Kwiatek, Ł. Hohol, M. (2016). Embodiment, simulation and the
meaning of language. In J. Stelmach, B. Brożek, Ł. Kwiatek (Eds.),
The normative mind (111–133). Kraków: Copernicus Center Press

Łukasz Kwiatek
Pontifical University of John Paul II
Copernicus Center for Interdisciplinary Studies

Mateusz Hohol
Institute of Philosophy and Sociology, Polish Academy of Sciences
Copernicus Center for Interdisciplinary Studies

Embodiment, Simulation and the Meaning of Language

Human languages differ greatly from any kind of communication performed by non-human animals, including relatively well-studied communicative acts like gestures and vocalizations of great apes,[1] the bee waggle dance,[2] alarm calls of vervet monkeys,[3] cuttlefish colour-changing displays[4] and so forth. The most important of the differences is, arguably, the fact that natural language has a symbolic dimension – that is the meanings of words used by humans in order to communicate are not genetically fixed or ontogenetically ritualized (which

[1] See, for instance, M. A. Arbib, K. Liebal, S. Pika, "Primate vocalization, gesture, and the evolution of human language", *Current Anthropology* 49 (6), 2008, 1053–1076; A. S. Pollick, F. B. M. De Waal, "Ape gestures and language evolution", *Proceedings of the National Academy of Sciences of the USA* 104, 2007, 8184–8189.
[2] See K. von. Frisch, *The Dance Language and Orientation of Bees*, The Belknap Press of Harvard University Press, Cambridge, MA 1967.
[3] See R. M. Seyfarth, D. L. Cheney, P. Marler, "Monkey responses to three different alarm calls: Evidence of predator classification and semantic communication", *Science* 14 (210/4471), 1980, 801–803.
[4] R. T. Hanlon, J. B. Messenger, *Cephalopod Behaviour*, Cambridge University Press, Cambridge 1996, pp. 120–131.

is the case with the signals used by animals),[5] they are rather more or less conventional. This forces human beings to learn the meanings of words, a process which occurs most dynamically during childhood and usually begins between the first and second birthday.

To effectively communicate, however, one needs to learn something more than just the conventional meanings of words, namely the ability to use words in accordance with proper grammatical and structural rules since those rules shape the meanings of complex linguistic expressions. This raises the question about the nature of linguistic rules and the type of psychological processes which underlie the human ability to follow these rules. This is a question which this paper aims to shed some light on.

One of the most popular answers to this question was proposed by Noam Chomsky, in his influential theory of Universal Grammar (UG). Chomsky and his numerous followers, for instance Steven Pinker,[6] claim that UG is one of the mind's many modules, one which encodes a set of general syntactical principles and specific parameters, common for the grammar of every language. What differentiates the grammar of one human language from the grammar of another is the content of the parameters. And, since UG, as Chomsky claims, is hard-wired and innate, thus it must be genetically determined and shaped by natural selection. Children are able to acquire language, Chomsky argues, because UG serves as Language Acquisition Device (LAD) – that is during infancy a child's UG module "tunes" it's parameters to the set of parameters of the grammar of her mother tongue.

The position of Chomsky and other related thinkers has been the subject of detailed criticism from many scientists and philosophers, and we do not aim to reconstruct or review the debate about the theory

[5] Cf. Ł. Kwiatek, M. Hohol, "The emergence of symbolic communication: From intentional gesterus of great apes to human language", in *The Emergence of Normative Orders*, J. Stelmach, B. Brożek, Ł. Kurek (eds.), Copernicus Center Press, Kraków 2016.
[6] S. Pinker, *Language Instinct: The New Science of Language and Mind*, Penguin Books, New York 1995.

of UG.[7] We mentioned this theory because it could be seen as a manifestation (or a consequence) of a more general *formal* or *computational* vision of human mind, the paradigm we think currently should be considered as empirically inadequate. In consequence, if one tries to explain how the mind processes linguistic rules, she should adopt another theoretical framework. We believe that a good candidate for that framework is the embodied mind paradigm, especially the theory of cognitive simulation.

Now, let us look closer at the computational paradigm and the major problem it faces with regard to how the *embodied cognition* paradigm emerged – an alternative vision of all human cognitive functions, including language processing.

1. Grounding problem

According to the (hard) computational paradigm,[8] cognitive processes (including language production and understanding) are based on computation performed by various modules of mind. Those computations are understood as a manipulation of amodal, meaningless symbols, analogously to the operations performed by (Universal) Turing Machine, according to innate, hard-wired set of abstract rules (for instance Chomsky's UG). One of the most famous examples of the theory within this paradigm in the philosophy of mind is Fodor's theory of *Language of Thought* or *Mentalese*.[9]

The formulation of the computational paradigm allowed cognitive science to develop rapidly; initially, it appeared to be a promising solu-

[7] See B. Brożek, *Granice interpretacji*, Copernicus Center Press, Kraków 2014; M. Tomasello, "Language is not an instinct", *Cognitive Development*" 10 (1), 1995, 131–156.
[8] There are certainly many versions of the computational paradigm. In this paper we address only what we consider as the most standard version, embraced by (among others) Steven Pinker (*How the Mind Works*, W.W. Norton & Company, NY – London 1997) or Jerry Fodor (*The Mind Doesn't Work That Way. The Scope and Limits of Computational Psychology*, The MIT Press, Cambridge, MA 2000).
[9] See J. Fodor, *The Language of Thought*, Harvard University Press, Cambridge, MA 1975.

