

3.1. Simulating Negation

According to many authors (Barsalou 1999; Pulvermüller 1999, 2002; Gallese & Lakoff 2005; Gallese 2008), 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. According to this hypothesis, our linguistic and social abilities are grounded in our sensory-motor system. The Mirror Neurons 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. This even holds true for the understanding of abstract linguistic meanings. Indeed, in that case, *mental imagery* and *metaphorical thought* allow us to map from a sensory-motor domain to an abstract domain. This mechanism, according to Gallese & Lakoff (2005), is the basis for the construction and comprehension of abstract linguistic meaning.

Moreover, it has been pointed out that language comprehension also relies on other kinds of embodied simulation, not only on motor simulation. For example, Engelen *et al*. (2011) elaborated and tested a model for the development of language comprehension in which perceptual simulation is central. According

to these authors, a perceptual simulation of an event is created every time we listen to or read a description of that event. In this view, children exploit the process of perceptual simulation even if they have a limited knowledge of the objects involved. The role of sensory simulation in language comprehension has also been highlighted by Wojciehowski & Gallese (2011). Their approach focuses on the idea of the "Feeling of the Body" that is the product of sensory-motor simulation processes that enable us to immediately understand not only basic motor intensions but also the feelings and emotions of others. The experience of the "Feeling of the Body", in the authors' view, is fundamental when we approach literary texts and explains the sense of identification with and connectedness to narrated characters that we feel while reading stories. Recently, also further research conducted on the role of embodied emotion and introspection in language comprehension (Barsalou *et al*. 2003, Kousta *et al*. 2011) has contributed to giving us a richer and more powerful picture of the embodied language studies.

According to this view, many features of language seem to be bodily grounded. Lately many studies have also been devoted to the understanding of simulation processes in the comprehension of negated sentences (for example, Kaup et *al.* 2006; Tettamanti *et al*. 2008). To date, the neural mechanisms that underlie the processing of negation are still unclear. Tettamanti and colleagues carried out an experiment that aimed to identify the brain mechanisms that underlie the comprehension of negative sentences.

As Tettamanti *et al*. (2008) noted, psycholinguistic data on the comprehension of negative utterances seems to lead to different conclusions. On one hand, data from sentence comprehension (for example, Carpenter & Just 1975) suggests that a negative sentence is cognitively more demanding than the corresponding affirmative sentence. And this should indicate a stronger neural activation for a negative sentence than for its affirmative counterpart. On the other hand, data from studies on the accessibility of information (for example, Kaup & Zwaan 2003) suggest that negated information is cognitively less accessible.

The main aim of the Tettamanti *et al*. study was to test whether the impact of negation on neural activation is dependent on the semantic field of the negated content. Considering previous results, two possible outcomes were predicted by the authors. Negation could determine a reduced accessibility of the content of the negated sentence with, consequently, a lower neural activation for simulation in the left fronto-parieto-temporal and in the posterior cingulate cortex (content dependent hypothesis). Alternatively, negation could determine higher cognitive loads, due to a greater syntactic complexity. In this case, the processing of negation will lead to a higher, content independent, neural activation in the left perisylvian areas.

Results of Tettamanti *et al*.'s (2008) study confirmed previous findings on the accessibility of information (Kaup & Zwaan 2003). The authors say that "Negation is encoded by our brain in terms of a reduced activation of the areas representing the negated information".

Thus, the Tettamanti *et al.* study seems to be congruent with the hypothesis proposed by Kaup & Zwaan (2003, 2007) that the processing of negation enables a lower neural activation of the negated content in the brain, both of action-related and abstract content.

For the sake of clarity it should be noted that Kaup & Zwaan (2007) proposed a *two-step simulation hypothesis of negation*. According to their model, the comprehension of a negative sentence is realized firstly by means of a simulation of the negated content that is soon followed by a brief simulation of the actual state of affairs. At this point, information about the negated content is less accessible, this finding is congruent with Tettamanti *et al*.'s (2008) results. Moreover, this hypothesis can even account for data from sentence comprehension tasks (for example Carpenter & Just 1975). Indeed, in the first step of the comprehension of a negative sentence, the comprehender has to manage with two simulations, i.e. the simulation of the negated content and the simulation of the actual state of affairs. Hence, it is plausible that in this first step, a negative sentence is cognitively more demanding resulting in a longer response time.