tion to, arguably, the most important issue of modern philosophy: the mind-body problem. Over time, however, a set of objections against this paradigm has been formulated. At least from 1970s, research done by linguists (most notably George Lakoff,[10] Ronald Langacker,[11] Giles Fauconnier,[12] Zoltan Kövecses[13]), philosophers (Mark Johnson[14]) and cognitive psychologists (Eleanor Rosch,[15] Francisco Varela,[16] Arthur Glenberg[17]) has begun to shape a completely new vision of human cognition – the embodied mind paradigm – which emphasises the fact that our bodies (and actions in natural and social environment, all our experiences) essentially influence our cognitive processes.[18]

For instance, Lakoff and Johnson identified a number of so called *conceptual* or *cognitive metaphors*, whereby the mind processes abstract concepts (like *time* or *joy*), based on the structure of concrete or primary concepts connected to one's experiences (like *money* or *heat*). *Exempli gratia*, the metaphor HAPPY IS UP; SAD IS DOWN manifests itself in expressions like "Things are looking *up*" or "He is really *low* these days." That means, Lakoff and Johnson claim, that we *think* (and – as a result – also speak) about mood (the target domain of the metaphor) using a conceptual structure of a different kind of experience (in this case physical orientation – a source domain of the metaphor). Physical and social interactions are the source of con-

---

10 See G. Lakoff, M. Johnson, *Metaphors We Live By*, University of Chicago Press, Chicago 1980.

11 See R. Langacker, *Cognitive Grammar: A Basic Introductio*n, Oxford University Press, Oxford 2008.

12 See G. Fauconnier, "Methods and generalizations", in *Cognitive Linguistics: Foundations, Scope, and Methodology*, T. Janssen, G. Redeker (eds.), Cognitive Linguistics Research 15, Mouton de Gruyter, Berlin 1999, pp. 95–127.

13 See Kövecses, *Language, Mind and Culture*, Oxford University Press, Oxford 2006.

14 See M. Johnson, *The Body in the Mind*, University of Chicago Press, Chicago 1987.

15 See E.H. Rosch, "Human categorization", in *Advances in Cross-Cultural Psychology*, vol. 1, N. Warren (ed.), Academic Press, NY 1977, pp. 1–72.

16 See F. Varela, E. Thompson, E. Rosch, *The Embodied Mind: Cognitive Science and Human Experience*, The MIT Press, Cambridge, MA 1991.

17 See M. de Vega, A. Glenberg, *Symbols and Embodiment: Debates on Meaning and Cognition*, Oxford University Press, Oxford 2008.

18 See M. Wilson, "Six views of embodied cognition", *Psychonomic Bulletin & Review*" 9 (4), 2002, 625–636, for more general discussion.

ceptual metaphors. Various human societies share at least partially the same set of conceptual metaphors (which is reflected in language), because they similarly experience the environment and live in similar social reality (at least when it comes to the set of social interactions). The famous book *Metaphors We Live By*, written by George Lakoff and Mark Johnson, where the authors presented the framework of the theory of conceptual metaphors, began the cognitive revolution in linguistics and led many scientists to reject Noam Chomsky's theory, indirectly challenging the entire computational paradigm of mind.

From the perspective of embodiment, the most important challenge to the computational paradigm was what Harnad later called the *grounding problem*.[19] The idea was that it is not clear how those amodal, nonperceptual, meaningless symbols of *Mentalese* could be connected to an individual's actions, her perception and experiences (how they are grounded into one's body and actions). This connection is – at best – entirely arbitrary, just like the connections between the words of natural language and their arbitrary, conventional meanings. In other words, symbols postulated by advocates of the computational paradigm, as Pucher and Zwaan pointed out, "are floating free in some mental ether and are therefore essentially meaningless."[20] How they acquire semantic dimensions is unknown.

Although the embodied paradigm implies the connection between cognition (including language) and individual perception and action (both in natural and social environment), at its beginning it lacked a cognitive mechanism which could explain how the embodied mind really works. Embodiment seemed more like an idea or principle, based on some identified psychological effects and philosophical claims, rather than a real explanation of how the mind works. But from 1990s, the idea of such a unifying cognitive mechanism which could explain *how* the mind is embodied, started to emerge.[21]

---

19 See S. Harnad, "The symbol grounding problem", *Physica D* 42, 1990, 335–346.

20 R.A. Zwaan, D. Pecher, "Revisiting mental simulation in language comprehension: Six replication attempts", *PLoS ONE* 7 (12), 2012, e51382.

21 B. K. Bergen, *Louder Than Words: The New Science of How the Mind Makes Meaning*, Basic Books, NY 2012.

2. The embodied simulation theory

One of the first steps toward the emergence of the idea of such a mechanism was made by Lawrance Barsalou. He rejected the assumptions of the computational paradigm of mind, according to which cognitive processes consist of the manipulation of meaningless symbols and are independent of perception. Barsalou suggested replacing those symbols with "perceptual symbols" which are directly linked to perception and cognition. He defined those symbols as:

> records of the neural states that underlie perception. During perception, systems of neurons in sensory-motor regions of the brain capture information about perceived events in the environment and in the body. At this level of perceptual analysis, the information represented is relatively qualitative and functional (e.g., the presence or absence of edges, vertices, colors, spatial relations, movements, pain, heat).[22]

What is important here is that they are not amodal and meaningless, but both modal and analogical, in contrast to the symbols of *Mentalese*:

> They are modal because they are represented in the same systems as the perceptual states that produced them. The neural systems that represent color in perception, for example, also represent the colors of objects in perceptual symbols, at least to a significant extent. On this view, a common representational system underlies perception and cognition, not independent systems. Because perceptual symbols are modal, they are also analogical. The structure of a perceptual symbol corresponds, at least somewhat, to the perceptual state that produced it.[23]

---

[22] L. Barsalou, "Perceptual symbol systems", *Behavioral and Brain Sciences* 22, 1999, 577–660 (582).
[23] *Ibidem*, p. 578.

Barsalou suggested that those perceptual symbols are organized into what he called "simulators," which perform mental or embodied "simulations of entity or event in its absence,"[24] which he considers as the basis of many cognitive functions.

Thus, according to Barsalou, when a person sees a ball, the visual cortex of her brain is processing information regarding the ball's shape, colour, etc. If a person touches or kicks the ball, the sensory-motor cortex of her brain captures additional information regarding how the ball moves and how to perform a kick of the ball. A similar process occurs – that is the activity of the visual and sensory-motor parts of the brain – when a person is only imagining playing with a ball or thinking about kicking the ball, or is recalling memories concerning her experiences with playing a ball, with the absence of a real ball. That is how embodied simulation, a multimodal process which underlays perception and cognition and action alike, works. Of course, the example above is an obvious simplification of Barsalou's theory, but we think it conserves its essence.

Embodied simulation is often linked with the process of mental imagery; however, the difference between those two may seem unclear. Some authors emphasise that embodied simulation is more abstract and is performed unconsciously, while mental imagery depends on someone's will and requires effort.[25] In that sense, mental imagery is a kind of conscious experience, one of many which are based on embodied simulation.

It is worth mentioning that the idea of embodied simulation later became very popular, especially in the field of social cognition. For instance, neuroscientist and philosopher Vittorio Gallese suggested that mindreading – the ability to attribute mental states such as intentions, emotions, beliefs, desires, to other individuals; to treat them as individuals that have minds – is also based on embod-

[24] *Ibidem*.
[25] Cf. V. Gallese, "Embodied simulation: From neurons to phenomenal experience", *Phenomenology and the Cognitive Sciences* 4 (1), 2005, 23–48.

ied simulation, especially the simulation of their emotional states and actions:

> According to my model, when we witness the intentional behavior of others, embodied simulation generates a specific phenomenal state of "intentional attunement." This phenomenal state in turn generates a peculiar quality of identification with other individuals, produced by establishing a dynamic relation of reciprocity between the "I" and the "Thou." By means of embodied simulation we do not just "see" an action, an emotion, or a sensation. Side by side with the sensory description of the observed social stimuli, internal representations of the body states associated with these actions, emotions, and sensations are evoked in the observer, "as if" he/she were doing a similar action or experiencing a similar emotion or sensation. That enables our social identification with others. To see others' behavior as an 'action' or as an experienced emotion or sensation specifically requires such behaviors to be mapped according to an isomorphic format. Such mapping is embodied simulation.[26]

Barsalou, however, was the first who suggested that language processing and comprehension may be based on embodied simulation. That is, when a person hears or reads a sentence, her brain performs a *simulation* of the *meaning* of the utterance. This idea may seem more philosophical than empirical but Barsalou suggested that if the idea of the simulation is sound, some experimental consequences could be observed:

> For example, "the cup on Anna's desk is blue" refers to a particular cup on a particular desk, and predicates that it is blue. To construct a simulation of this sentence, the comprehender simulates the individual desk and cup and then specializes the color of the cup.

[26] V. Gallese, "Embodied simulation theory and intersubjectivity", *Retu, Saperi, Linguaggi* 4, (2), 2012, 57–64 (61).

> Later sentences update the simulation by changing the individuals present and/or transforming them. Thus, “it contains pens and pencils” adds new individuals to the simulation, inserting them inside the cup. The affordances of a simulation may often produce inferences during comprehension. For example, spatial properties of the pens, pencils, and cup determine that the pens and pencils sit vertically in the cup, leaning slightly against its lip. If the pens and pencils had instead been placed in a drawer, their orientation would have been horizontal.[27]

The problem was how to design the experiment in which the effects concerning the orientation of simulated objects would be present. Stanfield and Zwaan proposed using a sentence-picture verification task. During the experiment, participants

> read a sentence in which the orientation of an object is implied, rather than stated explicitly, and then they decide whether the object shown in the subsequently presented picture was mentioned in the sentence. The key feature of the paradigm is that the orientation of the pictured object is manipulated; it is either horizontal or vertical. This means that the pictured object’s orientation either matches or mismatches the orientation of the object as it was implied by the sentence. If language comprehenders perform mental simulations, they should show sensitivity to this difference in orientation.[28]