The two-step simulation hypothesis was tested by means of a set of experiments that assessed time responses in recognition tasks. Participants read a sentence and then were shown a picture. They had to decide whether objects in the picture matched objects mentioned in the sentence. Responses were faster when depicted objects matched those mentioned in the sentences, even for negated contents. Thus, the same response-time pattern was found both for affirmative and negative sentences. In a different condition, pictures were shown with a longer delay. In this case, different response-time patterns were observed for negative and affirmative sentences, with negative sentences showing significantly slower responses. Thus, the results seemed to confirm the two-step simulation hypothesis, with less accessible information about the negated content in the second step.

It should be noted that in the studies on the simulative processes of negative sentences, negation is considered to be a monolithic syntactic function. The authors did not consider that different functions, with different cognitive and pragmatic demands, can be carried out in language by the same morpheme. Thus, to simulate the content, both the actual or the negated content of a sentence, does not supply a complete explanation of the comprehension of negation. "No" can express a rejection or a denial and the cognitive distance from the former to the latter is considerable. Moreover, it should be noted that Pragmatics usually classifies two different kinds of negation: descriptive and metalinguistic negation (Horn 1985). Descriptive negation refers to a state of affairs in the world while metalinguistic negation acts on presuppositions, implicatures and formal aspects of language like morphology or phonology. According to Kaup and colleagues, "the experiential view conceptualizes language comprehension as the performance of a sensory-motor simulation of the described sequence of events" (Kaup *et al*. 2007: 265). Hence, these studies seem to only be focused on descriptive negation. Language, however, is not always just the description of an abstract or action related state of events. Even if a simulation of the content occurs, and this seems to be the case, this does not sufficiently explain the complex inferential process that occurs in linguistic denial. In real life, in many cases, by denying a sentence, a speaker is denying presuppositions or implicatures of his co-speaker.

From the point of view of the speaker, this entails the ability of attributing mental states to the others and of following their inferences. The speaker is

explicitly attributing a mental content to the interlocutor and he is then negating that content. Thus, the speaker is holding the actual and the negated content of the inference in his mind and he is explicitly attributing one of them to the interlocutor. In addition, in order to realize this attribution the speaker needs to rely on background and shared knowledge.

From the point of view of the interlocutor, the comprehension of negative sentences is not always just a matter of simulation of the propositional content. In fact, in order to correctly understand a cancelling implicature negation, the interlocutor needs to understand the inferences that can be drawn from the negated content of the sentence. This entails explicit mindreading for the interlocutor as well. Intentional and highly inferential communication is often explicit in the minds of speakers.

A simulation process of the propositional content can also be taking place with cancelling implicature negation. This is not questioned here. However the simulation of the propositional content is only a part of the full process of language comprehension.

It would be interesting to test the simulative processes at work during the production of inferential negative sentences. Is the content of inferential communication simulated as well? Do we simulate both the literal and the inferential meaning of those sentences? Which are the brain circuitries that implement our more complex inferential abilities? These issues are still waiting for an answer.

Interesting studies have been carried out on the ability to draw inferences during language comprehension and to integrate semantics and world knowledge. For instance, Chow *et al*. (2008) carried out an fMRI study in which participants were asked to read short passages and predict the development of the situations by drawing correct inferences. To trigger the participants to generate the correct inference, each short passage was followed by a lexical-decision task. The authors manipulated the predictability of the target words in the lexical decision-task. Predictable words were those not explicitly mentioned in the short passages but inferable from them. This study, thus, investigated the neural mechanisms sub-serving inference processes. However, it does not seem to address the problem of so-called pragmatic intrusion, namely to what extent is semantics pragmatically determined? In other words, this study is focused on the problem of predictive inferences in language comprehension while it does not address the different problem of the "intended meaning" of an utterance. It seems likely that we need inferential abilities to understand the meaning of an utterance, what the speaker is talking about, and not only to predict the event that can follow from the uttering of that sentence.

Another issue, then, is worthy of remark here. Studies on the simulative processes of negative sentences are carried out in the field of embodied semantics. The definition of meaning in this field of research seems to be problematic. Action-related meanings are represented in the brain through a mental simulation realized in the same sensory-motor circuitries that enable actions. Thus, in this view, a part of our vocabulary is built on our sensory-motor possibilities. Metaphorical thought and mental imagery allow us to have abstract meanings (Gallese & Lakoff 2005).