In the experiment researchers used sentences like: “The ranger saw the eagle in the sky” (which suggests that the eagle has its wings outstretched) or “The ranger saw the eagle in the nest” (which suggests that the eagle has its wings drawn in), and “The pencil is in the cup” (which implies the vertical position) or “The pencil is in the

[27] L. Barsalou, “Perceptual Symbol Systems”, *op. cit.*, 605.
[28] R. A. Zwaan, D. Pecher, “Revisiting Mental Simulation in Language Comprehension…”, *op. cit.*

drawer" (which suggests horizontal position). After each sentence, the participants saw one picture that either 1) presented something completely different from the sentence or 2) a picture of the object mentioned in the sentence that matched the orientation implied by the sentence or 3) a picture of the object mentioned in the sentence that mismatched the orientation implied by the sentence. The results showed that participants were faster in verifying sentences when the pictures matched the implied orientation than pictures that mismatched. Those results have been explained in terms of embodied simulation theory (seemingly in accordance with Barsalou's prediction).[29]

A number of subsequent experiments showed the presence of similar "embodied" effects in the understanding of language. For instance, in a study conducted by Glenberg and Kaschak, participants were to decide whether a presented sentence was sensible (by pressing a "Yes" button) or nonsense (using a "No" button). The sentences were of three kinds: they could either be "toward" (like "Courtney handed you the notebook," which implies moving your hand toward your body) or "away" (like "You delivered the pizza to Andy," which implies moving your hand away from your body, towards the body of Andy) or simply nonsensical ones (like "Joe sang the cards to you"). Responses were made by pressing one of two buttons – the first one required moving a hand towards the participant's body, while pressing the second one required moving the hand away from the participant's body. The results showed the presence of the phenomenon termed by the researchers the *action–sentence compatibility effect* (ACE): when the "Yes" button was nearer the body of the participants, they responded faster to "toward" sentences, while in case when the "Yes" button was further from the body, participants responded faster to "away" sentences.[30] Another experiment confirmed

[29] R. A. Stanfield, R. A. Zwaan, "The effect of implied orientation derived from verbal context on picture recognition", *Psychol. Sci.* 12, 2001, 153–156.
[30] A. Glenberg, M. Kaschak, "Grounding language in action", *Psychonomic Bulletin & Review* 9 (3), 2002, 558–565.

the ACE also for third-person only sentences (like "John is opening/ closing the drawer").[31]

Interesting results from the perspective of embodied simulation were also obtained in several experiments that tried to answer the question of whether experts (for instance hockey players) and novices (people uninterested in hockey) differ in processing language concerning a specific domain (hockey). According to Bergen, studies like those conducted by Holt and Beilock,[32] Beilock et al.,[33] and Wassenburg and Zwaan[34] all suggest that experts have more detailed mental simulations than novices when they process sentences involving words from their expert domain. For instance, in a picture-sentence verification task, expert hockey players responded faster to pictures in a "matched condition," when the configuration of object (like a hockey helmet with the facemask closed) matched the configuration of the object implied by the sentence ("The referee saw the hockey helmet on the player," which – at least for experts – implies that the facemask on the helmet is clipped closed). Novices did not respond faster in the matched condition than in the mismatched condition (a picture of a helmet with a closed facemask after sentence *The referee saw the hockey helmet on the bench*).[35]

All of the aforementioned studies revealed effects which seem rather bizarre and hard to explain from the perspective of the hard computational paradigm and the Mentalese theory – this theory

---

31 B. Bergen, K. Wheeler, "Sentence understanding engages motor processes", *Proceedings of the Twenty-Seventh Annual Conference of the Cognitive Science Society*, Erlbaum Mahwah, NJ 2005, pp. 238–243.

32 L. E. Holt, S. L. Beilock, "Expertise and its embodiment: examining the impact of sensorimotor skill expertise on the representation of action-related text", *Psychonomic Bulletin & Review* 13, 2006, 694–701.

33 S. L. Beilock, I. M. Lyons, I. A. Mattarella-Micke, H. C. Nusbaum, S. L. Small, "Sports experience changes the neural processing of action language", *Proceedings of the National Academy of Sciences* 105, 2008, 13269–13273.

34 S. I. Wassenburg, R. A. Zwaan, "Readers routinely represent implied object rotation: The role of visual experience", *Quarterly Journal of Experimental Psychology* 63, 2010, 1665–1670.

35 B. K. Bergen, *Louder Than Words*, *op. cit.*

could not predict such results and would require many additional assumptions. The case seems very different when one is to consider those findings in terms of embodied simulation theory. As we could see, a core element of the theory of embodied simulation is the assumption that the mind simulates the meaning of sentences by using the same parts of brain which are used – for instance – for action execution. Thus, the process of embodied simulation during language comprehension could facilitate performing movements (like pressing the proper button) similar to those described in presented sentences.