The problem with this account is that it considers semantics, specifically

action-related words, as a stable field (dictionary model of language). For example, Meteyard *et al*. (2012) reviewed the work that has been done in the last decade on the topic of embodied language. The authors classified language theories, putting them on a continuum between those that are fully embodied and those that are fully disembodied. Semantics, in all of these works, seems to be conceived of as the link between a word and its representation, that can be more or less embodied. These representations also seem to be pretty stable, no room is left for pragmatics in the definition of semantic representations. However, language does not work as a rigid code. We can play with words, we can use irony, we can lie or we can simply be misunderstood. This is possible because meaning, in real-life linguistic activity, is mostly constructed in the context of speech. Indeed, many authors have been suggesting that we should abandon the distinction between semantics and pragmatics. Meaning, in this view, is constructed in every context of speech on the basis of the speakers, their background knowledge, their level of shared knowledge, their goals (Carapezza & Biancini 2012) and the physical context of the speech act.

Imagine a boy that returns home. His father sees him and asks: "So?" — and the boy answers with a smile: "It was fine". This conversation could only be understood by one who shares their same background knowledge. For example, the boy could have returned from an exam or a job interview. Or a date with a girl that he really likes. The father is asking about the outcome. 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 *It was fine* or, more likely, to the implicit meanings that can be inferred from those words? Moreover, these very same words uttered in a different context by different people would have a very different meaning.

Thus, studies on embodied language should discuss the notions of meaning and semantics further. Linguistic activity seems to not only be realized by means of a fixed and conventional repertoire of meanings, even in the case of action-related language. Up to now, the role of pragmatics and inferential processes are still missing in this research paradigm. Hence, inferential processes involved in language comprehension seem to be the next step that should be addressed in embodied language research.

In particular, studies of simulative processes of negation show an overt bias, the consideration of negation as mainly as descriptive while ignoring its metalinguistic functions (Horn 1985). Examples of negation that cancels presuppositions and implicatures, i.e. metalinguistic negation, can be easily found in everyday conversations. Below, are a few example dialogues:

(3) (Andy meets Barry.)
A: I saw you at the restaurant yesterday.
B: I did not move from my apartment.
A: Sorry, I was pretty sure that you were the man I saw with your wife!
After this conversation Barry goes home and says to his wife Carol:
B: You were at the restaurant with another man yesterday!
(Carol replies with a very classical answer.)
C: It isn't what you think!

(4) In a big company there was a cash deficit. The boss addresses one of his employees with these words:
Boss: You have recently bought a very expensive car, John.
John: I did not do anything that was beyond my possibilities.

In all of these examples, negative sentences negate a presupposition or implicature of the interlocutor. In the first case, Barry is negating the presupposition of Andy that Barry was the man at the restaurant. Carol is negating the implicature of Barry that she was cheating on him. Finally, the employee is negating the implicature of his boss that he stole money.

It is likely that in understanding these negative sentences, we start with a simulation. Following Kaup & Zwaan (2007), it is likely that we start with a simulation of the negated content and then we simulate the actual state of affairs. However, a simulation of the actual or the negated content is not sufficient in order to understand these dialogues. The boss is not explicitly saying that the employee stole the money. He is implying this sentence. And the employee is not explicitly negating this implicature. His negative sentence is an implicit negation of the boss's implicature.

Thus, the 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 the propositional content to those inferential meanings that are not explicitly stated but are explicitly accessed by speakers.

Simulative understanding is the first step in language acquisition that we reach during ontogeny and very likely it was the first step in phylogeny as well. However, at some point we got more complex socio-cognitive abilities that made more sophisticated linguistic activities possible. In competent speakers, these two mechanisms interact, making it hard to isolate one from the other.

Concerning the acquisition of linguistic negation, we can understand rejection and non-existence in the simulative paradigm. However, it is very unlikely that denial can be accounted for in this same paradigm, in particular for cases of presupposition cancelling negation or implicature cancelling negation. In order to account for denial we need to introduce explicit inferential abilities. The inferential level of linguistic negation will be the topic discussed in the next section.

3.2. The Inferential Level of Negation

The examples discussed in the previous paragraph seem to suggest that simulating the negated or actual content of a proposition is not always sufficient in order to understand negative sentences even if these are action-related. If our understanding of propositions such as those presented in the previous examples were based on a simulation of the propositional content, then much of the meaning of those dialogues would be lost. A simulation is most likely taking place. However, many questions arise about the content and temporal dynamic of this simulation. Only further empirical investigation can help to answer these questions.