Another possible approach to these results could be provided by so called *enacted mind* paradigm, which is closely related to the *embodied mind*. The former emphasises the primacy of actions in relation to cognition, that is, it indicates that all (or most) cognitive processes undergo primarily in order to execute certain action.

Michael Arbib coined the term *action-oriented perception* which emphasises the fact that perception (for instance, the perception of movement) serves action (like hunting and feeding) in animal brains. Analogously, we could use the term *action-oriented cognition* to characterize the claim that the fundamental function of the brain is action execution, and everything else (cognition and perception) – at least phylogenetically and ontogenetically – are just means of effective action execution. Such a view was proposed for instance by Glenberg, Javorski, Rischal and Levin.[36] From that perspective, "embodied effects" in experiments respecting language processing may be seen as some kind of preparation for the execution of an action (for instance an action depicted in heard or read sentences), and perhaps could be induced by some kind of associative learning.

[36] A. M. Glenberg, B. Jaworski, M. Rischal, J. R. Levin, "What brains are for: action, meaning, and reading comprehension", in *Reading Comprehension Strategies: Theories, Interventions, and Technologies*, D. McNamara (ed.), Lawrence Erlbaum Publisher, Mahwah, NJ 2007, pp. 221–240.

3. Mirror neuron system – a mechanism for simulation?

In the 1990s. a group of researchers from the University of Parma, including Giocamo Rizzolatti, Giuseppe di Pellegrino and Vittorio Gallese, performed a series of studies concerning the activity of neurons (using single-cell recording methods) from the rostral part of ventral premotor cortex (F5 area) in *Macaca nemestrina* monkeys. By that time it was well established that various neurons from the F5 area discharge when a monkey performs specific hand movements. Unexpectedly, the new study demonstrated that certain neurons discharge both when a monkey is performing a specific movement (like a firm grip or a precise grip), and also when it only is observing the same movement performed by other individual (monkey or human).[37] Those neurons were later called *mirror neurons*.[38] The team also identified neurons – called *canonical* – which discharge both when a monkey performs a specific hand movement (like precision grip) and when an object, which matches this type of movement (in this case a small object like a raisin), is presented to the monkey.

Subsequent studies proved – among others[39] – the existence of trimodal mirror neurons (which discharge not only for action-execution and observation of action, but also when the monkey heard sounds related to a specific action)[40] and the presence of similar kinds of neurons in human brain.[41] Other studies involving non-invasive neuro-

---

[37] G. Di Pellegrino, L. Fadiga, L. Fogassi, V. Gallese, G. Rizzolatti, "Understanding motor events: A neurophysiological study", *Experimental Brain Research* 91, 1992, 176–180.

[38] V. Gallese, L. Fadiga, L. Fogassi, G. Rizzolatti, "Action recognition in the premotor cortex", *Brain* 1996, 119 (Part 2), 1996, 593–609.

[39] For a general review of the studies on mirror neurons see: J. M. Kilner, R. N. Lemon, "What we know currently about mirror neurons", *Current Biology* 23, 2013, R1057–R1062.

[40] C. Keysers, E. Kohler, M. A. Umilta, L. Fogassi, L. Nanetti, V. Gallese, "Audio-visual mirror neurons and action recognition", *Experimental Brain Research* 153, 2003, 628–636.

[41] W. D. Hutchison, K. D. Davis, A. M. Lozano, R. R. Tasker, J. O. Dostrovsky, "Pain-related neurons in the human cingulate cortex", *Nature Neuroscience* 2 (5), 1999, 403–405; R. Mukamel, A. D. Ekstrom, J. Kaplan, M. Iacoboni, I. Fried, "Single-neuron responses in humans during execution and observation of actions", *Current Biology* 20 (8), 2010, 750–756.

imaging methods (TMS, EEG, MEG) suggest the existence of large populations of neurons (presumably consisting of mirror neurons and sometimes labelled as the mirror neuron system, MNS) in human brains which behave like mirror neurons (that is, some circuits in the brain activate both on action execution and during observation of the same action).[42]

Because they directly link perception (like hearing and seeing) and action, mirror neurons (and the entire MNS) are embodied *per se* and seem to be a good candidate for a brain mechanism of embodied simulation. The followers of the idea of embodied simulation – like Gallese[43] and Bergen – maintain such a position. Nevertheless, if mirror neurons are the basis for embodied simulation in terms of Barsalou, they should play an important role in language understanding, and the real question is whether they do so or not. Some studies indirectly suggest that the former case is true.[44]

For instance, the experiments conducted by Friedemann Pulvermüller's team demonstrated that reading verbs for head, arm or leg actions by participants induces the activation of the respective areas of their motor system.[45] Some subsequent studies demonstrated that this

---

42 See, for instance, M. Fabbri-Destro, G. Rizolatti, "Mirror neurons and mirror systems in monkeys and humans", *Physiology* 23, 2008, 171–179; P. Molenberghs, R. Cunnington, J.B. Mattingley, "Brain regions with mirror properties: A Meta-analysis of 125 human fMRI studies", *Neuroscience and Biobehavioral Reviews* 36 (1), 2012, 341–349.

43 V. Gallese, "Mirror neurons, embodied simulation, and the neural basis of social identification", *Psychoanalytic Dialogues* 19, 2009, 519–536.