Up to now, we have argued that complex socio-cognitive abilities are

needed in order to produce and comprehend denial, the most complex form of negation. The next question we are going to address will be: Is there any empirical evidence supporting this claim?

We try to answer this question by looking at the acquisition of linguistic negation in autistic children. Autism is a neurodevelopmental disorder with three characteristic features: social impairments, communicative-linguistic impairments, and repetitive and stereotyped behaviors (Tager-Flusberg 1999). The first two aspects of autism are usually referred to as a condition of "mind-blindness", that is, the inability to read our and other people's mental states (mindreading). Hence, according to this account, autistic subjects have a specific deficiency in understanding other people's mental states and, as a consequence of this lack of comprehension, they have communicative and social deficiencies. Indeed, the ability of attributing mental states such as intentions, beliefs, desires, etc., to other people is the ground for social behaviors and linguistic communication.

Because they lack the mindreading ability, autistic individuals have difficulties in interpreting other people's communication and behavior. Different hypotheses have been proposed to explain this disorder. Baron-Cohen (2002), following a hypothesis originally proposed by Asperger (1947), gave empirical support to the idea that autism can be considered as an extreme form of the male brain. In other words, autistic individuals demonstrate hyper-developed systemizing abilities, i.e. they perform over the average in tasks that require identifying the variables of a system and predicting its rule-governed behaviors while they perform poorly in all the tasks that require empathizing with others. It is worth noting that both men and women have the systemizing and empathizing skills but usually women have more developed empathizing skills then men and vice versa, men have more developed systemizing abilities. The extreme male brain that seems to characterize autism, thus, is a particular combination of these abilities that consists in hyper-developed systemizing skills and hypo-developed empathizing skills. This is, of course, only one of the hypotheses that have been put on the table about this enigmatic pathology. Lately, the alternative explanation that subjects with autism spectrum disorder have a dysfunction of the mirror neurons system consisting in its disordered activity has also been considered (Iacoboni & Dapretto 2006). According to this hypothesis, this dysfunction of the mirror system is responsible for the lack of that immediate and automatic attunement with others that makes us able to understand their basic motor intentions.

In any case, whatever can be considered to be the origin of this pathology, one of the defining characteristics of autism is mind-blindness. However, this mindreading deficiency can be experienced to different degrees and this means that differences among individuals in the severity of symptoms are likely to be observed.

So far, we have made two points. Firstly, we have examined the cognitive requirements underlying the acquisition of linguistic negation, arguing that in its complex forms, linguistic negation requires second-order mental representations and complex mindreading abilities. Secondly, we have identified a neuro-developmental disorder, autism, where subjects are expected to show a specific

deficiency in mindreading. Now, if these two assumptions are correct, autistic individuals should find complex forms of linguistic negations difficult to interpret correctly. And this seems, in fact, to be the case.

Shapiro & Kapit (1978) looked at the use of linguistic negation in autistic children and in typically developing 3- and 5-years-old controls. Subjects had to follow an experimenter's instructions eliciting comprehension, production or imitation of negative sentences. Findings suggested that autistic children used a different strategy than their controls in accomplishing the tasks. In fact, they performed better than controls in the imitation task but had significantly lower performances in production. All groups performed better in comprehension than in imitation. Still the autistic children's performances in comprehension were lower than the 5-years-olds and even lower than one of the two groups of 3-year-old normally developing controls. Shapiro & Kapit (1978: 349) find that "the autistic subjects produce fewer and more rigid negations as well as imitating well, suggesting adequate registration and reply but poor integrative processing of linguistic form for social and communicative use".

Moreover, Tager-Flusberg *et al*. (1990) looked at language acquisition in autistic children and children with Down syndrome. Children were visited in their homes and video-taped while playing with their mothers. Conversations were subsequently transcribed by the experimenters. Results showed that autistic and Down syndrome children acquired syntactic structure to express negation in the same order as typically developing children. However, autistic children only used syntactic structures of negation to express rejection and non-existence while at later stages, children with Down syndrome also express the function of denial. Significantly, the expression of denial was absent in the linguistic production of autistic children. The authors interpreted these findings as a result of a lack in Theory of mind, under the assumption that denial requires attributing mental states to the listener. "This paucity of denial reflects impairments in Theory of mind. […] These aspects of mental state understanding are specifically impaired in autism and it is therefore not surprising that this function of language, denial, is almost never used by young children with autism" (Tager-Flusberg 1999: 332).