44 Incidentally, some other premises indirectly support the idea that the MNS somehow contribute to language processing or evolution. Firstly, the F5 region of the *Macaca nemestrina* brain is considered to be homologous to Broca's area (Language within our grasp) – the part of the human brain where a lesion impairs the ability to produce language, and certain experiments suggests that Broca's area contains a population of mirror neurons Localization of grasp representations in humans by PET: 1. Observation versus execution. These hypotheses led Michael Arbib to propose his theory of the evolution of the language-read brain, and – according to this theory – mirror neurons play an important role in the emergence of symbolic language from gestural communication, through communication based on pantomime (M. Arbib, *How the Brain got Language. The Mirror System Hypothesis*, Oxford University Press, Oxford 2012).

45 F. Pulvermüller, "Brain mechanisms linking language and action", *Nat. Rev. Neurosci.* 6, 2005, 576–582.

activation plays a causal role in language processing – TMS stimulation (which can temporarily impair parts of the brain) over relevant motor areas affects performing linguistics tasks.[46]

Those findings are similar to results that have been obtained in at least two other studies. In their experiment Niedenthal, Winkielman, Mondillon and Vermuelen demonstrated that reading words that describe emotions activates the relevant facial muscles,[47] while Havas, Glenberg, Gutowski, Lucarelli and Davidson demonstrated that temporarily paralyzing these facial muscles with injections of Botox affects understanding of the sentences involving those emotions whose expression require the use of the paralyzed muscle.[48]

All of these findings (including those mentioned earlier), as Fischer and Zwaan noted, "suggest the intriguing possibility that language comprehension may incorporate, and possibly even require as an essential component, some activity of the motor system,"[49] what those authors labelled as "motor resonance." The "motor resonance" in language processing could be understood in the light of the embodied simulation theory, while this phenomenon may seem odd if one assumes *Mentalese* or Chomsky's Universal Grammar module. There is no direct evidence that all of these effects involve mirror neurons, but one can claim that mirror neurons are only a part – although presumably the most important – of the brain mechanism that underlies embodied simulation.

---

[46] F. Pulvermüller, O. Hauk, V. Nikulin, R. Iloniemi, "Functional links between motor and language systems", *European Journal of Neuroscience* 21, 2005, 793–797.

[47] P. Niedenthal, P. Winkielman, L. Mondillon, N. Vermuelen, "Embodiment of emotional concepts: Evidence from emg measures", *Journal of Personality and Social Psychology* 96, 2009, 1120–1136.

[48] D. A. Havas, A. M. Glenberg, K. A. Gutowski, M. J. Lucarelli, R. J. Davidson, "Cosmetic use of botulinum toxin-a affects processing of emotional language", *Psychol. Sci.* 21 (7), 2010, 895–900.

[49] M. Fischer, R. Zwaan, "Embodied language: A review of the role of the motor system in language comprehension", *The Quarterly Journal of Experimental Psychology* 61 (6), 2008, 825–850. See mentioned paper for detailed overview of the role of motor system in language understanding.

The entire scientific community, however, not the entire scientific community accept the embodied simulation theory and the claim that mirror neurons provide the neural mechanism for embodied simulation. A criticism of this view has been presented in Gregory Hickok's book *The Myth of Mirror Neurons*, with a telling subtitle: "The Real Science of Communication and Cognition."[50] Hickok begins his book by emphasising that scientific community, as well as science journalists and writers, have been over-enthusiastic regarding the role mirror neurons could have played both in human evolution and the development of human cognitive abilities (he enumerated more than thirty various phenomena to which – according to the authors of the relevant study – mirror neurons have contributed). Hickok emphasises the gap between the human brain and the monkey brain (where MNs were originally discovered) and calls for caution in extrapolating discoveries in monkey brains onto human brains. Nevertheless, he does not deny the existence of the MNs in human brain, but rather tries to rethink and discuss their functions anew.

The main target of Hickok's criticism is the theory of embodied simulation and the entire embodied cognition paradigm.[51] Hickok stresses that "everything about human behaviour – perception, motor control, all of psychology – is a result of information processing"[52] – that is, it is at some level "computational." At least, at the very basic level:

[50] Other than Hickok, Spaulding argues against Gallese's theory of mindreading based on embodied cognition. She claims that the MNs rather support another theory of mindreading – one version of so-called Theory Theory (TT). Although the TT originated within the computational paradigm, against which we argue, Spaulding's novel account does not support any kind of idea of language processing assumed by the computational mind paradigm. Therefore, even if embodied simulation is not a basis of mindreading (at least in Gallese's terms), it could still provide a mechanism that underlines the understanding of language.

[51] Hickok formulates several other objections against the most popular interpretation of the role of mirror neurons (for instance he strongly argues that they do not contribute to action-understanding, a position which is maintained by Rizzolatti's team), but they are rather beyond the scope of this chapter.

[52] G. Hickok, *The Myth of Mirror Neurons: The Real Neuroscience of Communication and Cognition*, W.W. Norton & Company, New York – London 2014.