Delayed negation processing was found by Schindele *et al*. (2008) even in adults diagnosed with high-functioning autism and Asperger's syndrome. Subjects were required to read short stories ending with either a negative or affirmative sentence. Depending on the context, the last sentence could be pragmatically felicitous or infelicitous. Normal controls only read negative final sentences in the pragmatically infelicitous context slowly while the two clinical groups had no context-related effect, showing longer reading times for negative sentences in both conditions.

The data about the production and comprehension of negative sentences in autistic individuals seems to support the conclusion that complex socio-cognitive abilities are needed in order to produce and comprehend denial. Indeed, when the ability to understand other people's mental states is impaired, production and comprehension of denial is impaired as well.

The next step will be to put all of these elements in a unitary model for language acquisition.

3.3. Putting Together Simulative and Inferential Abilities into a Two Step-Model for Language Acquisition

So far, we have seen that different kinds of embodied simulations occur in language comprehension. We have also seen that in many occasions the simulation of the propositional content does not sufficiently explain the pragmatic level of linguistic communication. Most linguistic meaning is implicitly communicated through inferential processes. What can all of this data tell us about the acquisition of language?

Children have a language-ready brain, but they need to be in a speaking community in order to start speaking themselves. Even Noam Chomsky made this kind of assertion (Chomsky 1988). Unlike what Chomsky believed, the claim here is that having a language-ready brain is not the same as having an innate, domain-specific, device for language.

Arbib (2009: 265) hypothesizes that the language-ready brain resulted from the evolution of a progression of mirror systems and linked brain regions ''beyond the mirror'' that made the full expression of their functionality possible.

Following the mirror system hypothesis advanced by Arbib and Rizzolatti for phylogeny (Arbib & Rizzolatti 1997, Rizzolatti & Arbib 1998), the proposal made here for ontogeny is that children have a language-ready brain that, based on mental simulation implemented by the mirror neuron system, makes the start of the acquisition of language possible. At this first step, the mirror neuron system provides us with the ability to approximately comprehend intentions, mainly motor intentions, and to start the process of language acquisition. In fact, the mirror neuron system can explain the so-called construction grammar model for language acquisition (Tomasello 1999) in terms of intention understanding, imitative learning and simulative understanding.

At this point, when the child enters the linguistic game, it is language itself that affects his or her cognitive functions and even brain. For example, the acquisition of literacy affects brain lateralization. Illiterate subjects, according to Arbib (2009), are more right-lateralized than literate controls.

Language makes our socio-cognitive abilities more complex. In particular, a full language shared by a cultural community makes our mindreading ability far more complex. Once the child acquires an explicit mindreading ability he or she is now ready to enter the second step of language acquisition. In fact, an explicit mindreading ability allows children to produce and comprehend inferential and implicit linguistic communication. The simulation of the propositional content by itself is not enough, even if it is very likely that simulations are taking place as well (Gallese & Sinigaglia 2011). Thus, at least two different neural mechanisms seem to be involved in language comprehension. On the one hand, language is deeply grounded in our sensory-motor abilities which are exploited via the mechanism of embodied simulation. On the other hand, we probably make use of a different neural mechanism that sub-serves inferential reasoning and that is an integral part of our linguistic skills (see for, example, Chow *et al*. 2008). Indeed, as pragmatics seems to suggest, linguistic symbols are a highly inferential communication system. And the more implicitly we are communicating, the more we need to be able to explicitly reason about other people mental states.

4. Conclusions

Summarizing the data discussed so far, negation can be considered a good example supporting the hypothesis that speaking is a complex ability realized by means of at least two different mechanisms that are likely developed at different and consecutive steps of cognitive and linguistic development. In fact, categories of linguistic negation have different levels of complexity with different cognitive requirements. Rejection and non-existence can be explained in a simulative account. Denial, instead, needs an inferential explanation.

It is worth noting again, that these two steps of language competence, despite the fact that they develop consecutively, interact in adult language making it really difficult to isolate one from the other.

The final remark is about human nature, its phylogeny and ontogeny. Embodiment does not sufficiently explain human language and cognition. We also must look at the co-evolutionary relationship of culture/language and the brain.

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