> Once you start looking inside the brain you can't escape the fact that it processes information. You don't even have to look beyond a single neuron. A neuron receives input signals from thousands of other neurons, some excitatory, some inhibitory, some more vigorous than others. The output of the neuron is not a copy of its inputs. Instead its output reflects a weighted integration of its inputs. It is performing *transformation* of the neural signals it receives. Neurons *compute*. This is information processing and it is happening in every single neuron and in every neural process whether sensory, motor, or <<cognitive>>."[53]

Therefore, "«grounding» cognition in sensory and motor systems" – the aim of the embodied mind/cognition approach – "amounts to grounding cognition in cognition."[54] Hence, although Hickok agrees that "physical properties of the world and the body matter for brain function," he does not accept the embodied cognition approach because, he thinks, it does not provide any explanation of brain mechanisms at all:

> It is important to recognize, however, that calling a process "embodied" doesn't solve any problems. It doesn't tell us how the process works functionally or neutrally; it only tells us in which systems it is happening and then delegates the problem solving to research in those systems.

The same kind of objections Hickok addresses to the embodied simulation theory:

> To say a cognitive operation is accomplished via simulation doesn't simplify the problem, it just hands if off to another domain of inquiry, in this case sensory and motor information processing. It's akin to a hy-

[53] *Ibidem*.
[54] *Ibidem*, p. 123.

> pothetical rogue head-of-state who calls in his top physicists and demands that they work out how to build a nuclear weapon. The physicists come back a week later and proclaim that they've got it all figured out:
> Physicists: We have determined that Oppenheimer and his team have succeded in building a nuclear weapon. All we need to do is simulate what they did.
> Head-of-state: Great! So how did they do it?
> Physicists: We don't know. But simulating their methods will definitely work.[55]

Part of Hickok's criticism is noncontroversial – no one could deny that "at some level" cognition, perception and action are *computational*, thus also motor cognition and embodied simulation require *some kind* of computations. Nevertheless, it does not mean that they require *exactly the kind* of computations which are assumed in traditional computational paradigm, in Chomsky's, Fodor's or Pinker's works – that is, abstract symbol manipulations. Moreover, Chomsky's, Pinker's or Fodor's views on language are linked with specific philosophical or empirical claims regarding, for instance, a modular view of mind,[56] the nature of meaning,[57] or how language evolved and how language acquisition by infants works. We believe that these "associated" claims are problematic – from the philosophical point of view – or empirically inadequate.

Peter Gärdenfors argues that the goal of cognitive science is to provide models for representations, and that various cognitive functions may require different approaches. For instance, connectionist models (artificial neural network) could be effective in modelling the process of pattern or sequence recognition,[58] but have some limits

[55] *Ibidem*.
[56] J. Fodor, *The Modularity of Mind*, The MIT Press, Cambridge, MA 1983.
[57] B. Brożek, "The normativity of meaning", in *The Many Faces of Normativity*, J. Stelmach, B. Brożek, M. Hohol (eds.), Copernicus Center Press, Kraków 2013.
[58] J. Kumar Basu, D. Bhattacharyya, T. Kim, "Use of artificial neural network in pattern recognition", *International Journal of Software Engineering and Its Applications* 4 (2), 2010.

in modelling other cognitive processes.[59] For its part, computational models – the algorithms processed by a Turing Machine – can model abstract or inductive reasoning, but for modelling semantics and conceptual knowledge, Gärdenfors proposes new theoretical framework, so-called conceptual spaces, which are a sort of geometrical model. Without going into details, let us stress that the most important lesson here is that all of these kinds of models are based on information processing, but only in one case – for computational models – does this information processing equal abstract symbol manipulation, like the operations performed by a Turing Machine.[60] Therefore, although we agree with Hickok that the brain certainly performs *some* kind of computation at some level, this does not mean that we are obliged to assume the entire computational paradigm, with all additional philosophical claims and connections. Other models are possible; moreover, as Gardenfors demonstrated, they are in some cases much more suitable.[61]

Hickok, however, seems to allow for the possibility that embodied cognition may not to be a pointless idea:

> [embodied cognition] could be a productive theoretical move, if the idea is correct, because situating the problem within sensory and motor systems may constrain the possible solutions. But this is a yet-to-be-tested possibility.

We certainly agree, but also think that Hickok underestimates the results of the empirical and theoretical studies mentioned above, con-

---

[59] Cf. P. Gärdenfors, *Conceptual Space: The Geometry of Thought*, A Bradford Book, Palatino 2004.

[60] It may be possible, however, to model all kinds of information processing in a computational framework involving algorithms performed by a Turing Machine. Nevertheless, other models (like ANNs or conceptual spaces) could be more suitable – for instance faster – when realized by an artificial device, or less problematic philosophically.

[61] It would be interesting to try to formalise embodied simulation theory using Gardenfors' conceptual spaces framework, but such an endeavour is definitely beyond the scope of this paper.

ducted within the embodied paradigm framework. Finally, yet importantly, embodied simulation theory perfectly fits with the "logic" of evolution and natural selection, which, instead of creating completely new solutions from scratch, rather uses and transforms already present mechanisms and organs. Embodied simulation, which uses the evolutionarily older parts of the brain (like the motor cortex) in novel ways (in language processing), could be seen as a result of the influence of evolutionary forces.

Thus, even if – with the current scientific data – we are not completely sure whether embodied simulation theory is correct, it should be considered at least as an interesting and probable hypothesis. Let us look, then, at what we could learn about linguistic rules and the philosophical issue of meaning from the perspective of this "interesting and probable hypothesis."

4. Simulation and linguistic rules

Previously when we talked about embodied simulation during language understanding, we focused on single words (like *eagle* or *pen*) of which at least a part of the meaning were to be simulated when a person processes an utterance (like the composition of an eagle's wings or the location of the pen). Nevertheless, if one is to argue that cognitive simulation contributes to meaning and enables an understanding of entire utterances, it should be somehow sensible to the linguistic rules – because those rules undoubtedly influence the meaning of the sentences and utterances. Without pointing out that grammar does have an influence on simulation, the whole theory would not be very interesting from the philosophical perspective.

According to Bergen, linguistic rules really do influence embodied simulation in several interesting ways.[62] Let us consider just two of the most basic examples. The first one concerns the perspective of

[62] See: B. K. Bergen, *Louder Than Words*, *op. cit.*

the simulated action. Consider the following sentences: 1) *You threw the baseball to the catcher*, 2) *The pitcher threw the baseball to the catcher*. The difference between them is obviously the grammatical person (*you* and *he*), and if embodied simulation theory is right, the simulation should somehow reflect the difference between those two sentences. As Bergen and his colleagues found, it really does. They had participants read sentences like those two mentioned above, and subsequently

> two pictures popped up on the screen in quick succession, and participants had to press buttons labeled "yes" or "no" to indicate whether the two pictures depicted the same object. Sometimes the two objects were the same (say, two baseballs in a row), and sometimes they weren't (a baseball and a shoe).[63]

If those two objects were the same, the authors manipulated the size or location of the second image, so that in addition to the first picture, as Bergen explains,

> it looked like the object was either moving away from the participant, or from their left to right (…). So in the experiment, we contrasted motion that appeared to be moving away from people with motion to their right. If people adopt a participant perspective when *you* is the subject, they should categorize objects moving away from them faster, and if they adopt a participant perspective when someone else is the subject, categorization of rightward moving objects should be faster.[64]

The results showed that

> people responded significantly faster when the perspective induced by the grammatical person and that of subsequently moving images

---

[63] *Ibidem*, pp. 216–217.
[64] *Ibidem*, pp. 219–220.

> were compatible. This suggests that person acts as a grammatical cue that modulates the character of embodied simulations; in particular, that who is described as engaging in an activity affects the perspective we're more likely to adopt in mentally representing that activity (…). What's interesting about this is that in this case, grammar appears not to be telling you what to simulate, but rather, how to simulate - what perspective to simulate the event from. Instead of acting as the script in this case, grammar is acting as the director.[65]

Grammar is also able to express a structure of the event depicted in the utterance – for instance whether it is ongoing – using a progressive form (*John is closing the drawer*) or completed – using a perfect form (*John has closed the drawer*). In research done by Madden and Zwaan, participants were to decide whether the presented image (like a drawer during closing – which depicts an ongoing state, or a drawer completely closed – which depicts a completed state) depicts the event described in the sentence which was shown just before the image. The sentences were either progressive or perfect, and the results showed that participants responded faster to completed-state pictures than to ongoing-state pictures, which were presented after perfect sentences.[66] These results seem coherent with the claim that grammar is able to influence the embodied simulation during processing linguistic utterances in various ways.

5. Conclusions

So, where have all of these considerations led us to? The theory of embodied simulation could have many implications, but let us stay here within the bounds of the philosophical problem of meaning. If the embodied simulation theory is right, meaning should primarily be consid-

[65] *Ibidem*.

[66] Cf. *ibidem*, p. 199.

ered as embodied into a person's actions in a social and physical world and her memories and experiences. Therefore, one could argue, there exists something like "private meaning," as Bergen sums up:

> If meaning is based on experience with the world–the specific actions and percepts an individual has had – then it may vary from individual to individual and from culture to culture. And meaning will also be deeply personal – what polar bear or dog means to me might be totally different from what it means to you.[67]

So, if there are private meanings in our heads, a serious problem arises: how can we effectively communicate with one another? The answer could be that although meaning is partially private – because embodied simulation is private – it is also strongly shaped by our physical, social and cultural environment which helps to "tune" private meanings, that even if they vary, the differences in meanings are not severe. That is because we live in similar worlds, we engage in similar activities and experience similar emotions. Moreover, when we communicate with other persons, we always engage in a joint social context which influences the way we simulate meanings. Finally, we also use linguistic rules, which serve as tools of effective communication, since they also hold in check our simulating brains so that we simulate more or less what our interlocutor wanted us to simulate.

Let us also stress that the embodied simulation theory seems especially attractive since it presents language as a natural expansion of our (evolutionarily) older cognitive functions that we share with other animals. That could explain why are able – to some extent – to effectively communicate with other animals by means of symbolic communication of communication (and how it was possible for them to learn language-like communication). Other approaches – like the computational mind paradigm which assumes a special language module – do not provide such elegant and coherent explanations in tune with the scientific data.

---

[67] *Ibidem*.